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TOXICOLOGICAL RISK ASSESSMENT OF 3-MCPD AND GLYCIDYL ESTERS IN CHILDREN CONSUMING POTATO CHIPS IN TURKEY

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ABSTRACT 3-Monochloropropane-1,2-diol esters (3-MCPDE) and glycidyl esters (GE) are the contaminants which have been detected in many foods and are of potential toxicological concern in recent years. This study aimed to assess whether these chemicals cause health risks in children considering their amounts in potato chips available for consumption in Turkish market. Based on the conservative scenario in our study, the average daily intake of 3-MCPDE was estimated as 2.41 µg/kg bw while at high exposures it was reached to 3.45 µg/kg bw. According to the average and the highest consuming levels, margin of exposures (MoEs) for GE were calculated as 2170 and 1478, respectively. The results of this risk assessment study indicate that, daily intake levels of 3- MCPDE and GE were exceeded the safety limits therefore constitute a significant health risk to children with current dietary habits in Turkey.

KEYWORDS : 3-MCPD, glycidol, risk assessment, toxicity

INTRODUCTION

3-Monochloropropane-1,2-diol (3-MCPD) esters (3-MCPDE) and glycidyl esters (GE) are the food-processing contaminants formed during the heat treatment of refined oils. High-temperature (220-270°C) treatments during deodorization and deacidification of vegetable oils lead to the formation of 3-MCPDE and GE by triggering chemical reactions such as hydrolysis and oxidative degradation[1]. The cooking processes which require high temperatures (> 160 ° C) comparable with deodorization, such as deep frying, also lead to produce these contaminants. During these processes, the oil is used continuously and repetitively and is also hydrolytically and oxidatively degraded when contacted with air. Therefore, 3-MCPDE and GE presence are also important in foods such as bread, biscuits, cakes, smoked fish products, chips, crackers, fries as well as infant formulas[2,3].

The presence of 3-MCPDE and GE in food is considered a potential health problem. These contaminants may be present in foods in free form as well as in higher amounts esterified form. Studies have shown that these chemicals are transformed into free forms, 3-MCPD and glycidol, with hydrolysis in the gastrointestinal tract and have the potential for toxic effects[4,5]. In vivo studies have shown that the main target organs are kidneys and testes in 3-MCPD-induced toxicity, while glycidol is a genotoxic carcinogen[6]. The International Agency for Research on Cancer (IARC) classified the glycidol as group-2A[7] and 3-MCPD as group-2B[8].

Real and scientific risk perception of these food contaminants can only be established through a systematic assessment and risk analysis that facilitates the identification of human health risks. The presence of these chemicals in frequently consumed foods, lead the regulatory bodies to focus on the subject to protect both occupationally exposed workers and the public from their health risks. European Food Safety Authority (EFSA) and Joint FAO/WHO Expert Committee on Food Additives (JECFA) determined the tolerable daily intake (TDI) and provisional maximum tolerable daily intake (PMTDI) values for 3-MCPD and its esters while the margin of exposure (MoE) was established for GE[6,9,10].

In Turkey, the annual individual consumption of chips, which was 400 g in 2004, increased to approximately 1 kg in 2012[11]. It is thought that these amounts will increase rapidly considering the young rate population that is prone to snacks in Turkey. Particularly, children are more vulnerable than adults to chemicals because of physiological and behavioral features. In this context, this study aims to determine whether these chemicals have the potential for health risk in children who consume chips more often than adults, based on the quantity of 3-MCPDE and GE in potato chips sold in Turkey market.

MATERIAL AND METHODS

The toxicological risk assessment includes the following steps; i) hazard identification, ii) dose-response assessment, iii) exposure assessment, iv) characterization of the risk[12].

Hazard identification and dose-response assessment

Epidemiological data have revealed the health hazard as a result of exposure to 3-MCPDE and GE. Moreover, No Observed Adverse Effect Level (NOAEL) values have been obtained from dose-response curves[6]. Thus, our study will be continued with exposure assessment by taking the data in Turkey.

Exposure assessment

Onal et al. determined the amounts of 3-MCPD esters and glycidyl esters in potato chips in Turkey. Briefly, in that study, a total of 24 potato chips samples from four different brands had been collected twice with one-year intervals and 3-MCPDE and GE levels had been determined by GC / MS method[13]. Among these measurements, the highest and the mean levels of 3-MCPDE and GE were selected for risk assessment with the conservative approach (the worst scenario). The mean levels of 3-MCPDE and GE were 1.11 ± 1.0 mg/kg and 2.36±1.79 mg/kg, respectively. The highest levels were 2.99±0.04 mg/kg for 3-MCPDE and 6.01±0.05 mg/kg for GE. We accepted the amount of 3-MCPDE and GE as mean + 1 SD levels for the risk assessment. In our study, children in the age group of 7-8 years were considered as representing childhood. According to the Obesity Investigation in Childhood in Turkey (COSI-TUR, 2013)[14], the average body weight of this age group (for both gender) was determined as 26.4 ± 0.08 kg (mean - 1 SD for the body weight was accepted in this study) and the majority of children (60%) consume chips 1-3 times a week. In our study, the worst scenario approach was followed for risk the assessment, and we accepted that children consume 1 package of chips (0.07 kg) 3 times a week.

Risk characterization

In the risk assessment for non-genotoxic chemicals, TDI values are considered as safety limits. However, the MoE approach is used for chemicals with genotoxic and carcinogenic potential. In this study, TDI for 3-MCPDE and MoE for GE which were established by EFSA were taken into consideration.

RESULTS AND DISCUSSION

Calculation of estimated daily intake (EDI) for 3-MCPDE:

$$EDI = \frac{c \; x \; dc}{bw}$$

c is the concentration of 3-MCPDE in chips (mg/kg)
dc stands for daily consumption of chips (kg)
bw represents the body weight (kg)

dc was calculated as 0.03 kg ((0.07 kg x 3)/7).

Based on the mean level of 3-MCPDE in chips samples, EDI was found as 2.41 µg/kg bw.

Based on the highest level of 3-MCPDE in chips samples, EDI was found as 3.45 µg/kg bw. The EFSA determines the tolerable daily intake (TDI) value for 3-MCPD and its fatty acid esters as 2.0 µg/kg body weight[9]. When the estimated daily intake (EDI) for the average and the highest consumed levels of 3-MCPDE were compared to the TDI of 2.0 µg/kg body weight established by EFSA, this age group consumption is above the safe limit, suggesting a potential health risk concern.

Calculation of Margin of Exposure (MoE) for GE:

$$MoE = \frac{T25}{EDI}$$

T25 represents the dose corresponding to a 25% incidence of tumors. This value is 10.2 mg/kg bw per day according to EFSA[6].

Based on the mean level of GE in chips samples, EDI was 4.7 µg/kg bw and MoE was 2170.

Based on the highest level of GE in chips samples, EDI was 6.9 µg/kg bw and MoE was 1478. EFSA concluded that MoE of 25,000 or lower would be of high health concern for exposure to GE. In our study, since all values of MoE are below 25000, it indicates high health risk under these circumstances.

The risk analysis approach can be contributed to legal authorities to evaluate the health risk related to food, set safety regulations, and minimize the health risk by communicating with the public and the producer. Although there are studies that determine the exposure assessment of 3-MCPDE and GE in various food groups in different markets, the number of risk assessment studies are very limited. In the risk assessment study conducted in Brazilian infant formulas, it was reported that both 3-MCPDE and GE levels were above safety limits and can cause health risks[15]. On the other hand, the levels of the thermal processed products have been determined in carbohydrate-rich foods, such as breakfast products, snacks, and biscuits present on the market in Poland and found that some of these products targeted for children contained a high amount of 3-MCPD[16]. EFSA has evaluated a total of 7.175 exposure data for 3-MCPD and glycidol and reported that 3-MCPDE and GE can be found in high amounts in many foods[6]. The results of our study, similar to other risk assessment studies, point out that these high consumed contaminants are a significant global health risk factor especially for children who have not yet acquired healthy eating habits.

CONCLUSION

This study is the first report in risk assessment of 3-MCPDE and GE in Turkish children consuming potato chips. The exposure of children to these contaminants may raise a potential health concern in childhood group. Some precautions such as reducing frequencies of chips consumption in children, increasing food process-control and using different cooking methods should be taken into consideration by stakeholders including industry, government, and parents.

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