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ANTIOXIDANT ACTIVITY OF DAIRY PRODUCTS FOR BABY FOOD

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Increasing the biological and nutritional value of breast milk substitutes by enriching different macro- and micronutrients is an important issue. To a certain extent, the nutritional value of milk is determined by its antioxidant activity.

***The research aims** to compare the antioxidant activity of dairy products for baby food and breast milk.*

***The current research** studied cow pasteurized milk, drinking ultra-pasteurized "Tyoma," sterilized milk for baby food "Agusha," "NAN," "Nutrilon," and "Malyutka" milk mixtures, as well as breast milk of 17 women. The antioxidant activity was determined by the titrimetric permanganate method in aqueous and alcoholic milk extracts. The content of antioxidants in alcoholic extracts of milk and all dairy products significantly exceeds their levels in aqueous solutions. The content of water-soluble antioxidants in breast milk is significantly lower than in cow's milk "Luzhaykino" and "Agusha," but in infant formula, it corresponds to the indicators of breast milk. The level of alcohol-soluble antioxidants is lower in NAN and Nutrilon milk mixtures when compared with cow and breast milk. The milk mixture "Malyutka" does not differ from breast milk in terms of the antioxidant activity of alcohol- and water-soluble components.*

***Discussion.** The use of separate determination of hydrophilic and hydrophobic antioxidants revealed significant differences between breast and cow's milk. The enrichment of milk with easily destructible, water-soluble ascorbic acid did not affect the antioxidant activity of dairy products for baby food ("Agusha" and "Tyoma").*

***The results** obtained on the significant differences in the antioxidant properties of dairy products based on cow's milk from breast milk indicate the need to optimize the composition of milk antioxidants for baby food and the creation of breast milk substitutes.*

***Keywords:** cow's pasteurized milk; breast milk; antioxidants; fat-soluble and water-soluble antioxidants; antioxidant activity; baby food*

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АНТИОКСИДАНТНАЯ АКТИВНОСТЬ МОЛОЧНЫХ ПРОДУКТОВ ДЛЯ ДЕТСКОГО ПИТАНИЯ

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Повышение биологической и пищевой ценности заменителей грудного молока путём обогащения различными макро- и микронутриентами является важной проблемой. В определённой степени питательная ценность молока определяется его антиоксидантной активностью.

***Цель** работы – сравнение антиокислительной активности молочных продуктов для детского питания и грудного молока.*

***Материал и методы.** В работе исследовали коровье пастеризованное молоко, питьевое ультрапастеризованное «Тема» и стерилизованное молоко для детского питания «Агуша», молочные смеси, предназначенные для детского питания – NAN, Nutrilon, «Малютка», грудное молоко 17 женщин. Определение антиоксидантной активности осуществляли титриметрическим перманганатным методом в водных и спиртовых экстрактах молока.*

***Результаты и обсуждение.** Содержание антиоксидантов в спиртовых экстрактах молока и всех молочных значительно превышают их уровни в водных растворах. Содержание водорастворимых антиоксидантов в грудном молоке значительно ниже, чем в коровьем молоке «Лужайкино», «Агуща», но в детских молочных смесях оно соответствует показателям грудного молока. Уровень спирторастворимых антиоксидантов снижен в молочных смесях NAN и Nutrilon, при сравнении с коровьем и с женским молоком. Молочная смесь «Малютка» по антиокислительной активности спирторастворимых, как и водорастворимых компонентов не отличается от грудного женского молока.*

***Обсуждение результатов.** Использование раздельного определение гидрофильных и гидрофобных антиоксидантов позволило выявить значительные отличия грудного и коровьего молока. Обогащение молока легко разрушаемой, водорастворимой аскорбиновой кислотой не повлияло на антиокислительную активность молочных продуктов для детского питания - «Агуши» и «Темы». Заключение. Полученные результаты о существенных отличиях антиокислительных свойств молочных продуктов на основе коровьего молока от женского грудного молока указывают на необходимость оптимизации состава антиоксидантов молока для детского питания и создания заменителей грудного молока.*

***Ключевые слова:** коровье пастеризованное молоко; грудное молоко; антиоксиданты; жиро- и водорастворимые антиоксиданты; антиоксидантная активность; детское питание*

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Introduction

The ideal way to provide newborns with all necessary nutrition is breastfeeding [19]. Since breast milk is the source of all the essential ingredients of the child's growth and development, it is necessary to constantly study its composition and properties [8]. In the absence of breastfeeding possibility, the quality of breast milk substitutes is of particular importance. They are most often made based on cow's milk with the addition of various components, bringing the nutrient content closer to that of the breast milk, adapting to the needs of the child's organism. For maximum approximation to breast milk, its substitutes include vitamins, minerals, nucleotides, polyunsaturated fatty acids, prebiotics, and other ingredients [9]. Among the most important nutrients in the milk mixtures composition are antioxidant protection components, vitamins E, A, C, and selenium [2]. However, the antioxidant protection of milk is determined by a diverse composition, including proteins, peptides, compounds containing SH-groups [16]. Casein, lactoglobulin, lactoferrin, uric acid, corticosteroids, estrogens, and milk progesterone play a certain role in antioxidant protection. Phospholipids of fat balls can play the role of antioxidants' synergists. Enzymes are an important component of the antioxidant system, but their activity is absent after thermal exposure [5; 16]. Technological actions in the dairy products manufacture mainly increased temperatures, reduced their biological activity by destroying component components (micronutrients) [4]. In the manufacture of dairy products intended for baby food, enrichment with vitamins and minerals is particularly important [11; 14]. In addition to the micronutrient content, in the process of dairy manufacturing, the level of antioxidant activity also decreases [6; 18]. The enrichment of dairy products intended for children leads to higher antioxidant activity than sterilized milk when determining chemiluminescence in the model system [3]. The composition of modern breast milk substitutes includes compounds with antioxidant properties: L-carnitine, biotin, inositol, taurine, nucleotides [13]. According to [17], existing differences in the antioxidant activity of infant formula and breast milk indicate the need for further optimization of the antioxidant component of milk mixtures to approximate their biological and nutritional adaptation to breast milk. Until recently, the study of breast milk substitutes investigated the overall antioxidant activity; however, the

components of antioxidant protection differ not only in catalytic activity, molecular weight, mechanism of action but also solubility in the aqueous or lipid phase [12]. Accordingly, a separate definition of water-soluble and fat-soluble antioxidants is of particular interest.

Materials and methods. The study aims to compare the antioxidant activity of dairy products for baby food and female breast milk.

The research objectives are as follows:

1. Develop methodological approaches for determining the level of antioxidants with different solubility in dairy products;
2. Determine the content of antioxidants with different solubility in breast milk and pasteurized, ultra-pasteurized cow's milk, milk "Tyoma" and "Agusha" intended for baby food;
3. Determine the content of antioxidants in milk mixtures "NAN" and "Nutrilon Premium".

The study examined the milk received from 17 nursing mothers, with infants aged between 3 and 6 months. Milk samples were collected in the morning. All women were pre-screened for vitamin intake. Motivated consent for the processing of personal data was obtained from them. The average age of women was 27.9±1.17 years. Of these, 37.5% were primiparous, 62.5% gave second and third births.

The study used raw natural milk obtained from cows of black-and-white breed of the Omsk region forest-steppe zone. Since the basis of breast milk substitutes is most often cow's milk after pasteurization, the antioxidant activity in pasteurized and ultra-pasteurized milk obtained at the Munros-M milk processing enterprise (Omsk branch of Wimm-Bill-Dann JSC) was also determined in accordance with GOST 31450-2013 [10]. Dairy products intended for baby food were studied – ultra-pasteurized drinking milk, 3.2% fat mass fraction "Tyoma" (Omsk branch of Wimm-Bill-Dann JSC) and sterilized drinking milk enriched with vitamin A and C, with 3.2% fat mass fraction "Agusha" (DANONE-RUSSIA JSC), milk mixtures "NAN" from 0 to 12 months (Nutricia) and "Nutrilon Premium" from 6 to 12 months (Nestle), "Malyutka" from 0 to 6 months (DP "Istra-Nutricia" JSC).

The titrimetric method [7; 15] was used to detect antioxidant activity. To determine the content of biologically active substances, both aqueous and alcoholic extracts of milk and dairy products were used.

The statistical significance of the intergroup differences was assessed by the Student's t-criterion. Statistical hypotheses were tested at a critical significance level of $p=0.05$.

Results

The study of pasteurized cow's milk "Luzhaykino" and enriched milk intended for baby food revealed significant differences in their antioxidant activity from breast indicators (Table 1).

Table 1.

The content of antioxidants in dairy products for baby food, mg/ml

Milk	Aqueous extracts	Alcoholic extracts	Alcoholic/aqueous
	X ± m	X ± m	X ± m
Breast milk	1.89±0.07 (n=13)	7.05±0.15 (n=11)	3.73±0.08
"Luzhaykino"	2.94±0.02 <0.0001	7.27±0.12 0.27	2.47±0.16 <0.0001
"Agusha" P P_1	2.64±0.01 <0.0001 <0.0001	6.74±0.18 0.2 0.02	2.55±0.09 <0.0001 0.66
"Tyoma" P P_1	2.74 ±0.05 <0.0001 0.001	6.38±0.29 0.05 0.01	2.66±0.17 <0.0001 0.43

*Note**: The values of P – in comparison with breast milk, P1 – in comparison with cow pasteurized milk "Luzhaykino."

Table 2.

Antioxidant content of infant formula, mg/ml

Dairy product	Water-soluble fractions	Alcohol-soluble fractions	Alcoholic/aqueous
	X ± m	X ± m	X ± m
Breast milk	1.89±0.07 (n=13)	7.05±0.15 (n=11)	3.73±0.08
"Luzhaykino" P	2.94±0.02 <0.0001	7.27±0.12 0.26	2.47±0.1 <0.0001
NAN P P_1	2.00±0.01 0.13 <0.00001	6.41±0.19 0.01 0.001	3.21±0.18 0.02 0.002
Nutrilon P P_1	2.01±0.01 0.1 <0.00001	6.36±0.17 0.01 0.001	3.16±0.16 0.001 0.001
"Malyutka" P P_1	1.86±0,001 0.67 <0.00001	7.44±0.21 0.32 0.06	4.00±0.2 0.22 <0.0001

*Note**: The values of P – in comparison with breast milk, P_1 – in comparison with cow pasteurized milk "Luzhaykino."

If the level of alcohol-soluble antioxidants in cow's milk does not differ significantly from that of breast milk, then the antioxidant activity of water-soluble components is significantly higher than in breast milk.

A slightly different pattern is observed in the study of the antioxidant activity of breast milk substitutes (Table 2). The content of water-soluble antioxidants in all substitutes is significantly lower than in pasteurized cow's milk but corresponds to the indicators of breast milk.

In contrast, the level of alcohol-soluble antioxidants is lower in NAN and Nutrilon milk mixtures, both when compared with cow and breast milk. However, the milk mixture "Malyutka" does not differ from breast milk in terms of the antioxidant activity of alcohol- and water-soluble components.

Discussion

The study of antioxidants with different solubility allowed us to establish the predominance of fat-soluble components in milk and dairy products, primarily tocopherols [1]. Numerous data on the level of "general" antioxidant activity without considering their solubility may carry distorted information. The data obtained confirm the conclusion of Shilina, Ivanushkina & Kon [17] on the need to improve the antioxidant properties of dairy products for their adaptation to breast milk. The divergence of differences between breast milk and cow's milk indicates the need to consider the peculiarities of the breast milk antioxidant properties when creating its substitutes.

Conclusion. In dairy products intended for baby food and enriched with vitamins, the level of antioxidants did not differ significantly from the indicators of pasteurized milk "Luzhaykino" both in terms of water-soluble and fat-soluble antioxidants content, but there were significant differences from the breast milk indicators.

Differences have been established in the level of antioxidants in both aqueous and alcoholic extracts. However, if the level of antioxidants in aqueous extracts of female breast milk is significantly lower, then in alcoholic, on the contrary, it is much higher. Thus, despite the enrichment of dairy products with various micronutrients, including the water-soluble antioxidant - ascorbic acid, the antioxidant activity of dairy products intended for baby food is significantly lower than that of breast milk. To compensate for the deficiency of fat-soluble antioxidants, increasing the concentration of fat-soluble antioxidants in milk and dairy products is necessary, primarily alpha-tocopherol. The solution to the problem of enriching foods with antioxidants is impossible without a detailed study of the fat-soluble antioxidants composition in breast milk.

References

1. Bulgakova D. A., Bulgakov A. M. Khimicheskiy sostav moloka v zavisimosti ot urovnya mineral'no-vitaminnogo pitaniya korov [Chemical composition of milk depending on the level of mineral and vitamin nutrition of cows]. *Vestnik Altayskogo Gosudarstvennogo Agrarnogo Universiteta*, 2019, vol. 1, no. 171, pp. 77-82.
2. Vereshchagina T. G. Sovremennyye printsipy adaptatsii detskikh molochnykh smesey [Modern principles of adaptation of infant formula]. *Rossiyskiy Vestnik Perinatologii i Pediatrii* [Russian Bulletin of Perinatology and Pediatrics], 2009, vol. 4, pp. 11-14.
3. Veselov P. V., Vysokogorsky V. E. Antioksidantnyye svoystva detskogo molochnogo produkta po dannym khemilyuminestsentsii [Antioxidant properties of infant milk product according to chemiluminescence]. Proceedings from: *Scientific-practical conference: The use of innovative technologies to solve the problems of agriculture in modern conditions*. Volgograd, 2009. pp. 28–29.
4. Balakireva Yu. V., Zaytsev S. Yu., Karimova F. G., Akulov A. N., Akhmadullina F. Yu. Vliyaniye rezhima pasterizatsii na polipeptidnyy sostav moloka [Influence of pasteurization mode on the polypeptide composition of milk]. *Uchenyye Zapiski Kazanskoy Gosudarstvennoy Akademii Veterinarnoy Meditsiny Im. N. E. Baumana* [Scientific Notes of the Kazan State Academy of Veterinary Medicine Named After N. E. Bauman], 2011, vol. 207, pp. 60-66.
5. Vysokogorskiy V. E. Antiokislitel'naya aktivnost' moloka i kislomolochnykh produktov [Antioxidant activity of milk and dairy product]. Proceedings from: *All-Russian scientific-practical conference with international participation: Prospects for the production of new-generation food products*. Omsk, 2017. p. 299–301.
6. Vysokogorskiy V. E., Ignatieva G. V. Khemilyuminestsentnyy analiz pasterizovannogo moloka [Chemiluminescent analysis of pasteurized milk]. *Pishchevaja Promyshlennost*, 2012, vol. 10, pp. 34–35.
7. Gapparov M. M., Levachev M. M. Pitaniye detey pervogo goda zhizni: vzglyad nutritsiologa [Nutrition of children of the first year of life: look of a nutriciologist]. *Voprosy Pitaniya* [Questions of Nutrition], 2001, vol. 4, pp. 23-27.
8. Zaharova I. N., Machneva E. B., Oblogina I. S. Grudnoye moloko – zhivaya tkan'! kak sokhranit' grudnoye vskarmlivaniye? [Breast milk is a living tissue! How to keep breastfeeding?]. *Meditsinskiy Sovet* [Medical Council], 2017, vol. 19, pp. 24–29. https://doi.org/10.21518/2079-701X-2017-19-24-29
9. Lukoyanova O. L. Grudnoye moloko kak etalonnaya model' dlya sozdaniya detskikh molochnykh smesey [Breast milk as a reference model for creating infant formula]. *Voprosy Sovremennoy Pediatrii* [Questions of Current Pediatrics], 2012, vol. 11, no. 4, pp. 111-115.

10. *Moloko pit'yevoye. Tekhnicheskiye usloviya GOST 31450-2013, 2014 g* [Drinking milk. Technical conditions GOST 31450-2013, 2014]. URL: https://docs.cntd.ru/document/1200103303
11. Kodentsova V. M., Vrzhesinskaya O. A., Spirichev V. B., Shatnyuk L. N. Obosnovaniye urovnya obogashcheniya pishchevykh produktov vitaminami i mineral'nymi veshchestvami [The justification of the level of food fortification with vitamins and minerals]. *Voprosy Pitaniya* [Questions of Nutrition], 2010, vol. 79, no. 1, pp. 23-33.
12. Nilova L. P., Vytovtov A. A., Kambulova E. V., Kaygorodtseva M. S. Opredeleniye antioksidantnoy aktivnosti poroshkov iz rastitel'nogo syr'ya permanganatnym metodom [Determination of antioxidant activity of powders from plant raw materials by permanganate method]. *Proceedings from: III International scientific-practical conference: Consumer market of Eurasia: Current state, theory and practice in the conditions of the Eurasian economic Union and the WTO*. Yekaterinburg, 2015. pp. 118–122.
13. Panova L. D., Farkhutdinov R. R., Panova A. N., Korneeva O. V., Pinchuk G. I., Brezgina N. N., Mukminova A. V. Otsenka antioksidantnoy aktivnosti detskikh molochnykh smesey i grudnogo moloka metodom registratsii lyuminolzavisimoy khemilyuministsentsii [Evaluation of the antioxidant activity of infant formula and breast milk by registering luminol-dependent chemiluminescence]. *International Journal on Immunorehabilitation*, 2009, vol. 11, no. 1, pp. 118.
14. Spirichev V. B., Shatnyuk L. N. Obogashcheniye pishchevykh produktov mikronutriyentami: nauchnyye printsipy i prakticheskiye resheniya [Fortification of food products with micronutrients: scientific principles and practical solutions]. *Pishchevaja Promyshlennost*, 2010, vol. 4, pp. 20-24.
15. *Sposob opredeleniya antiokislitel'noy aktivnosti, RU2170930C1, 2001 g* [Method for determining antioxidant activity, RU2170930C1, 2001]. URL: https://yandex.ru/patents/doc/RU2170930C1_20010720
16. Shidlovskaya V. P., Yurova E. A. Antioksidanty moloka i ikh rol v otsenke ego kachestva [Antioxidants in milk and their role in the assessment of its quality]. *Molochnaya Promyshlennost* [Dairy Industry], 2010, no. 2, pp. 24–27.
17. Shilina N. M., Ivanushkina T. A., Kon T. A. Vliyaniye dlitel'nogo khraneniya sukhikh molochnykh smesey dlya detskogo pitaniya na soderzhaniye v nikh vitaminov a, ye, velichinu perekisnogo chisla i antioksidantnuyu aktivnost'. sravneniye s grudnym molokom [Influence of long-term storage of dry milk mixes for baby food on the content of vitamins A, E, the value of the peroxide number and antioxidant activity. Comparison with breast milk]. *Voprosy Pitaniya* [Questions of Nutrition], 2007, vol. 76, no. 6, pp. 48-53.

18. Shcherbakova Yu. V. *Vliyaniye teplovoy obrabotki na komponenty antioksidantnoy sistemy moloka i yego integral'nuyu antioksidantnuyu aktivnost'* [Influence of heat treatment on the components of the antioxidant system of milk and its integral antioxidant activity]: Abstract diss. cand. bio. sciences. Moscow, 2011. 21 p.
19. *Infant and young child nutrition, 2003*. URL: http://www.who.int/nutrition/publications/infantfeeding/en

Список литературы

1. Булгакова Д. А., Булгаков А. М. Химический состав молока в зависимости от уровня минерально-витаминного питания коров // Вестник Алтайского государственного университета. 2019. Т. 1. № 171. С. 77-82.
2. Верещагина Т. Г. Современные принципы адаптации детских молочных смесей // Российский вестник перинатологии и педиатрии. 2009. № 4. С. 11-14.
3. Веселов П. В., Высокогорский В. Е. Антиоксидантные свойства детского молочного продукта по данным хемилюминесценции // Труды Международного Форума по проблемам науки, техники и образования. В., 2009. С. 28–29.
4. Влияние режима пастеризации на полипептидный состав молока / Балакирева Ю.В. Зайцев С. Ю. Каримова Ф.Г. Акулов А.Н. Ахмадуллина Ф.Ю. // Ученые записки Казанской государственной академии ветеринарной медицины им. Н. Э. Баумана. 2011. № 207. С. 60-66.
5. Высокогорский В. Е. Антиокислительная активность молока и кисломолочных продуктов // Материалы Всероссийской научно-практической конференции с международным участием, посвященной памяти профессора Сапрыгина Георгия Петровича: Перспективы производства продуктов питания нового поколения. О., 2017. С. 299–301.
6. Высокогорский В. Е., Игнатьева Г. В. Хемилюминесцентный анализ пастеризованного молока // Пищевая промышленность. 2012. № 10. С. 34–35.
7. Гаппаров М. М., Левачев М. М. Питание детей первого года жизни: взгляд нутрициолога // Вопросы питания. 2001. № 4. С. 23-27.
8. Захарова И. Н. Мачнева Е. Б. Облогина И. С. Грудное молоко – живая ткань! как сохранить грудное вскармливание? // Медицинский совет. 2017. № 19. С. 24–29. https://doi.org/10.21518/2079-701X-2017-19-24-29
9. Лукоянова О. Л. Грудное молоко как эталонная модель для создания детских молочных смесей // Вопросы современной педиатрии. 2012. Т. 11. № 4. С. 111-115.
10. Молоко питьевое. Технические условия ГОСТ 31450-2013, 2014 г. URL: https://docs.cntd.ru/document/1200103303

11. Обоснование уровня обогащения пищевых продуктов витаминами и минеральными веществами / Коденцова В. М., Вржесинская О. А., Спиричев В. Б., Шатнюк Л. Н. // Вопросы питания. 2010. Т. 79. № 1. С. 23-33.
12. Определение антиоксидантной активности порошков из растительного сырья перманганатным методом / Нилова Л. П., Вытовтов А. А., Камбулова Е. В., Кайгородцева М. С. // Материалы III Международной научно-практической конференции: Потребительский рынок Евразии: современное состояние, теория и практика в условиях евразийского экономического союза и ВТО. Е., 2015. С. 118–122.
13. Оценка антиоксидантной активности детских молочных смесей и грудного молока методом регистрации люминолзависимой хемилюминисценции / Панова Л. Д., Фархутдинов Р. Р., Панова А. Н., Корнеева О. В., Пинчук Г. И., Брезгина Н. Н., Мукминова А. В. // International journal on immunorehabilitation. 2009. Т. 11. № 1. С. 118.
14. Спиричев В.Б. Шатнюк Л.Н. Обогащение пищевых продуктов микронутриентами: научные принципы и практические решения // Пищевая промышленность. 2010. № 4. С. 20-24.
15. Способ определения антиокислительной активности, RU2170930C1, 2001 г. URL: https://yandex.ru/patents/doc/RU2170930C1_20010720
16. Шидловская В. П., Юрова Е. А. Антиоксиданты молока и их роль в оценке его качества / Молочная промышленность. 2010. № 2. С. 24–27.
17. Шилина Н. М., Иванушкина Т. А., Конь Т. А. Влияние длительного хранения сухих молочных смесей для детского питания на содержание в них витаминов а, е, величину перекисного числа и антиоксидантную активность. сравнение с грудным молоком // Вопросы питания. 2007. Т. 76. № 6. С. 48-53.
18. Щербакова Ю. В. Влияние тепловой обработки на компоненты антиоксидантной системы молока и его интегральную антиоксидантную активность: Автореферат дис. канд. биол. наук. М., 2011. 21 с.
19. Infant and young child nutrition, 2003. URL: http://www.who.int/nutrition/publications/infantfeeding/en

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