Chemosphere 148 (2016) 395–402

Contents lists available at ScienceDirect

Chemosphere

journal homepage: www.elsevier.com/locate/chemosphere

Assessment of health risk from organochlorine xenobiotics in goat milk for consumers in Poland

Agata Witczak [a, *], Anna Pohoryło [a], Anna Mituniewicz-Małek [b]

[a] Toxicology Dep., West Pomeranian University of Technology, Szczecin, Poland
[b] Department of Dairy Technology and Food Storage, West Pomeranian University of Technology, Szczecin, Poland

HIGHLIGHTS

- Analysis of organochlorine pesticides in goat milk in years 2009–2013 revealed a slow gradual downward trend in residue level.
- The estimated LADDs for the OCPs were considerably lower than ADI.
- The Hazard Quotients were the maximum value of $5.55 \cdot 10^{-2}$ and the examined goat milk was safe for adult consumers' health.

ARTICLE INFO

Article history:
Received 29 August 2015
Received in revised form
10 December 2015
Accepted 7 January 2016
Available online 30 January 2016

Handling Editor: Caroline Gaus

Keywords:
Human health risk
Hazard quotient
Organochlorine pesticide
Goat milk

ABSTRACT

The occurrence of organochlorine xenobiotics in goat milk is a one of bioindicators of environmental pollution, and, consequently, food contamination.

This study estimates contamination level of goat milk produced at two organic farms in years 2009–2013. Analysis covered determination of 18 organochlorine pesticides, including HCH isomers (α, β, γ, δ), DDT and its metabolites, endosulfan and its derivatives, and methoxychlor. Pesticide content was determined using GCMS method. The detected levels of organochlorine residues in goat milk were low, in most cases below 8 ng g^{-1} lipids. Among HCH isomers, γ- and β-HCH occurred in the highest concentrations, up to 4.85 ng g^{-1} lipids. While among DDT metabolites *p,p′*-DDD dominated, up to 7.86 ng g^{-1} lipids.

The detected residues were below the current maximum residue limits (MRLs) for the pesticides. Considering the average milk consumption in Poland, the goat milk from both farms was safe for consumers' health. The lifetime average daily dose (LADD) for the sum of the compounds under study ranged within 1.73×10^{-5}–1.06×10^{-4} mg kg bw^{-1} d^{-1} and were well below the acceptable daily intake (ADI) for particular compounds. This was also confirmed by the values of hazard quotient (HQ), which were very low and ranged within 3.42×10^{-3}–5.55×10^{-2}.

1. Introduction

Milk plays a significant role in human diet, regardless the consumers' age. In different geographical areas, milk is acquired from different animal species. In Poland, cow milk is the most popular, but in recent years an increased interest is being observed in the consumption of goat milk and goat dairy products. Goat milk is usually perceived as an organic product, more beneficial for health than cow milk (Pietrzak-Fiećko et al., 2000; Darnerud, 2006; Polder et al., 2010; Mituniewicz-Małek and Dmytrów, 2011). Cow milk and goat milk both have a similar protein content, but goat milk proteins are assimilated more easily (Park and Guo, 2006; Schettino et al., 2013).

At present, the global production of goat milk is estimated at 2025 million L. In the world the largest producers of goat milk are the USA (100 million L), Canada (60 million L), and Mexico (50 million L) (Górska, 2015). Goat milk production in European countries accounts for 26% of world production (Olechnowicz et al. 2007).

Despite numerous beneficial properties, goat milk has lipophilic properties (similarly as cow milk), and therefore tends to accumulate various contaminants, including organochlorine pesticides (OCPs) that are especially dangerous (Duarte-Davidson and Jones, 1996; Fries, 1996). OCPs are distinguished by long-standing

* Corresponding author.
E-mail address: Agata.Witczak@zut.edu.pl (A. Witczak).

http://dx.doi.org/10.1016/j.chemosphere.2016.01.025
0045-6535/

persistence and toxicity. Even low doses of these chemicals may produce adverse health effects in human organisms, including hormonal disorders, reduced intelligence, fertility disorders, and cancers (Gupta, 2004).

The main source of OCP contaminants for milk animals are forage and fodder, followed by drinking water, soil (partly ingested during grazing) and inhaled air (Blüthgen, 2000; Heck et al., 2007; Rychen et al., 2014). In animal bodies, these compounds are easily distributed from the alimentary tract, and accumulate mainly in the liver, adipose tissue and milk (La Rocca and Montovani, 2006; Turrio-Baldassarri et al., 2007; Durand et al., 2008).

Regarding high proportion of milk and dairy products in human diet (ca. 30%) (Focant et al., 2003; Mamontova et al., 2007), OCP residues contained in milk may increase consumers' health risk.

This study covers analysis of OCP content, including α-, β- and γ-HCH, DDT and its metabolites, α-endosulfan, β-endosulfan, endosulfan sulfate, and methoxychlor, in goat milk from the north-west Poland (Fig. 1), and assessment of health risk from goat milk consumption.

The selected research points are the only large organic goat farms in the West Pomeranian province. Due to the fact that the composition of goat milk (protein, fat, lactose) varies greatly depending on the duration of lactation, season of the year, and feed type, the study was conducted over a relatively long period of five years.

The consumers' health risk assessment was based on the LADD, and the calculated HQ, where values of HQ < 1 indicated that the milk under study was safe for consumers.

The LADD and HQ factors were calculated according to Buranatrevedh (2004), Kumar et al. (2013), and Witczak and Pohoryło (2015).

2. Materials and methods

Raw goat milk was acquired from two organic farms in the West Pomeranian region of Poland: Kozi Gródek (Wołczkowo near Szczecin)—farm A, and Jesionek (Cewlino near Koszalin)—farm B (Fig. 1). Milk samples were collected during a five-year period from winter 2009 to summer 2013. In each season, the milk was collected once a week for the first month of the season, each time 500 mL (which made an overall sample of 2 L). In summer 2012 and summer 2013 milk samples were collected for 2 months (for each season, 2 overall samples were made, each one of 2 L) (Table 1). Parameters such as density, acidity, and dry weight were determined directly after delivery to the laboratory. Density was determined by the aerometric method, and acidity (in °SH)—by titration method according to National Standard (AOAC, 1995). Fat content was determined using the Gerber's method (AOAC, 1990; PN-ISO 488:2002), while the dry mass content was measured gravimetrically. Prior the analysis of organochlorine compounds, the samples were freeze-dried in a LyoLab 3000 apparatus, and stored at −18 °C in sealed glass containers until analysis. Determination of organochlorine compounds in milk samples was done according to methods described by Witczak et al. (2013). The quantification of concentration and recovery was carried out by fortified samples (with mixed OCP standards, SS TCL PesticidesMix, Supelco, USA) and internal standard (*cis*-chlordane 100 mL, 80 ng mL^{-1}; N11480-10MG, Supelco, USA). The limit of detection (LOD) for each compound was determined as the concentration in the extract which produced an instrumental response at two different ions to be monitored with a signal to noise ratio of 3:1 for the less sensitive signal (Commission Directive 2002/63/EC).

A method blank was included for every ten samples. The LOD for

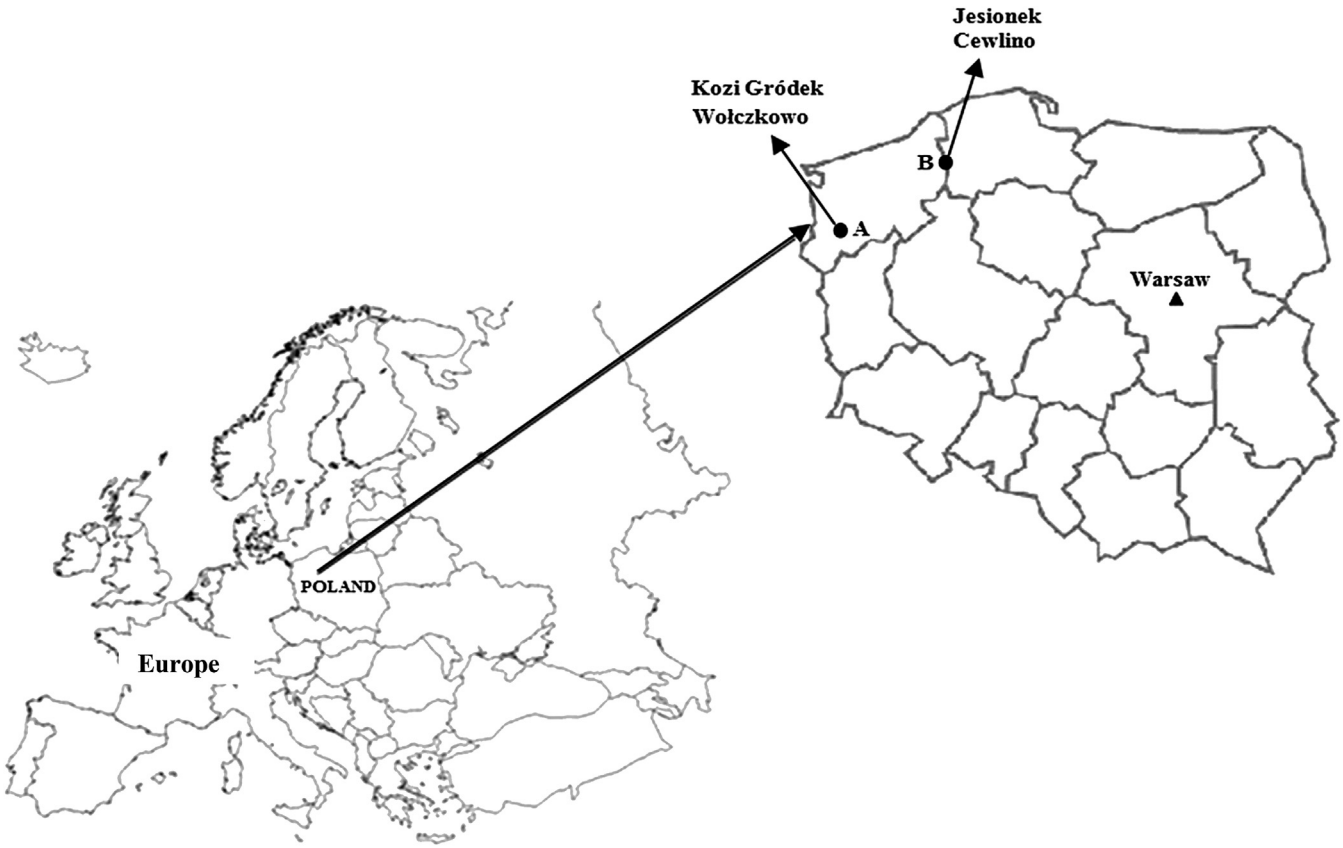

Fig. 1. The location of goat milk production sites.