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STALL AND PASTURE FEEDING AS A FACTOR POTENTIALLY AFFECTING THE CONTENT OF DETRIMENTAL CHEMICAL COMPOUNDS IN SELECTED DAIRY PRODUCTS

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Key words: external chemical compounds, DDT, HCH, PCB, lead, cadmium, nitrates, stall feeding, pasture feeding

The study was aimed at determining the impact of the milk production period and selected dairy products on the level of external chemical compound residues in milk. For this reason the experimental material was sampled in the summer and in winter season. A total of 120 dairy products were assayed for the concentrations of lead, cadmium, Σ DDT (as a total sum of DDT+DDE+DDD), γ HCH, total PCB, nitrates (V), and nitrates (III).

In reference to the current local requirements, the concentrations of individual contaminants were low. The examined contaminants were present in all the examined products. The determined concentrations of the external chemical compounds reported in the products originating from the winter and summer feeding were similar, thus it may be assumed that a Polish consumer is exposed to similar intakes of these contaminants with milk and dairy products, irrespective of the season.

INTRODUCTION

According to data reported in the available literature, food acquired under current environmental conditions is not free from external compounds which are not its natural constituents. Sources of food contamination may originate from polluted air, soil and water. Especially detrimental contaminants include those which accumulate in a human body and are likely to produce negative health effects in the future.

Previous investigations [Radzymińska *et al.*, 2004, 2005] by the authors as well as those of other authors [Pilsbacher & Pfleger, 2001; Pilsbacher & Grubhofer, 2002] have demonstrated the presence of chemical contaminants in milk and dairy products.

As claimed by a number of researchers, the chemical composition of milk may be modified by various factors, including the feeding method of cows. Międzobrodzka *et al.* [1995] have reported that different species of grass and overground parts of root crops are the most susceptible to contamination.

In European countries, dairy cattle breeding has transformed into all-year-round indoor breeding. This enables feed standardisation and, consequently, obtaining milk of a similar chemical composition over the entire productive year. In Poland, dairy cattle are still bred, to a great extent, under pasturage and indoor conditions, which is likely to affect the concentrations of detrimental chemical compounds in milk.

Taking this into account, the study was aimed at determining the impact of the production period of milk on the levels of external chemical compound residues in milk and selected dairy products.

MATERIAL AND METHODS

The experimental material included samples of raw milk, liquid milk, sour cream, fresh white cheese and butter produced in four dairy plants located in the central and south-eastern regions of Poland. The samples of dairy products were collected in consumer package (raw milk in bottles approved for contact with food) twice in the summer and winter seasons. Analyses were carried out in three replications on three batches of each product originated from different feeding periods. A total of 120 samples of milk and dairy products was examined.

The samples were assayed for concentrations of lead, cadmium, Σ DDT (as a total sum of DDT+DDE+DDD), γ HCH, total PCB (determined as Aroclor), nitrates (V), and nitrates (III).

The contents of lead and cadmium, after dry mineralisation of the biological material and extraction to an organic phase (APDC/MIBK), were measured with the method of atomic absorption flame spectrophotometry using a UNICAM 939 AA apparatus [Starska *et al.*, 1996].

Chloroorganic pesticides and polychlorinated biphenyls were extracted from the samples with petroleum ether and acetone together with fat. The extracts were hydrolysed with

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sulfuric acid. The identification and quantitative determination of the compounds analysed were carried out with gas chromatography using a UNICAM PU 4600 apparatus with an electron capture detector, following procedures published by the Methodological Publishing House of the State Institute of Hygiene [Ludwicki *et al.*, 1996].

The contents of nitrates (V) and nitrates (III) were assayed with the modified spectrophotometric method [Borawska *et al.*, 1996], according to Polish Standard [PN-EN ISO 14673-1: 2002 (U)].

To analyse the significance of differences between the contents of the compounds examined in particular products originating from two different feeding periods, a variance analysis and a NIR test (test of the least significant difference) were applied. They enabled a comparison of the data in multiple repetitions as well as concluding which means affected the rejection of the null hypothesis [Jóźwiak & Podgórski, 1997]. The mean values were compared at two levels of significance: $\alpha=0.05$ and $\alpha=0.01$. Calculations were made by means of Statistica 6.0 software.

RESULTS AND DISCUSSION

The mean concentrations of individual contaminants in the dairy products examined originating from two seasonal batches are presented in Figures 1, 2 and 3.

In all the products originating from the period of pasturage feeding, the mean contents of metals (Figure 1) ranged from 0.009 to 0.011 mg/kg in the case of lead and from 0.001 to 0.004 in the case of cadmium. These values were slightly higher than the contents of the respective metals in the products made in winter, however statistically significant differences were not observed between them.

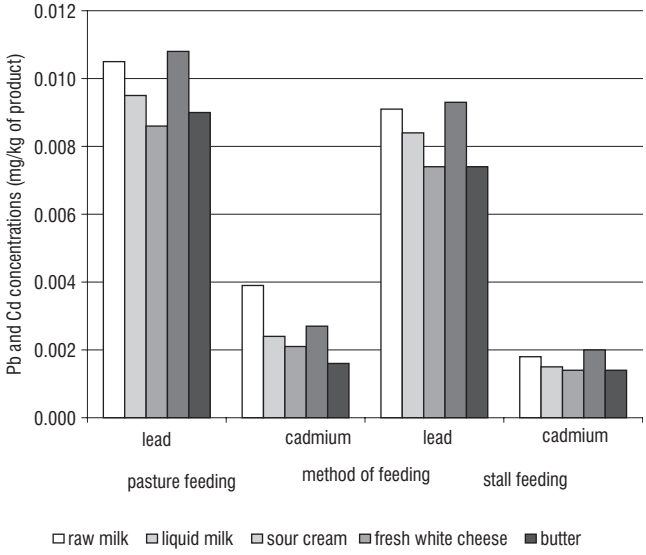

FIGURE 1. A comparison of mean concentrations of lead and cadmium (mg/kg of a product) between dairy products originating from two feeding seasons (no statistically significant differences were found at the levels of $\alpha=0.05$ and $\alpha=0.01$).

The slightly higher contents of those metals in the products originating from the summer season may be due to the fact that during the summer feeding cows are exposed to the intake of lead and cadmium not only with food (waste-originated contaminants) but also through the respiratory tract [Lipiec & Litwińczuk, 1999].

Also, Popiołek-Pyrz [1998] did not observe ant significant effect of the feeding season on the cadmium content of milk. In milk samples collected in March and December, Górska & Litwińczuk [1996] found that the mean contents of lead and cadmium were significantly different from the contents of these compounds in milk collected in June and September.

The differences in the residues of chloroorganic compounds between particular dairy products originating from two feeding seasons are presented in Figure 2.

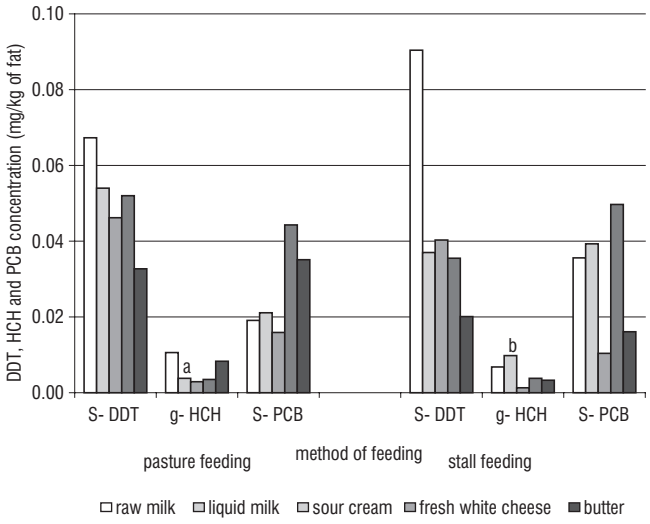

FIGURE 2. A comparison of mean concentrations of Σ DDT, γ HCH and Σ PCB (mg/kg of fat) between dairy products originating from two feeding seasons (mean values without superscripts are not significantly different at the level of $\alpha=0.05$ and $\alpha=0.01$; a, b – different letters indicate that the means are significantly different at the level of $\alpha=0.05$, and are not significantly different at the level of $\alpha=0.01$; S – sum; g – γ).

The mean residues of Σ DDT in the dairy products did not exceed 0.090 mg/kg of fat. In general, in products originating from the summer and winter season the concentrations of this pesticide were similar. The statistical analysis demonstrated that the period of sampling had no significant effect on the content of this compound in dairy products.

The analysis of γ HCH concentrations (Figure 2) in individual types of products indicated statistically significant differences between liquid milk from the summer and winter season, in which the contents of those compounds accounted for 0.004 and 0.010 mg/kg of fat, respectively. The obtained Σ DDT and γ HCH values are considerably lower than the highest permissible levels of these compounds specified by the Minister of Health. According to the national legal regulations, the Σ DDT and γ HCH contents in dairy products with over 2% fat content should not exceed 1.0 and 0.025 mg per kg of fat, respectively [Regulation of the Minister of Health, 2004].

Similarly, the products from the winter and summer season had similar concentrations of PCB. The mean levels of this compound were reported to range from 0.010 to 0.050 mg/kg of fat in the products from the winter season and from 0.016 to 0.044 mg/kg of fat in those produced in

summer. It was demonstrated that the sampling period was not a factor differentiating the concentration of this compound.

In Poland, the degree of contamination with chloroorganic compounds is determined by the range of their application in the country and their transfer throughout Poland with atmospheric fronts (from different parts of the world, presumably from the West, South and East) [Falandysz, 1996]. All plants are exposed to the absorption of pesticide residues from the soil [Łakota, 1995; Lewandowska, 1997].

In all the analysed samples (Figure 3) originating from the winter season, the levels of nitrates (V) and nitrates (III) were higher. Nevertheless, significant differences in the concentration of nitrates (V) were observed only between raw milk from summer, in which their mean concentration reached 1.61 mg/kg and was three times lower than that of milk from the winter season. In the case of nitrates (III), significant differences were reported in the concentrations of those compounds between sour cream samples. In the sour cream produced in the summer season, the mean level of those compounds was about three times lower than that in the cream produced in winter.

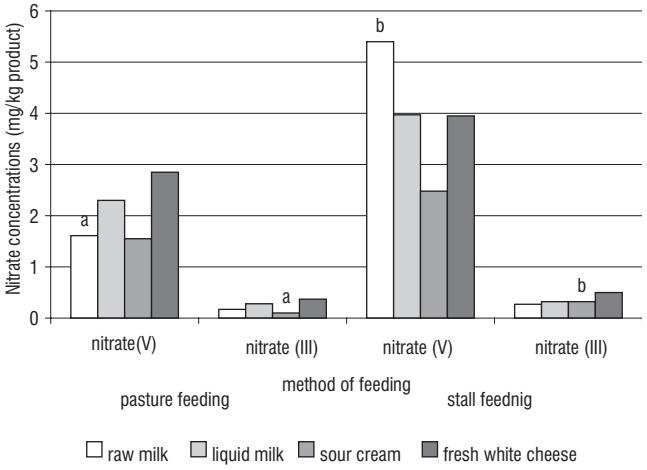

FIGURE 3. A comparison of mean levels of NO(V) and NO(III) ions (mg/kg of a product) between dairy products originating from two feeding seasons (mean values without superscripts are not significantly different at the level of α=0.05 and α=0.01; a, b – different letters indicate that the means are significantly different at the level of α=0.05, and are not significantly different at the level of α=0.01; S – sum; g – γ).

It is difficult to explain the tendency toward higher concentrations of nitrates (V) and nitrates (III) in products from the stall feeding. This tendency may result from the composition of feed rations for cattle. In the summer feeding, the basic feed for cows is green forage, whereas winter feeding involves higher doses of forage from lucerne, maize, soybean, sunflower, cotton, and cereals. Such feeding stuffs could have originated from more intensively fertilised pastures, namely from other areas of Poland characterised by a higher contamination with nitrates.

Żbikowski *et al.* [2000] have demonstrated the highest content of nitrates in raw milk sampled in November (2.38 mg NO(V)/kg and 0.17 mg NO(III)/kg on average). In February, the mean concentration of these compounds accounted for 1.34 mg NO(V)/kg and 0.06 mg NO(III)/kg, whereas in August – for 1.30 mg NO(V)/kg and 0.07 mg NO(III)/kg. In contrast, a higher level of nitrates was assayed by Przybyłowski *et al.* [1989] in milk from spring, summer and autumn, whereas their concentration appeared to be twofold lower in the winter season.

CONCLUSIONS

The above data depict to what extent a Polish consumer of dairy products is exposed to the contaminants analysed. All the products examined: raw milk, liquid milk, sour cream, fresh white cheese and butter, were demonstrated to simultaneously contain lead, cadmium, Σ DDT, γ HCH, PCB, nitrates (V), and nitrates (III), though their concentrations were found to be low.

The study indicated that milk and dairy products obtained in the pasture feeding basically did not differ in terms of the contents of detrimental chemical compounds, compared with those originating from stall feeding. Hence, it may be assumed that both in the summer and winter season consumers are exposed to similar intakes of external chemical compounds with milk and dairy products.

REFERENCES

1. Borawska M., Markiewicz R., Omieljaniuk N., Witkowska A., Nitrate and nitrite content of milk and dairy products marketed in Białystok. Bromat. Chem. Toksykol., 1996, 29, 139–142 (in Polish; English abstract).
2. Falandysz J., An assessment on the environmental exposure on persistent and toxic organohalogens. Roczn. PZH, 1996, 47, 1, 41–57 (in Polish; English abstract).
3. Górska A., Litwińczuk Z., The content of lead, cadmium and inhibiting substances in milk from Podlasie region. Med. Wet., 1996, 52, 9, 591–592 (in Polish; English abstract).
4. Jóźwiak J., Podgórski J., Statystyka od podstaw. 1997, PWE, Warszawa (in Polish).
5. Lewandowska A., Transformations and pathways of pesticides and their residues in the environment. Pestycydy, 1997, 3/4, 63–68 (in Polish; English abstract).
6. Lipiec A., Litwińczuk A., Changes in lead and cadmium level in cow milk during summer feeding at the territory of the central and east Poland. Zesz. Nauk. PTZ Prz. Hod., 1999, 47, 113–119 (in Polish).
7. Ludwicki J.K., Góralczyk K., Czaja K., Struciński P., Determination of Organochlorine Insecticides and Polychlorinated Biphenyls Residues in Food by Gas Chromatography Method. 1996, Wyd. Met. PZH, Warszawa (in Polish; English abstract).
8. Łakota S., Pesticides and ecological menaces. Ekopartner, 1995, 12, 50, 24–25 (in Polish; English abstract).
9. Międzobrodzka A., Sikora E., Cieślik E., The content of selected minerals and some heavy metals in food products from southern Poland. II. Milk and dairy products. Zesz. Nauk. AR Krak. Technol. Żyw.,1995, 301, 7, 89–93.
10. Pilsbacher L., Pfleger R., Contenet of aflatixin M1, organochlorine pesticides, polychlorinated biphenyls, lead and cadmium in Australian raw milk, 1996–2000. Ernaehrung, 2001, 25, 9, 348–353.

11. Pilsbacher L., Grubhofer F., Mercury, lead and cadmium in Austrian raw milk – a comparison to earlier analyses and to analyses from foreign countries. Wien Tierarztl Monatsschr, 2002, 89, 9, 249–253.
12. Polish Standard PN-EN ISO 14673-1 U: 2002, Milk and dairy products. Determination of nitrate (V) and nitrate (III) contents. Part I. Method using cadmium reduction and spectrometry.
13. Popiołek-Pyrz M., A sanitary value of raw milk from the central and eastern regions of differentiated degree of environment contamination in Poland II. Presence of inhibitors, in that beta-lactamic antibiotics and a content of heavy metal toxic ions. Ann. Univ. M. Curie-Skłodowska Sect. EE., 1998, 16, 41, 313–320 (in Polish; English abstract).
14. Przybyłowski P., Kisza J., Janicka B., Sajko W., Presence of nitrates and nitrites in raw milk depending on the system of milk purchasing. Roczn. PZH, 1989, 40, 1, 6–15 (in Polish; English abstract).
15. Radzymińska M., Smoczyńska K., Smoczyński S.S., Health quality of milk and chemical compounds contaminations. Towaroznawstwo wobec integracji z Unią Europejską. Wyd. ITE Radom, 2004, 504–507 (in Polish).
16. Radzymińska M., Dymkowska-Malesa M., Skibniewska K.A., Borejszo Z., Smoczyński S.S., Polychlorinated biphenyles in selected Polish-origin products. 2005, *in*: Current Trends in Commodity Science. Vol. .I, Akademia Ekonomiczna Poznań, pp. 589–595.
17. Regulation of the Minister of Health from 16 April 2004 on the maximum acceptable levels of pesticides residues that can be found in food products or their surface. Dziennik Ustaw RP Nr 85, poz. 801 (in Polish).
18. Starska K., Wojciechowska-Mazurek M., Brulińska-Ostrowska E., Ćwik-Ludwicka K., Method of Lead, Cadmium, Copper and Zinc Determination in Food by Flame Atomic Absorption Spectrometry Technique. 1996, Wyd. Met. PZH, Warszawa (in Polish; English abstract).
19. Żbikowski Z., Żbikowska A., Baranowska M., Content of nitrates and nitrites in whole milk powder in different regions of Poland. Roczn. PZH, 2000, 51, 1, 29–35 (in Polish; English abstract).

ŻYWIENIE OBOROWE I PASTWISKOWE JAKO CZYNNIK POTENCJALNIE WPŁYWAJĄCY NA ZAWARTOŚĆ SZKODLIWYCH ZWIĄZKÓW CHEMICZNYCH W WYBRANYCH PRODUKTACH MLECZARSKICH

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Według danych opublikowanych w dostępnym piśmiennictwie żywność pozyskiwana w obecnych warunkach środowiskowych nie jest wolna od obcych związków, które naturalnie w niej nie występują. Źródła zanieczyszczeń żywności mogą pochodzić ze skażonego powietrza, gleby i wody. Szczególnie niebezpieczne są te, które gromadzą się w organizmie człowieka i w przyszłości mogą wywoływać negatywne skutki zdrowotne.

Hodowla bydła mlecznego w krajach europejskich uległa przeobrażeniu w kierunku całorocznego pobytu zwierząt w warunkach oborowych. Sprzyja to możliwości standaryzowania paszy, a w konsekwencji uzyskania mleka zbliżonego składem chemicznym w ciągu całego roku produkcyjnego. W Polsce hodowlę bydła mlecznego w znacznym stopniu prowadzi się jeszcze w warunkach pastwiskowych i oborowych, co może wpływać na zawartość szkodliwych związków chemicznych.

W tej sytuacji w niniejszej pracy podjęto próbę określenia wpływu okresu pozyskiwania mleka oraz wybranych produktów mleczarskich na poziom pozostałości w nich obcych związków chemicznych. Próbki przetworów mleczarskich w opakowaniach jednostkowych (mleko surowe w butelkach posiadających atest do kontaktu z żywnością) pobierano dwukrotnie w okresie lata i zimy. Łącznie przebadano 120 produktów mleczarskich pod kątem zawartości w nich ołowiu, kadmu, sumy DDT (jako łączną sumę DDT+DDE+DDD), γ HCH, ogółem PCB, azotanów (V) i azotanów (III).

Stwierdzone w pracy ilości obcych związków chemicznych w produktach z zimy oraz z lata kształtowały się na zbliżonych poziomach, stąd można przyjąć, że polski konsument narażony jest na pobranie podobnych ilości tych kontaminantów, niezależnie od poru roku. Pomimo, że zawartości poszczególnych kontaminantów kształtowały się na niskich poziomach, w stosunku do aktualnie obowiązujących uregulowań prawnych, to we wszystkich badanych próbkach stwierdzono obecność badanych związków.