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**RESEARCH ARTICLE**

# The Determination of Dioxin and Dioxin-like Compound Levels in Beef and Chicken Meat Samples Consumed in Turkey [1]

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## Summary

The polychlorinated dibenzo-p-dioxins (PCDDs), polyclorinated dibenzofurans (PCDFs) and dioxin-like polychlorinated biphenyles (PCBs) residues in beef and chicken samples obtained from the different cities of Turkey were investigated. For this purpose, 120 beef and 120 chicken samples collected from different regions of Turkey between February 2006 and May 2008 and analyzed for dioxin and dioxin like compounds. The results showed that the mean levels of PCDD/Fs in lower bound of toxic equivalent concentrations (TEQ) were 2.83 and 3.17 pg TEQ/g fat for beef and chicken, respectively and in upper bound were 3.45 and 4.21 pg TEQ/g fat for beef and chicken, respectively. PCDDs were more dominant congeners according to PCDFs in both beef and chicken. Furthermore, the concentration of PCB congeners in lower bound were found 0.0108 and 0.0085 pg TEQ/g fat in order of beef and chicken, respectively and in upper bound were determined 0.0572 and 0.0595 pg TEQ/ g fat in beef and chicken, respectively. According to the obtained findings, on a lipid basis, levels of dioxins in beef and chicken were slightly higher than other countries and World Health Organization (WHO) limits. However, mean values of PCBs were lower than the other countries at all samples. In conclusion, the findings of this study showed that the TEQ levels of PCDD/Fs are slightly higher in beef and chicken samples consumed in Turkey and long-term consumption of these foods may cause health risk for human and animals.

**Keywords:** *Dioxin, PCDD/Fs, PCBs, Beef meat, Chicken meat*

# Türkiye'de Tüketilen Kırmızı Et ile Tavuk Eti Örneklerinde Dioksin ve Dioksin Benzeri Bileşik Düzeylerinin Belirlenmesi

## Özet

Yapılan bu çalışmada, Türkiye'nin değişik bölgelerinden toplanan tavuk eti ve kırmızı etlerde Poliklorludibenzo-p-dioksin (PCDD), Poliklorludibenzo furan (PCDF) ve dioksin benzeri bileşikler olan Poliklorlubifenil (PCB) bileşik düzeyleri araştırıldı. Bu amaçla, Şubat 2006 ile Mayıs 2008 tarihleri arasında Türkiye'nin değişik illerinden toplanan 120'şer adet tavuk eti ve kırmızı et numunesinde dioksin ve benzeri bileşiklerin kalıntı düzeyleri tespit edildi. Analizler sonucunda, PCDD/F bileşiklerinin toksik eşdeğer konsantrasyonları (TEQ) için alt sınırın kırmızı et ve tavuk etinde sırası ile 2.83 ve 3.17 pg TEQ/g yağ, aynı değerin üst sınırının ise yine sırası ile 3.45 ve 4.21 pg TEQ/g yağ olduğu belirlendi. Ayrıca PCDD bileşiklerinin miktar olarak PCDF bileşiklerine göre daha yüksek düzeyde olduğu saptandı. Buna ilaveten, PCB bileşiklerinin alt sınır düzeyleri kırmızı et ve tavuk etinde sırasıyla 0.0108 ve 0.0085 pg TEQ/g yağ iken, üst sınır değeri yine sırasıyla 0.0572 ve 0.0595 pg TEQ/ g yağ olduğu belirlendi. Elde edilen bulgular ışığında, yağ dokusu bazında, ülkemizde tüketilen kırmızı et ve tavuk etindeki PCDD/F bileşik düzeylerinin diğer ülkeler ve Dünya Sağlık Örgütünün (WHO) belirlediği limitlere göre çok az miktarda yüksek olduğu bununla birlikte, PCB bileşik düzeylerinin ise daha düşük olduğu tespit edildi. Sonuç olarak, Türkiye'de tüketilen kırmızı et ve tavuk etinde PCDD ve PCDF'lerin toksik eşdeğer konsantrasyonlarının az miktarda yüksek olduğu ve bu gıdaların uzun süreli tüketiminde insan ve hayvan sağlığı açısından risk oluşturabileceğini göstermektedir.

**Anahtar sözcükler:** *Dioksin, PCDD, PCDF, PCB, Kırmızı et, Tavuk eti*

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## INTRODUCTION

Dioxins, which included polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and dioxin-like polychlorinated biphenyls (PCBs) are highly toxic chemicals and occur as widespread, low-level in animal feeds, human foods and environment [1,2]. The hydrophobic properties of these compounds cause their accumulation in the fatty content of food products [3]. The consumption of animal fats is the primary pathway for human exposure [4,5]. These compounds can induce various toxic responses including immuno-toxicity, carcinogenicity, and adverse effects on reproduction, development, and endocrine functions [6,7]. Dioxins caused significant food safety crises in 1996 in United States and Europe. The Belgian crises in 1999 is one of them, involved mineral oil containing high PCDD/F levels as a contaminant for poultry feed [8]. These incidents showed that the monitoring of dioxin concomitants in foodstuffs is required for human and animal health. For this reason, the toxicity and pollution risks of dioxin compounds have been investigated for 20 years in the world. However, there is no investigation about PCDD/Fs and PCBs levels in foods till now in Turkey.

The objective of this study is to determine the some dioxin and dioxin-like polychlorinated biphenyls compounds levels in beef and chicken samples consumed in Turkey between February 2006 and May 2008 and to compare these levels with international standards. This paper is also the first study about the residue levels of dioxin and dioxin-like compounds animal originated foods, chicken and beef meat, consumed in Turkey.

## MATERIAL and METHODS

### *Sampling*

Samples of beef and chicken were randomly purchased from the local market from thirteen major cities of Turkey (Ankara, Istanbul, Afyon, Kayseri, Gaziantep, Van, Konya, Bursa, Şanlıurfa, Elazığ, Hatay, Adapazarı, Izmit). The samples were stored at -20°C in the dark and extracted within 30 days. Every year, 40 beef and 40 chicken samples were bought from markets. Finally, we used 240 individual food samples in the 3 years for this investigation.

### *Materials*

All chemicals and silica gel, type 60, 70/230 mesh were analytical grade for dioxin analyses and purchased from Merck (Germany). PCDDs, PCDFs and dioxin-like PCBs standards were bought from AccuStandard (New Haven, USA). $^{13}C_{12}$- labeled standards were obtained from Wellington Laboratories (Canada).

### *Extraction*

The extraction was done according to modified method 8290 and 1613 of United States Environment Protection Agency (USEPA) [9]. A 20 g homogenized sample mixed with anhydrous sodium sulfate was spiked with $^{13}C_{12}$ - labeled standards (100 µl of 4 ng/ml), allowed to dry and then extracted for 16 h using methylene chloride: hexane (1:1) in a soxhalet extractor. The solvent was evaporated and the lipid content was determined gravimetrically.

The lipid residue was dissolved in toluene and the mixture was placed onto an acidic silica column. The column was prepared with a glass wool plug, 20 ml toluene and 1 g silica gel and then 4 g of 40% (w/w) sulfuric acid-impregnated silica gel was added. This column was washed twice with toluene and refluxed with toluene for 30 min. Finally, the eluate was evaporated to dryness and redissolved in toluene containing injection standards.

### *Analyses*

Ten PCDD/Fs and three PCBs congeners were analyzed by PTV-LV-GC/MS, GC (Schimadzu QP 2010 plus) coupled with a Plus Mass Spectrometer operating the EI mode 70 eV and with a resolution of 10.000. The capillary column was a TRB5 MS capillary column (60 m x 0.32 mm I.D., 0.25 µm film thickness, Teknokroma S. Coop. C. Ltda, Barcelona, Spain) connected to a BEST PTV injector and PTV-LV 2.75×2TRC for PCDD/Fs and PCBs verification. The oven temperature was maintained at 100°C for 6 min, ramped at 52°C $min^{-1}$ to 200°C; ramped at 2.9°C $min^{-1}$ to 250°C for 6 min; ramped at 2.9°C $min^{-1}$ to 260°C and finally ramped at 10°C $min^{-1}$ to 300°C for 5 min. The equipment conditions were designed for Eppe et al. [10]. During the analysis the injection volumes were increased from 1 µl to 4 µl with the PTV-LV inlet. At the result, analytical sensitivity is greatly enhanced for analysis of samples.

### *Calculations*

The TEQ values of PCDD/Fs and PCBs were calculated using the toxic equivalent factor (TEFs) according to World Health Organization [11]. The data below the detection limit (LOD) were calculated as lower, and upper bound levels, assuming that all levels of the different congeners were equal to zero or equal to their LOD, respectively. The recovery always ranged from 60% to 120%.

## RESULTS

The metabolism and lifetime of an animal might affect the amount of residue and congener patterns of dioxin compounds in meat tissues. Totally, 240 beef and chicken samples were analyzed for PCDDs, PCDFs and non-ortho dioxin-like PCBs in this study. The minimum, maximum and mean concentration values for individual congeners and the fat content are showed in *Table 1*, the sum of all congeners are also included.

The results indicated that the concentrations of PCDDs were higher than PCDFs in beef and chicken samples. The highest PCDD/Fs levels were found in chicken samples. These levels were raised depending on the presence of 2,3,7,8 TCDD and 1,2,3,4,7,8 HxCDD. However, The Congeners 1,2,3,4,6,7,8 HpCDD, 1,2,3,4,6,7,8 HpCDF and 1,2,3,4,7,8,9 HpCDF were not determined in beef and chicken samples consumed in Turkey. The average lower and upper bound WHO-TEQ values for PCDD/Fs and non-ortho PCBs are given in *Table 2*. The TEFs recommended by the World Health Organization (WHO) in 1998 were used to calculate the toxicological concentration as TEQ. The Congeners 2,3,7,8-TCDD and 1,2,3,7,8-PeCDD with the highest toxic equivalent factors (TEFs) values were determined in

***Table 1.*** *Mean, minimum and maximum concentration values of PCDD, PCDFs and PCBs (pg/g fat) in the samples beef and chicken consumed in Turkey*

***Tablo 1.*** *Türkiye'de tüketilen kırmızı et ve tavuk etinde PCDD, PCDF ve PCB bileşik kalıntı düzeylerinin ortalama, minimum ve maksimum konsantrasyonları. (pg/g yağ)*

| Congeners | Beef (n = 120) Percent Fat (%) 4.96 | | | Chicken (n = 120) Percent Fat (%) 16.3 | | |
|---|---|---|---|---|---|---|
| | Min | Max | Mean | Min | Max | Mean |
| **PCDDs** | | | | | | |
| 2,3,7,8 TCDD | 0.43 | 3.16 | 1.56 | 0.93 | 4.5 | 2.10 |
| 1,2,3,7,8 PeCDD | 0.12 | 2.23 | 0.92 | 0.16 | 3.2 | 1.0 |
| 1,2,3,4,7,8 HxCDD | 0.40 | 3.80 | 2.17 | 0.43 | 3.10 | 1.42 |
| 1,2,3,6,7,8 HxCDD | 0.20 | 2.70 | 1.40 | 0.32 | 2.82 | 1.28 |
| 1,2,3,7,8,9 HxCDD | 0.25 | 2.45 | 1.10 | 0.25 | 2.12 | 0.95 |
| 1,2,3,4,6,7,8 HpCDD | nd | nd | nd | nd | nd | nd |
| OCDD | 1.43 | 5.10 | 3.65 | 2.85 | 9.05 | 5.01 |
| **Sum PCDD** | **2.83** | **19.44** | **11.1** | **4.94** | **26.79** | **11.76** |
| **PCDFs** | | | | | | |
| 2,3,7,8 TCDF | 0.09 | 1.02 | 0.20 | 0.11 | 1.12 | 0.30 |
| 1,2,3,7,8 PeCDF | 0.20 | 2.70 | 1.00 | 0.40 | 2.5 | 1.2 |
| 2,3,4,7,8-PeCDF | 0.11 | 1.24 | 0.20 | 0.14 | 1.38 | 0.21 |
| 1,2,3,4,7,8 HxCDF | 0,04 | 1.04 | 0.14 | 0.10 | 1.20 | 0.24 |
| 1,2,3,6,7,8 HxCDF | 0.05 | 0.95 | 0.12 | 0.15 | 1.25 | 0.21 |
| 1,2,3,7,8,9 HxCDF | 0.03 | 0.90 | 0.11 | 0.09 | 0.98 | 0.15 |
| 2,3,4,6,7,8 HxCDF | 0.04 | 0.84 | 0.07 | 0.07 | 0.90 | 0.10 |
| 1,2,3,4,6,7,8 HpCDF | nd | nd | nd | nd | nd | nd |
| 1,2,3,4,7,8,9 HpCDF | nd | nd | nd | nd | nd | nd |
| OCDF | 1.05 | 4.86 | 2.22 | 1.15 | 5.24 | 3.11 |
| **Sum PCDF** | **1.61** | **13.55** | **4.06** | **2.21** | **14.57** | **5.52** |
| **Sum of PCDD/Fs** | **4.44** | **32.99** | **15.16** | **7.15** | **41.36** | **17.28** |
| **Non-ortho PCBs** | | | | | | |
| 3,3',4,4'TCB | 0.6 | 2.1 | 1.31 | 0.9 | 4.1 | 1.98 |
| 3,4,4',5 TCB | 0.7 | 2.8 | 1.20 | 0.9 | 3.3 | 1.42 |
| 3,3',4,4',5PeCB | 0.01 | 0.34 | 0.09 | 0.03 | 0.41 | 0.11 |
| 3,3',4,4',5,5' HxCB | 0.9 | 6.8 | 2.52 | 1.1 | 7.1 | 2.38 |
| 2,3,3',4,4',5,5' HpCB | 1.5 | 7.4 | 4.46 | 0.9 | 8.3 | 3.42 |
| **Sum PCB** | **3.71** | **19.44** | **9.58** | **3.83** | **23.21** | **9.31** |

***n*** *= number of samples;* ***nd*** *= not detected*

both beef and chicken samples. The TEQ levels of PCDD/Fs increased depending on the high TEF values of 2,3,7,8-TCDD and 1,2,3,7,8-PeCDD congeners. The congener profiles of TEQ levels are showed in *Fig. 1*.

***Table 2.*** *Lower and upper bound concentrations of PCDD/Fs and PCBs in beef and chicken samples (pg TEQ/g fat)*

***Tablo 2.*** *Kırmızı et ve tavuk eti örneklerinde PCDD, PCDF ve PCB bileşiklerinin toksik eşdeğer konsantrasyon olarak alt ve üst sınırı (pg TEQ/g yağ)*

| Sample | PCDD/Fs pg TEQ/g | | PCBs TEQ pg TEQ/g Fat | |
|---|---|---|---|---|
| | Lower Bound | Upper Bound | Lower Bound | Upper Bound |
| Beef | 2.83 | 3.45 | 0.0108 | 0.0572 |
| Chicken | 3.17 | 4.21 | 0.0085 | 0.0595 |

The toxicity of the individual congeners may vary orders of magnitude. The TEQ concept has been developed to facilitate risk assessment and regulatory control [11].

There is no investigation about the concentrations of PCDDs, PCDFs and PCBs in food, water, animals, soil and air in Turkey. However, there is only a study about measurement of dioxin compounds in the soil and air of Kocaeli, a city of Turkey. Bakoglu and coworkers [13] reported that PCDD/Fs concentrations in surface soils were between 0.4 and 4.27 pg TEQ/kg. Besides, the concentrations of these toxic compounds in ambient air were between 23 and 563 fg/m³ in Kocaeli. These ambient air concentrations are higher compared to those monitored in European countries ranging about 100 fg/m³ [14,15]. Dioxin compounds enter atmospheric air

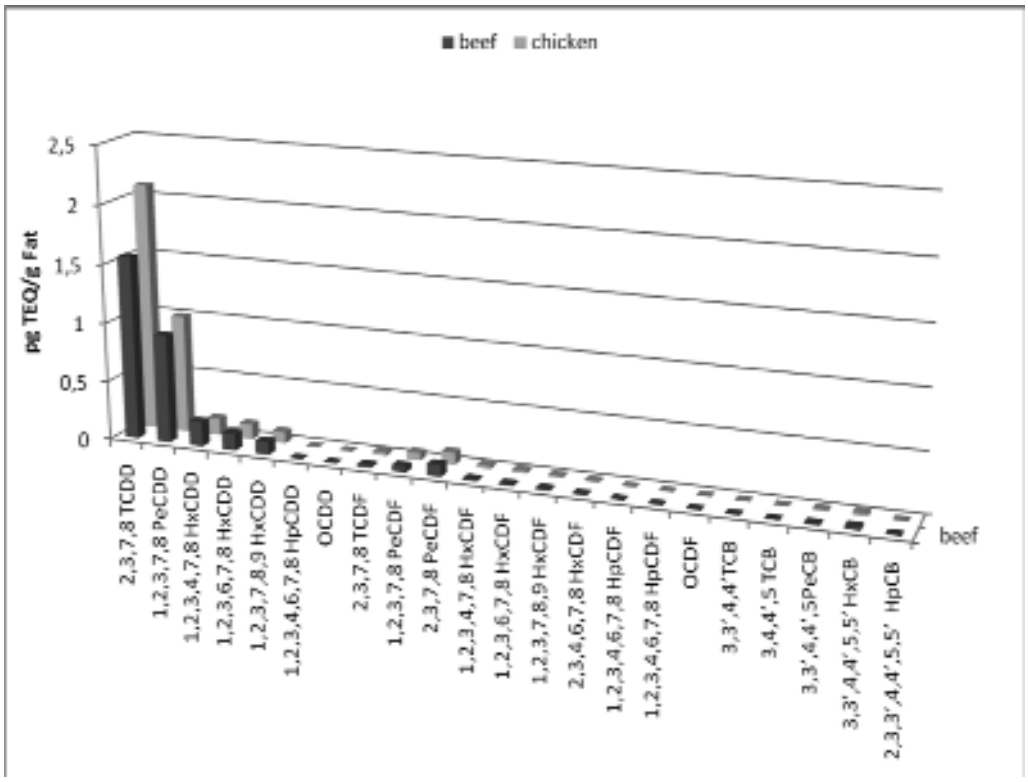


**Fig 1.** Congener profiles for TEQ levels of PCDD/Fs in beef and chicken meat

**Şekil 1.** Kırmızı et ve tavuk etinde bulunan PCDD ve PCDF bileşiklerinin toksik eşdeğer konsantrasyon düzeylerine göre profilleri

## DISCUSSION

The exposure of human to PCDDs, PCDFs and PCBs occur through environmental, and accidental and occupational contamination. Over 90 percent of human exposure is determined to occur through the diet from animal origin. The sources of PCDD and PCDF contamination of animal foods are contaminated feed for animals, chicken and farmed fish, improper of sewage sludge, garden composts flooding of pastures and certain types of food processing [12]. Toxic equivalent (TEQ) measures all toxic dioxins, furans and PCBs in terms of the most toxic form of dioxin, 2,3,7,8-TCDD. from different sources and diffuse to the ground then directly transferred to animals through inhalation and indirectly taken through crops by animals [16]. The fats and proteins obtained from these animals contain PCDD/Fs residues are also used as feed. The consumption of these contaminated feed by animals cause accumulation of dioxin compounds in the body of animals. However, the investigation of the sources of dioxin contaminations is a very complex subject because Turkey is importing 60% of consumed feed and their additives.

It was reported that the values of PCDD/Fs TEQ were between 0.89 and 2.26 pg/g fat for beef and were

between 1.36 and 8.92 pg/g fat for chicken. Additionally, non- ortho PCB TEQ levels ranging from 0.15 to 0.44 pg/g fat for beef and were between 0.56 and 3.74 pg/g fat for poultry [17]. Guruge et al.[18]. suggested that the concentrations of PCDD/FS in the fat of chicken samples in Japan were 1.71 pg TEQ/g lipid. Besides, Kim et al.[19] reported that the mean values of PCDD/Fs in upper bound were 0.21 and 0.04 pg WHO TEQ/g fat for beef and chicken in South Korea. The findings of this study revealed that the mean values of PCDD/Fs in lower bound were 2.83 and 3.45 pg WHO- TEQ/g fat for beef and chicken, respectively. Additionally, the same values in upper bound were 3.17 and 4.21 pg WHO- TEQ/g fat for beef and chicken, respectively *(Table 2)*. It is very difficult the comparison of the levels of PCDD/Fs and PCBs with reported concentrations in the other countries. Because all samples were obtained from livestock had different environmental conditions and feed regime. Although, in this study, PCDD/Fs concentrations of beef and chicken samples were higher than the levels in Japan and South Korea, these values were similar levels reported in European countries (PCDD/Fs TEQ 3-4.5 pg/g fat for beef) [20].

The human and animals receives its major exposure to PCDD/Fs through the intake food. The findings of this study showed that the levels of PCDD/Fs TEQ are high in beef and chicken samples consumed in Turkey. For this reason, the consumption of these foods for a long time can cause health risks in human. To avoid dioxin contamination, the dioxin residues in food, air, soil and other environmental factors could be monitored in Turkey and continuous efforts are required to identify and decrease the sources of PCDD/Fs and PCBs release into the food chain.

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