Quality Characteristics of Yogurt from Goat's Milk, Supplemented with Fruit Juice

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Abstract

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Yogurt was prepared from goat's milk, supplemented with aronia juice and blueberry juice. The dynamics of acidification, number of lactic acid bacteria, and fatty acids composition were investigated. Yogurt from goat's milk, supplemented with aronia juice and blueberry juice, coagulated at a lower acidity and faster than natural yogurt. The numbers of lactic acid bacteria in supplemented yogurts were higher compared to control samples. The addition of aronia and blueberry juices increased the amount of unsaturated fatty acids in yogurt by 6.9% and 8.5%, respectively. Polyunsaturated fatty acids increased by 11.2% in yogurt with aronia juice in comparison with natural yogurt.

Keywords: goat's milk; yogurt; aronia (*Aronia melanocarpa* L); blueberry; fatty acids; lactic acid bacteria counts

The particular interest in goat's milk is prompted by its indisputable dietetic properties. By chemical composition, goat's milk is similar to cow's milk, but the amounts of ingredients differ. The former has higher contents of dry matter, total protein and casein, milk fat and mineral substances, which determines its higher nutritive value (Haenlein 2004). Goat's milk fat contains more vitamin A than cow's milk. The fatty acid composition of goat's milk is also different, being richer in volatile fatty acids (caproic, caprylic, and capric) that are responsible for the specific taste and odour of the respective dairy products. The higher content of medium-chain fatty acids accounts also for the more prolonged bacteriostatic stage.

Recently, an increasing number of studies appeared on the production of Bulgarian yogurt with various supplements (Katsharova *et al.* 2003). The purpose was to improve on the organoleptic and healing properties of milk. Most commonly, yogurt is supplemented with various fruit juices that add a pleasant taste and aroma.

Aronia (*Aronia melanocarpa* L.) juice is rich in biologically active substances – vitamins (E and C), bioflavanoids, mineral salts, and trace elements. It has the highest ORAC (Oxygen Radical Absorbance Capacity) value known. ORAC values of aronia range from 97.3 to 2087.1 μmol/g (Prior & Cao 1999), thus making it one of the most potent antioxidants. Aronia fruits contain significant amounts of flavonoids and phenols. The main subgroups of flavonoids are proanthocyanins, anthocyanins, flavonols, and catechins (Oszmianski & Wojdylo 2005), that possess antioxidant, anti-inflammatory, antiviral, antibacterial, and anticarcinogenic effects (Szaefer *et al.* 2006).

Rich sources of flavonoids are also blueberries that have one of the highest *in vitro* antioxidant capacities documented – ORAC values range from 54.2 μmol/g to 3984.5 μmol/g (Prior & Cao 1999). This is due to the high content of phenolic compounds and anthocyanins in particular (Fukumoto & Mazza 2000). The blueberry extract, rich in anthocyanins, induces the production of tumour necrosis factor δ and acts as immune response modulator in activated macrophages. The phenolic compounds in blueberry fruits are able to reduce the NO-induced oxidative stress and are thus beneficial in cardiovascular illness and chronic inflammations (Wang & Mazza 2002a,b). Kay and Holub (2002) observed that the intake of dried blueberries after fat meat consumption increased the serum antioxidant status. This increase is interpreted as one of the alternatives for reducing the risk of many chronic degenerative disorders (Kaplan & Aviram 1999; Vendemiale *et al*. 1999).

The purpose of the present work was to investigate the effects of fruit supplements of aronia (*Aronia melanocarpa* L.) and blueberry juices on the acidity dynamics, lactic acid bacterial counts, syneresis, and fatty acid composition of yogurt.

MATERIAL AND METHODS

Fresh milk and starter cultures. Fresh raw goat milk and a starter culture, containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus* (Lactina 17, Bankya, Sofia, Bulgaria) ready for direct vat inoculation were used for yogurt preparation. The goat's yogurt was prepared in laboratory conditions.

Yogurt preparation. The milk was pasteurised (95°C/30 min), cooled to 45°C, and inoculated with 1.5% yogurt culture consisting of *Lactobacillus delbrueckii* ssp. *bulgaricus* and *Streptococcus thermophilus* (Lactina 17, Bankya, Sofia, Bulgaria). The raw milk was divided into three lots – control and 2 experimental. Prior to adding the starter, 5 g/kg fruit juice from either aronia or blueberry was added to the experimental milk samples. The samples were then cultivated at 42°C until coagulation, then cooled and stored in a refrigerator at 4–6°C.

Physicochemical analyses. The titratable acidity of milk was determined on the 1st h and 2nd h after milk culturing, at the time of coagulation, and after storage in a refrigerator for 24 h and 48 h, using titration with 0.1N sodium hydroxide (AOAC 1990).

The active acidity (pH) was determined after coagulation and storage of yogurt.

The syneresis of yogurt (Shidlovskaya 1979) was studied immediately after coagulation and after the storage of milk at 4–6°C for 24 h and 48 hours.

The extraction of milk fat was done after the method of Rose-Gottlieb using diethyl ether and petroleum ether (Methodenbuch, Bd. VI VDLUFA-Verlag, Darmstadt). After the extraction, the solvents were evaporated on a vacuum-rotary evaporator. For receiving methyl esters of the fatty acids, sodium methylate (CH_3ONa) was used (Jahreis *et al*. 1997). The fatty acid composition of yogurt, both natural and with juice supplements, was determined by gas chromatography Pay-Unicam 304 (Pay-Unicam, Cambridge, England) with flame

Table 1. Acidity dynamics of yogurt supplemented with either blueberry or aronia juice (n = 5)

Parameters	Natural		Supplemented with: blueberry		Supplemented with: aronia	
	$\bar{x}$	$S_{\bar{x}}$	$\bar{x}$	$S_{\bar{x}}$	$\bar{x}$	$S_{\bar{x}}$
Initial acidity (°T)	16.3	0.408	16.3	0.408	16.3	0.408
Acidity by the 1st h of culturing (°T)	19.6	0.707	20.0	0.816	20.0	0.707
Acidity by the 2nd h of culturing (°T)	41.0	3.937	39.7	5.017	43.3	0.816
Acidity at coagulation (°T)	84.0[bc]	0.707	74.7[ab]	1.633	69.3[ac]	0.408
pH at coagulation (–)	4.37	0.051	4.46[a]	0.023	4.52[a]	0.004
Time for coagulation (min)	175.0[a]	3.536	160.0	7.071	143.3[a]	4.082
After 24 hours						
Acidity (°T)	98.7[a]	2.944	95.7[a]	0.816	85.0[a]	4.301
pH (–)	3.95[a]	0.064	4.13[a]	0.041	4.17[a]	0.019
After 48 hours						
Acidity (°T)	106.7	1.080	107.0	3.937	96.0	6.819
pH (–)	3.88[a]	0.051	4.00[a]	0.004	4.05[a]	0.015

[a] $P < 0.05$; [b] $P < -0.01$; [c] $P < 0.001$

Table 2. Lactic acid bacterial counts in goat's yogurt supplemented either with blueberry or aronia juice (thousand/ml) ($n = 5$)

Type of yogurt	At coagulation			After 24 h			After 48 h		
	natural	with blueberry	with aronia	natural	with blueberry	with aronia	natural	with blueberry	with aronia
Total count	712 071	925 002	1 279 046	1 010 670	1 200 800	1 461 135	1 108 020	1 479 796	1 627 338
L. bulgaricus (1)	130 626	281 430	349 575	320 370	388 370	513 300	377 010	504 880	638 793
S. thermophilus (2)	581 445	643 572	929 471	690 300	812 430	947 835	731 010	974 916	988 545
Ratio (1:2)	1:4.4	1:2.28	1:2.66	1:2.15	1:2.1	1:1.85	1:1.94	1:1.93	1:1.55

ionisation detector and column EC^{TM}- WAX, 30 m, ID 0.25 mm, film: 0.25 µm.

Microbiological analyses. The counts of *L. delbrueckii* ssp. *bulgaricus* and *S. thermophilus* in coagulated milk were enumerated by direct counting on microscopic preparations using the method of Breed (A.P.H.A. 1916). The preparations were made from 1:10 dilutions immediately after milk coagulation and after the storage at 4–6°C for 24 h and 48 hours. The counts of lactic acid rods and oval bacteria were determined individually in 50 observation fields.

Statistical analysis. For statistical analysis, ANOVA was performed on the three batches and the corresponding replicates, using a statistical software (Statistica 6.0). Fisher test was used for means comparison.

RESULTS AND DISCUSSION

Acidity dynamics

During the first hour of culturing, the titratable acidity of milks supplemented with aronia or blueberry juice was higher than that of control (Table 1). By the 2nd h, this trend was preserved in the milk batch with aronia juice whereas the samples supplemented with blueberry juice exhibited acidity slightly lower than that of controls. At the time of milk coagulation, the acidity of both experimental samples was lower in comparison to control sample. It was 74.7 °T in milk supplemented with blueberry juice and 69.3 °T in milk with aronia juice compared to 84 °T for natural yogurt. Goat's yogurt with aronia juice coagulated at a lower titratable acidity compared to cow's milk with the same supplement (Dimitrov *et al.* 2002).

The data about titratable acidity and active acidity of goat's yogurt with fruit juice produced by us were not in agreement with those reported by Nilufar (1999), who observed an increase in titratable acidity and a reduction in active acidity in yogurt supplemented with mango juice.

After storage of milk in refrigerator for 24 h and 48 h, the sample with aronia juice exhibited a slower increase in acidity that was beneficial with regard to yogurt stability. The same effect was obtained by Celik and Bakirci (2003) with yogurt supplemented with concentrated mulberry pekmez and by Ozturk and Oner (1999) with yogurt supplemented with concentrated grape juice after storage for 4 weeks. Similar results were also communicated by our team for fermented cow's

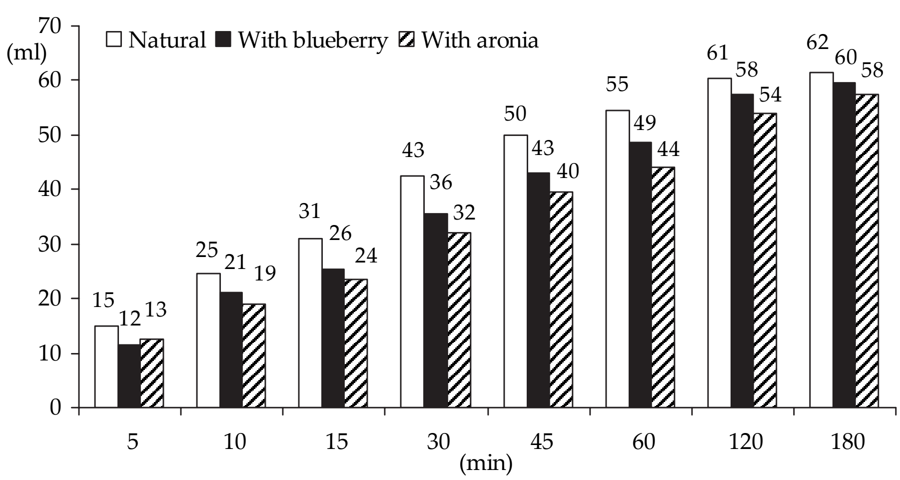

Figure 1. Syneresis of yogurt at coagulation

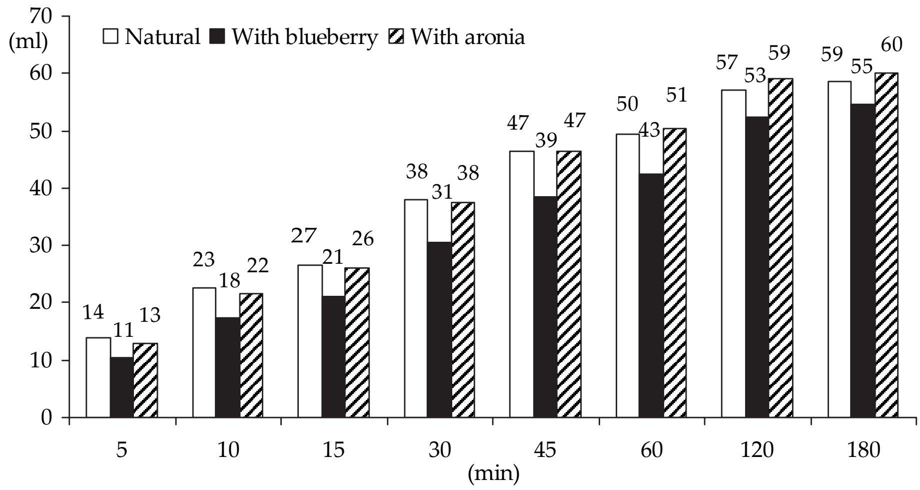

Figure 2. Syneresis of yogurt after 24-h storage

milk supplemented with 10% natural aronia juice (Dimitrov *et al*. 2002).

Milk coagulation occurred first in the sample with aronia juice (2 h 23 min) as compared to the sample with blueberry juice (2 h 40 min) and to natural yogurt (2 h 55 min).

The active acidity of the yogurt produced, both natural and supplemented with fruit juice, was similar to the values reported by Magalhaes *et al*. (2005) on goat's fermented milk supplemented with tropical fruit nectar.

Lactic acid bacterial counts

The data on lactic acid bacterial counts in yogurt supplemented with juice of either aronia or blueberry (Table 2) showed that by the time of coagulation, lactic bacteria were the most numerous in the sample containing natural aronia juice – 1.28×10^9/ml. This was valid for both rods and cocci. Similar results were reported for cow's fermented milk with aronia juice supplement (Dimitrov *et al*. 2002). In our view, this was due to the presence of biologically active substances (vitamins, amino acids etc.) in natural aronia juice. Most probably, these compounds stimulated the development of lactic acid bacteria.

The yogurt prepared with the addition of blueberry juice occupied the second place in lactic acid bacteria numbers. In 1 ml of this yogurt, 9.25×10^8 cells were enumerated, out of which 3.5×10^8 rods and 6.44×10^8 cocci. This trend was also preserved after 24 h and 48 h of milk storage at 4–6°C.

The ratio between rods and cocci in goat's fermented milk by the time of coagulation was smallest in controls (1:4.4), followed by the yogurt supplemented with aronia juice (1:2.66). During the storage, it increased up to 1:1.55 by the 48th h in the sample supplemented with aronia. The rods to cocci ratio in high-quality yogurt should be from 1:1 to 1:2.7 (Persic 1991), and our data were within this range.

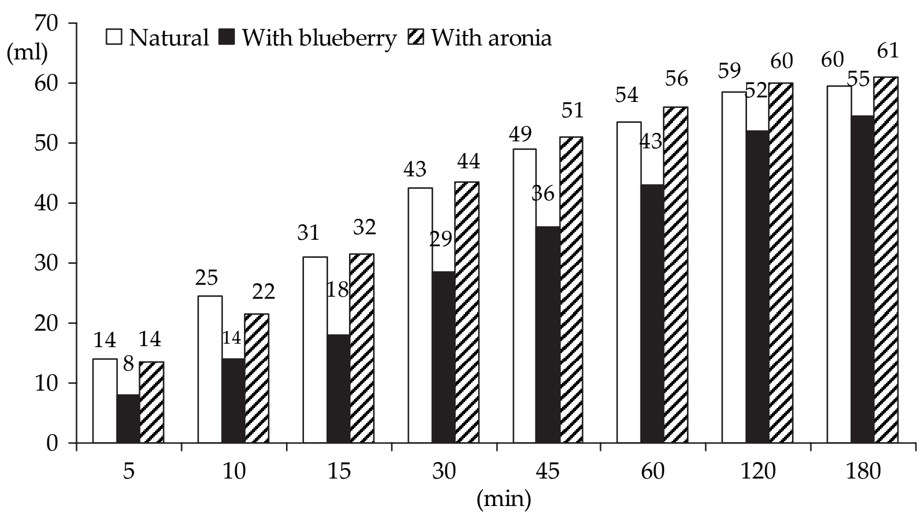

Figure 3. Syneresis of yogurt after 48-h storage

Syneresis of goat's yogurt

The least amount of serum was released by the yogurt with aronia juice and the largest amount by control samples (natural fermented milk) (Figure 1). The differences in the amounts of the separated liquid between the three samples were the highest from the 40th min to the 60th minutes. Thereafter, the syneresis curves got closer and by the 180th min, the differences in the amounts of whey were the least significant.

After 24 h of storage at 4–6°C, the yogurt supplemented with blueberry juice exhibited the least syneresis (Figure 2). The yogurt with aronia juice and the natural samples almost did not differ with regard to the amount of the separated serum. The same tendency was observed after 48 h of storage as well (Figure 3). The yogurts prepared with blueberry and aronia juices, were not different from the natural fermented milk from the technological point of view, and yet they were of superior quality.

Table 3. Fatty acid composition of goat's yogurt supplemented with either blueberry or aronia juice (n = 5)

Fatty acids (%)	Control		Blueberry		Aronia	
	mean	$S_{\bar{x}}$	mean	$S_{\bar{x}}$	mean	$S_{\bar{x}}$
C4:0	3.88	0.201	3.83	0.088	3.66	0.569
C6:0	5.34	0.529	4.43	0.090	4.99	0.539
C7:0	0.48	0.152	0.42	0.047	0.61	0.182
C8:0	4.74^{a}	0.181	4.25^{a}	0.125	4.56	0.243
C9:0	0.37	0.120	0.64	0.194	0.35	0.116
C10:0	15.91	0.681	14.62	0.384	15.25	0.453
C10:1	0.13	0.025			0.13	0.026
C11:0	0.20	0.028	0.27	0.049	0.21	0.017
C12:0	4.03^{c}	0.216	2.21^{cb}	0.082	3.79^{b}	0.298
C12:1	0.07^{a}	0.017	0.59^{a}	0.165	0.09^{a}	0.011
C13:0	0.26^{a}	0.047	0.32^{a}	0.070	0.10^{a}	0.031
C14:0	8.72	0.259	9.84	0.531	8.57	0.360
C14:2	0.16	0.024	0.30	0.082	0.39	0.105
C15:0	0.35	0.022	0.50^{a}	0.074	0.33^{a}	0.020
C16:0	22.67^{a}	0.307	25.14^{a}	0.460	23.31	0.427
C16:1	0.33	0.112	0.18	0.016	0.36	0.162
C16:2	0.33	0.065	0.20	0.017	0.29	0.055
C17:0	2.56	0.135	2.12	0.163	2.28	0.110
C18:0	8.62	0.970	7.57	0.146	8.65	1.156
C18:1	18.94	1.451	20.67	0.409	20.13	0.986
C18:2	1.29	0.119	1.12	0.052	1.35	0.201
C18:3	0.63	0.032	0.68	0.050	0.65	0.035
Saturated	78.71	1.608	75.97	0.151	76.93	0.730
Unsaturated	21.88	1.608	23.74	0.423	23.39	0.935
Monounsaturated	19.48	1.470	21.44	0.539	20.71	0.800
Polyunsaturated	2.41	0.186	2.30	0.127	2.68	0.195
Short-chain (C4-C10)	30.84	1.213	29.28	0.937	29.53	0.763
Medium-chain (C11–C17)	40.21	0.382	40.39	0.870	40.01	1.030
Long-chain (> C18)	29.48	1.411	30.04	0.306	30.78	1.834
C18:2/C18:3	2.05		1.65		2.08	

$^{a}P < 0.05$; $^{b}P < -0.01$; $^{c}P < 0.001$

Fatty acid composition

The results obtained for the fatty acid composition of the yogurts (Table 3) showed that, in the group of saturated fatty acids in control (natural) and experimental fermented milk samples, the highest levels were those of palmitic acid (C16:0) – 22.67% in controls and 25.14% and 23.31% in yogurts with blueberry and aronia juices, respectively, the differences being statistically significant at $P < 0.05$. This was followed by capric (C10:0), myristic (C14:0) and stearic acids (C18:0). The sum of C10:0, C14:0, C16:0, C18:0, and C18:1 accounted for more than 75% of the total amount of fatty acids, being similar to the findings of Alonso *et al.* (1999) and Park *et al.* (2007) for goat's milk. The amounts of C8:0 and C10:0 in goat's milk samples (control and experimental) were almost 1.5 times higher compared to the respective values for raw goat's milk (Alonso *et al.* 1999; Mihaylova 2007).

The yogurt supplemented with blueberry juice had by 45.17% lower lauric acid content compared to control yogurt but by 12.84% higher amount of myristic acid. The supplemented yogurts exhibited lower concentrations of C6:0 and C8:0 and a higher one of C16:0.

From the group of unsaturated fatty acids, the highest levels were those of the oleic acid (C18:1) – 18.94% in natural yogurt, 20.67% in the fermented milk with blueberry juice, and 20.13% in that with aronia juice. In our experiments, the content of linolenic acid (C18:3) in goat's milk was slightly higher (by 0.65% to 0.68%) compared to that observed by Wojttowski *et al.* (2003) (0.6%). The higher contents of oleic and linolenic acids in experimental yogurts compared to the natural milk were due to the higher contents of these fatty acids in blueberry and aronia fruits (Zlatanov 1999).

The total amount of saturated fatty acids in the yogurt with blueberry juice was by 3.49% lower as compared to controls, whereas in the milk with aronia juice – by 2.25%. The amounts of unsaturated fatty acids in both experimental samples were higher compared to control sample – by 8.5% and 6.9% for milks supplemented with blueberry and aronia juices, respectively.

The content of monounsaturated fatty acids in the yogurt with blueberry juice was by 10.12% higher than that in the natural yogurt, and in the samples with aronia juice – by 6.37% higher. The amount of polyunsaturated fatty acids was higher in the milk with aronia juice by 11.2% vs the natural yogurt, whereas in the milk with blueberry juice was lower compared to control sample.

The amount of short-chain fatty acids was in both experimental groups somewhat lower than that in the natural fermented milk, but the differences were not statistically significant. There were almost no difference in long-chain fatty acids amounts, and the content of medium-chain ones was slightly higher in the milk with blueberry juice. The differences in medium-chain fatty acids between different samples were statistically insignificant ($P > 0.05$).

The ratio C18:2/C18:3, that should be under 5 according to nutrition guidelines (Weil *et al.* 2002), varied from 1.65 (blueberry yogurt) to 2.08 (aronia yogurt). It was lower than that reported by Wojtowski *et al.* (2003) in raw goat's milk and was probably due to the changes occurring in the fatty acid composition during the lactic acid fermentation.

The ratio of unsaturated to saturated fatty acids was almost equal in the three yogurt samples and varied within a narrow range: from 0.28 in control sample to 0.31 in the yogurt supplemented with blueberry juice.

CONCLUSIONS

(1) The goat's fermented milk, supplemented with either aronia or blueberry juice, coagulated at a lower acidity and for a shorter time than the natural yogurt did.

(2) The lactic acid bacterial counts in the yogurt with aronia and blueberry juice was higher by 79.6% and 29.9%, respectively, compared to natural goat's yogurt. This tendency was also preserved after storage of the product for 48 hours.

(3) The addition of aronia or blueberry juice to goat's yogurt increased the amounts of unsaturated fatty acids compared to natural fermented milk. In blueberry yogurt, the increase was mainly on the account of monounsaturated fatty acids whereas in the yogurt supplemented with aronia – polyunsaturated fatty acids increased by 11.2% compared to control samples.

References

Alonso L., Fontecha J., Lozada L., Fraga M.J., Juarez M. (1999): Fatty acid composition of caprine milk: Major, branched-chain and trans fatty acids. Journal of Dairy Science, **82**: 878–884.

A.P.H.A. (1916): "Microscopic method of analysis" in Standard methods of bacteriological analysis of milk. American Public Health Association, **6**: 1315.

AOAC (1990): Official Methods of Analysis. 15th Ed. Association of Official Analytical Chemists, Arlington.

Celik S., Bakirci I. (2003): Some properties of yoghurt produced by adding mulberry pekmez (concentrated juice). International Journal of Dairy Technology, **56**(2): 26–29.

Dimitrov T., Boycheva S., Iliev T., Zheleva N. (2002): Production of fruit yogurt with various supplements. In: Proceedings Scientific Conference with International Participation, 2, Union of Scientists, Stara Zagora: 323–327.

Fukumoto L., Mazza L. (2000): Assessing antioxidant and prooxidant activity of phenolic compounds. Journal of Agriculturel and Food Chemistry, **48**: 3597–3604.

Haenlein G.F.W. (2004): Goat milk in human nutrition. Small Ruminant Research, **51**: 155–163.

Jahreis G., Fritsche J., Steinhart H. (1997): Conjugated linoleic acid in milk fat: High variation depending on production system. Nutrition Research, **17**: 1479–1484.

Kaplan M., Aviram M. (1999): Oxidized low-density lipoprotein: Aterogenic and proinflammatory characteristics during macrophage foam cell formation. An inhibitory role for nutritional antioxidants and plasma paraoxonase. Clinical Chemistry and Laboratory Medicine, **37**: 777–787.

Katsharova S., Bogdanova M., Kulikov I. (2003): Technology for production of fruit – milk desserts with functional properties. Annual Reports of University of Food Technologies Plovdiv, **L**, 2.

Kay K.D., Holub B.J. (2002): The effect of wild blueberry consumption on postprandial serum antioxidant status in human subjects. British Journal of Nutrition, **88**: 389–397.

Magalhaes M.A., Santos S.F.M., Silva D.J., Cruiz V.M. F., Oliveira E.L. (2005): Nectars of tropical fruits enriched with goat milk yogurt. In: 2nd Mercosur Congress on Chemical Engineering; 4th Mercosur Congress on Process Systems Engineering, Costa Verde, Brasil.

Mihaylova G. (2007): Fatty acid content and functional properties of fat milk and milk products, originating from various agroecosystems. [Dissertation Thesis Doctor of Science.] Trakian University, Stara Zagora.

Nilufar Y. (1999). Utilization of mango (*Mangifera indica*) juice for preparation of yogurt. [MS Thesis.] Department of Dairy Science, BAU, Mymensingh.

Oszmianski J., Wojdylo A. (2005): Aronia melanocarpa phenolics and their antioxidant activity. European Food Research and Technology, **1**: 1–5.

Ozturk B.A., Oner M.D. (1999): Production and Evaluation of yogurt with concentrated grape juice. Journal of Food Science, **64**: 530–533.

Park Y.W., Juarez M., Haenlein G.F.W. (2007): Physicochemical characteristics of goat and sheep milk. Small Ruminant Research, **68**: 88–113.

Persic D. (1991): Evaluation of quality of yogurt microflora. Hrana I Ishrana, **32**: 193–194.

Prior R.L., Cao G. (1999): Variability in dietary antioxidant related natural product supplements: The need for methods of standardization. The Journal of the American Nutraceutical Association, **2**: 46–58.

Shidlovskaya V.P. (1979): Evaluation of syneresis of cultured milk products. Molochnaya Promyshlennost, No. 4: 23–25.

Szaefer H., Krajka-Kuzniak V., Baer-Dubowska W. (2006): Modulation of the activity and expression of enzymes metabolizing xenobiotics by orally administered aronia juice in rat liver and mammary gland. In: 41st Meeting of the Polish Biochemical Society, Supplement, **53**: 42.

Vendemiale G., Grattagliano I.., Altomare E. (1999): An update on the role of free radicals and antioxidant defense in human disease. International Journal of of Clinical & Laboratory Research, **2**: 49–55.

Wang J., Mazza G. (2002a): Inhibitory effects of anthocyanins and other phenolic compounds on nitric oxide production in LPS/IFN-γ-activated RAW 264.7 macrophages. Journal of Agricultural and Food Chemistry, **50**: 850–857.

Wang J., Mazza G. (2002b): Effects of anthocyanins and other phenolic compounds on the production of tumor necrosis factor-δ in LPS/IFN-γ-activated RAW 264.7 macrophages. Journal of Agricultural and Food Chemistry, **50**: 4183–4189.

Weil P., Schmitt B., Ghesneau G., Daniel N., Safraou F., Legrand P. (2002): Effects of introducing linseed in livestock diet on blood fatty acid composition of consumers of animal products. Annals of Nutrition and Metabolism, **46**: 182–191.

Wojtowski J., Dankow R., Skrzypek R. (2003): Fatty acid profile of bovine, ovine, and caprine milks. Journal of Animal Science, **80** (Suppl. 1): 285.

Zlatanov M. (1999): Lipid composition of Bulgarian chokeberry, black currant and rose hip seed oils. Journal of the Science of Food and Agriculture, **79**: 1620–1624.

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