Report of the Scientific Committee of the Spanish Agency for Food Safety and Nutrition (AESAN) in relation to the risk associated with the presence of lead in wild game meat in Spain

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Abstract

There are many well known toxic effects that lead (Pb) has on the body, with the CNS (Central Nervous System) being its toxicity's main target. There is clear evidence that shows that young children and foetuses are particularly sensitive to the neurotoxic effects of Pb. In adults, the cardiovascular and nephrotoxic effects have been identified as critical.

Recently, the European Food Safety Authority (EFSA) published an opinion report about the presence of Pb in food, which states that within meat, meat products and offal high Pb levels have been detected in game meat. The EFSA concluded that the PTWI established by the JECFA was no longer appropriate.

The Commission Regulation (EC) No 1881/2006 does not establish any Pb limits in game meat and, although consumption of wild game meat by the general population is low, it could be consumed more by hunters and their families. With this in mind, the Executive Director of the Spanish Agency for Food Safety and Nutrition (AESAN) has asked the Scientific Committee to assess the situation of the possible presence of lead in wild game meat in Spain in order to establish appropriate risk management measures.

Although the information available in Spain regarding the Pb content in wild game meat and its consumption is incomplete, following the analysis of data available in Spain, it has been shown that the average Pb content in pieces of large and small game exceeds the European Union general limits for meat and offal (there are no specific limits for this food) and these contents are similar to those found throughout Europe and other countries.

It has been proven that wild game meat is consumed in Spain, although it is more common in hunters and their families. It is not restricted to the hunting season, and its consumption or products that come from it, such as cured sausage or *pâté*, by the general public in restaurants is not negligible.

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The risk assessment associated with consuming wild game meat in Spain shows a situation almost identical to the one described by the EFSA for the entire population of Europe. No negative effects can be discarded in the adult population that has diet that includes a lot of wild game meat.

Regarding managing measures that could be taken for game meat, fixing specific limits would not be an adequate solution. Firstly this is due to the big differences in Pb content (even within the same animal), and secondly because official controls for this food would not be effective enough, as most of this meat is consumed directly by the hunters and their families, without going through the usual distribution channels for food that is subject to regulations.

In this Committee's opinion, considering the situation in Spain, the most appropriate measure regarding the consumption of wild game meat that is contaminated with Pb as a result of using Pb ammunition would be to reduce the possible exposure to Pb from this source. This would be done following specific recommendations for consuming and preparing food for groups of the population that consume this type of meat, and encouraging banning Pb ammunition and/or replacing it with existing alternatives.

Key words

Lead, food, game meat, occurrence, exposure, consumption, tolerable weekly intake, risk assessment.

Abbreviations

AESAN: Spanish Agency for Food Safety and Nutrition.
BfR: The German Federal Institut for Risk Assessment.
BMD: Benchmark dose (dose of a substance that is expected to result in a 10% level of measurable effect/response).
BMDL: Benchmark dose level.
b.w.: body weight.
CDC: Center for Disease Control and Prevention.
CDEP: Connecticut Department of Environmental Protection.
CDPHE: Colorado Department of Public Health and Environment.
DG SANCO: Directorate General Health & Consumers.
EFSA: European Food Safety Authority.
ENIDE: Spanish National Survey on Dietary Intake.
FAO: Food and Agriculture Organization of the United Nations.
FERA: The Food and Environment Research Agency.
IARC: International Agency for Research of Cancer.
JECFA: Joint FAO/WHO Expert Commitee on Food Additives.
LB: Lower Bound.
LD50: Letal dose 50.
LOD: Lmit of detection.
LOQ: Limit of quantification.
MARM: Ministry of Agriculture, Food and the Environment.
MOE: Margin of exposure.
Pb: Lead.
PNIR: Integrated National Waste Plan.
PTWI: Provisional Tolerable Weekly Intake.
SAF: Sampling Adjustment Factor.
SCF: Scientific Commitee for Food.
UB: Upper Bound.
WHO: World Health Organization.

Introduction

Lead (Pb) is a pollutant either naturally present in the environment or caused by various anthropogenic activities. It is predominantly found in its inorganic form in the environment although it exists in both organic and inorganic form (EFSA, 2010). The accumulation of Pb on the ground and on surface waters depends on various factors such as pH, mineral composition or the amount and type of organic material present.

Humans are exposed to Pb through foods, water, the air, the ground and dust but food is the main source of exposure.

There are many well known toxic effects of Pb on the body, with CNS (Central Nervous System) being its toxicity's main target organ, especially a developing brain. There is clear evidence that shows a particular sensitivity to the neurotoxic effects of Pb in young children and foetuses. In adults cardiovascular effects and nephrotoxicity have been identified as critical.

The International Agency for Research on Cancer (IARC) has classified inorganic Pb compounds as probably carcinogenic to humans (IARC, 2006).

The presence of Pb in food and drink has been continuously assessed. Consequently, in 1986 the Joint FAO/WHO Expert Committee on Food Additives (JECFA) established a Provisional Tolerable Weekly Intake (PTWI) of 0.025 mg Pb/kg b.w. (WHO, 1986). This value was later reassessed and confirmed by JECFA in 1999. In addition, in 1989 the Scientific Committee on Food (SCF) published an opinion report in which the PTWI established by the JECFA was endorsed (SCF, 1989). But, in a later opinion report on the contents of Pb in food and drink the need to re-evaluate the toxicity of this metal was outlined (SCF, 1992). Subsequently, in 2004 the European Commission used newly available data to re-evaluate the exposure to this metal. The results obtained were used to establish and update the limits for maximum Pb content in food (EFSA, 2010).

The European Food Safety Authority (EFSA) has recently published its opinion report on the presence of Pb in food. One of its aims was to evaluate if the PTWI of 0.025 mg Pb/kg b.w. established by JECFA can still be considered as appropriate based on the newly available data (EFSA, 2010). In order to carry out this research, the EFSA reassessed around 140,000 data on Pb content in different groups of food and tap water. The data were provided by 14 Member States and Norway.

The results obtained by EFSA showed that lead exposure in the diet of an average adult consumer varies between 0.36 μg Pb/kg b.w./day (the lowest limit for the country with the least average exposure) and 1.24 μg Pb/kg b.w./day (the highest limit for the country with the greatest average exposure). However, in the case of high consumers, the results obtained ranged from 0.73 to 2.43 μg Pb/kg b.w., respectively. The EFSA concluded that the PTWI established by the JECFA was not longer appropriate using an approach based on the margin of exposure to carry out risk characterization (EFSA, 2010).

The food groups that contribute the most to Pb exposure include cereal products, potatoes, cereals (except rice), cereal mix based dishes, leafy vegetables, and tap water.

Furthermore, within the meat, meat products and offal food group, game meat showed to have a rather high Pb content, with the maximum level reaching 867.0 mg Pb/kg (Table 1).

Table 1. Lead content in game meat

Food category	N	<LOD[a]	Lead concentration (mg/kg)					
			P5	Median	Mean	P95	Máximum	SAF[d]
Game meat	2,521	59.4%	LB[b]	LB	LB	LB	LB	0.2%
			0.0000	0.0000	3.137	1.525	867.0	
			UB[c]	UB	UB	UB	UB	
			0.0060	0.0200	3.153	1.525	867.0	

[a]LOD: limit of detection, [b]LB: lower bound, [c]UB: upper bound, [d]SAF: sampling adjustment factor. **Source:** (EFSA, 2010).

However, the Regulation (EC) No 1881/2006 (EU, 2006) does not establish maximum Pb limits for game meats (Table 2).

Table 2. Maximum lead levels in meat and offal established by the Regulation (EC) No 1881/2006

Foodstuffs	Maximum Lead Levels
Meat (excluding offal) of bovine animals, sheep, pig and poultry	0.10 mg/kg wet weight
Offal of bovine animals, sheep, pig and poultry	0.50 mg/kg wet weight

Source: (EU, 2006).

In terms of game meat and its classification, the Regulation (EC) No 853/2004 (EU, 2004) sets out the following definitions:

- Wild game: wild ungulates and lagomorphs, as well as other land mammals that are hunted for human consumption and are considered to be wild game under the applicable law in the Member State concerned, including mammals living in enclosed territory under conditions of freedom similar to those of wild game; and wild birds that are hunted for human consumption.
- Farmed game: farmed ratites and farmed land mammals other than those referred to in point 1.2 (domestic ungulated).
- Small wild game: wild game birds and lagomorphs living freely in the wild.
- Large wild game: wild land mammals living freely in the wild that do not fall within the definition of small wild game.

In Spain, the practice of hunting has gradually spread through all sectors of the population. In this respect, Ontiveros (1991) states that one of the indicators of this increase in hunting activity in Spain is the number of hunting licences issued between 1940 and 1987. This figure rose from its lowest of this period of 139,918 in 1946 to 1,283,353 in 1987: an increase of more than a million licences. Furthermore, according to data from the Ministry of Agriculture, Food and the Environment (MARM, 2009) and the Federation of Associations for Hunting and Conservation of the EU (FACE, 2010), the number of hunting licences in Spain in 2009 was 980,000 (1,041,360 according to MARM). This made Spain the second country in the European Union in terms of hunting licence number after France (France: 1,331,000;

United Kingdom: 800,000; Italy: 750,000; Germany: 351,000). Furthermore, the total number of hunting reserves in Spain in 2008 amounted to 29,102,494 ha whilst the number of catches in the same year rose to 16 million (MARM, 2010). The hunting "boom" in Spain can be attributed to a number of factors: the fact that parts of the country are ideal for this type of activity, the adaptation of the agrarian structures of a large part of the Spanish middle mountain region for hunting reserves, and the key instigating role that the agrarian crisis in the Spanish mountains played in the hunting "boom" (Ontiveros, 1991).

With regard to game meat consumption in Spain, it is eaten frequently by hunters and their families not just during hunting season because catches can be frozen and consumed throughout the year (Mateo et al., 2011). In addition, catches can also be supplied to restaurants.

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Lead

1. Absorption, distribution and excretion

Absorption of ingested inorganic Pb in the gastrointestinal tract depends on physiological factors (such as age, pregnancy, etc.) as well as the physicochemical characteristics of the ingested particles (size, solubility, etc). The presence of food decreases the absorption of water-soluble Pb compounds. What is more, absorption of said compounds is higher in children than in adults (EFSA, 2010).

In children Pb absorption is affected by iron nutritional status as low iron intake and deficient iron status are associated with an increased Pb concentration in the blood (Watson et al., 1986). Furthermore, an inverse relationship between the dietary ingestion of calcium and Pb concentration in the blood has been observed. This is such that Pb absorption is higher in children with calcium deficiency (EFSA, 2010).

When absorbed, the Pb is carried in the blood inside the erythrocytes and then transferred to soft tissue (including the liver and the kidneys) and the bone tissue where it accumulates more the older the person. The average life of inorganic Pb in the blood and bones is approximately 30 days and between 10 and 30 years respectively. It is mainly excreted in the urine and faeces.

2. Toxicity

Generally, no adverse health effects have been observed after a single exposure. An oral LD50 (50% lethal dose) greater than 2,000 mg/kg b.w. has been established for Pb salts.

The chronic toxicity of Pb is of most concern for humans due to the long elimination half-life of Pb in the body. From the first evaluation of Pb carried out by the Joint FAO/WHO Expert Committee on Food Additives (WHO, 1972), a Provisional Tolerable Weekly Intake (PTWI) of 50 µg Pb/kg b.w./week was established taking into account all sources of Pb exposure. This PTWI is only applicable to adults. In 1986 the JECFA Committee (WHO, 1986) established a PTWI of 25 µg Pb/kg b.w./week for infants and children due to their increased sensitivity. Assuming that food contributes to 50% of daily intake of Pb, a TDI of 18 µg for children aged 0-6 months and 27 µg for children aged 0.5-2 years was established. In 1993, JECFA (WHO, 1993) re-evaluated Pb and proposed a PTWI of 25 µg Pb/kg b.w./week for the entire population (children and adults). In 2010, the EFSA's Scientific Panel on Contaminants in the Food Chain (EFSA, 2010) concluded that, in accordance with the latest findings from research into the effects of Pb, the current PTWI of 25 µg Pb/kg b.w./week (3.6 µg Pb/kg b.w./day) was no longer adequate. The reason for this was that there was no evidence to support the existence of a threshold for the critical effects caused by Pb, i.e. neurotoxicity in brain development and nephrotoxicity in adults. The JECFA Committee came to the same conclusion in their 73rd meeting in June of 2010 (WHO, 2011).

The studies and experimental models performed on animals have highlighted that chronic exposure at low Pb concentrations causes neurotoxicity (EFSA, 2010).

In humans, high Pb concentrations can cause damage to internal organs, especially to the CNS, and can even reduce our ability to create new blood cells. In adults, the kidneys are the most sensitive to chronic exposure to Pb. In children up to the age of 7, the nervous system is the most sensitive and such a threat is even greater in infants and small children (BfR, 2011). In this respect, relatively low Pb concentrations have been found in the blood in adults that are associated with raised systolic blood pressure and chronic kidney disease (EFSA, 2010).

Neurotoxicity associated with Pb exposure in adults affects information processing, causes psychiatric symptoms and damages manual dexterity. In the case of children there is much evidence to suggest that Pb neurotoxicity affects developing brains to a greater extent compared to mature brains. Consequently, high Pb concentrations in the blood have been associated with a reduced IQ (Intelligence Quotient) and cognitive functions in children younger than 7 years (EFSA, 2010). Similar conclusions can be applied to the case of foetuses. Furthermore, during pregnancy the foetus can be exposed to higher Pb concentrations than those provided solely by the mother through her diet. This is attributed to the fact that if the mother does not have sufficient calcium intake, Pb is released along with calcium stored in the bones resulting in increased exposure for both mother and foetus (BfR, 2011).

With regard to carcinogenicity, previous studies have shown that raised Pb concentrations can cause tumours in rodents (EFSA, 2010). As for humans, lead has been classified as being probably carcinogenic (Group 2A) based on the limited evidence suggesting its carcinogenicity in humans and the sufficient evidence on animals (IARC, 2006). On the other hand, genotoxicity data indicates that Pb may be a weak indirect genotoxin. However, it is generally considered improbable that Pb exposure through foods represents a significant risk of cancer.

Lead occurrence in game meat

Lead ammunition in water bird hunting has started to be replaced by other types of ammunition. Various studies have highlighted how lead ammunition is responsible for the growing death rate of this species of bird, which ingest pellets deriving from hunting and target shooting. In Spain, the Royal Decree 581/2001 (Real Decreto, 2001) prohibits the possession and use of ammunition that contains Pb for hunting and target shooting purposes in the Spanish wetlands listed in the Convention on

Wetlands of International Importance. This ban also extends to wetlands which fall under current natural space protection laws.

However, Pb ammunition is still used for other types of large and small game hunting in many countries. On the other hand, different authors indicate that game meat can contain varying levels of Pb in small fragments due to the use of this type of ammunition. This is down to the way in which it tends to break up upon impact with the prey and spreads throughout the wound thus remaining in the tissue. These fragments could constitute a source of dietary exposure to Pb for those who consume this type of meat; such is the case for hunters and their families. This form of exposure could even be a health risk (Johansen et al., 2001) (Haldimann et al., 2002) (Bjerregaard et al., 2004) (Hunt et al., 2009) (Mateo et al., 2011). This dietary Pb exposure depends on various factors such the frequency and quantity of meat consumed, the degree of fragmentation, the path that the ammunition has taken, the level of care taken to remove the flesh surrounding the wounds or the way in which the meat is cooked. The latter constitutes a factor to be considered given that acidic preparation of the meat can help to dissolve Pb (Hunt et al., 2009). Some of these factors are analysed below.

1. Lead occurrence in game meat (determining factors)

Number of lead pellets or fragments

Game meat contamination as a result of the fragmentation of Pb present in ammunition has been dealt with in many studies. Pb concentration is related to the number of pellets and/or fragments in the meat or offal. The greater the number, the higher the lead concentration in those samples analysed.

This was demonstrated by Falandysz (1994) in pieces of large game captured in the north of Poland between 1987 and 1991. The findings were later confirmed in other countries and in other large game species (Tsuji et al., 2009) (Knott et al., 2010) and in birds (Pain et al., 2010). In Spain, Mateo et al. (2011) have studied Pb content and fragmentation in red-legged partridges. It was found that those samples containing pellets and small fragments of metal had a higher Pb content that those that were free from pellets or fragments. In the case of birds, the high Pb concentrations could be a consequence of sources other than the pellets used to hunt them. For examples, pellets could have been ingested (Kreager et al., 2008) or the birds could have been exposed to local Pb sources. However, such possible exposures seem small given that, as a general rule, the highest lead concentrations in birds, not related to ammunition, are located in the bones and tissue (liver and kidneys) whereas the lowest concentrations are found in the muscles and the fat (the tissue that was consumed and used in these studies) (Pain et al., 2010).

The impact of cooking

The impact of cooking on the final Pb concentration of meat has been proven by different studies. Small games (mainly partridge, rabbit and quail) are often cooked in vinegar (pickling brine). It has been found that this type of cooking can increase the rate at which the Pb is transferred from the ammunition remains present in the meat (Mateo et al., 2007). Consequently, some studies have shown that the metal Pb particles in game meat can dissolve. This gives rise to soluble Pb salts which contaminate parts of the meat that would otherwise remain unaffected. In addition, these salts have a higher bioavailability and suppose a greater risk compared to metallic Pb particles (Mateo et al., 2007) (Pain et al., 2010). In this respect, the study by Mateo et al. (2011) is the most important. It was based on an *in vitro* simulation to compare the bioaccessibility of the Pb ammunition remains present in red-legged partridge meat cooked using different recipes (vinegar, white wine). The comparison was made to provide consumers of game meat with information on how reduce their exposure to lead by implementing changes to the ways in which the meat is cooked. The study concluded that cooking small game meat under acidic conditions (pickling vinegar) increases final Pb concentrations in meat along with its bioaccessibility.

Bioavailability of lead present in game meat

As we have already seen, the bioavailability of Pb increases in small game meat with same types of cooking. However, there is evidence to suggest that the bioavailability of Pb in large game meat is high even when it does not undergo such preparations. With this in mind, Hunt et al. (2009) determined the incidence and bioavailability of Pb fragments present in deer meat. More evidence of the bioavailability of Pb present in game meat is the relationship between game meat consumption and lead levels in the blood, which has been shown in many studies (Lévesque et al., 2003) (CDC, 2005) (Tsuji et al., 2008a, 2008b) (Hunt et al., 2009) (Iqbal et al., 2009). Each investigation came to the conclusion that Pb concentrations in the blood were always higher in individuals who consumed game meat compared to those who did not. Nonetheless, some studies indicate on the other hand that frequent consumption of wild game meat has no significant effect on Pb concentrations in the blood (Haldimann et al., 2002).

2. Lead in game meat and its health implications

The adverse health implications of Pb in game meat for those who consume it are clear, both in terms of its acute and chronic effects. Carey (1977) and Reddy (1985) had already described the accumulation of Pb fragments in the appendix of the Canadian indigenous populations who had undergone an appendectomy. Durlach et al. (1986) wrote about the acute Pb intoxication in a farmer who regularly consumed game meat. Some 29 fragments of Pb were extracted from the colon and appendix and the lead-plasma concentration was 674 µg/l. Another case published by Gustavsson and Gerhardson (2005) attributes acute intoxication (550 µg/l of lead in the blood) to game meat consumption in a male of 45 years of age who had a single Pb fragment in the gastrointestinal tract. Mincheff (2004) described the case of a 9 years old child complaining of abdominal pain who had a lead concentration of 16 µg/dl in the blood. The appendix was removed and a Pb fragment was found, which was verified as coming from eating game meat containing bullet fragments.

It must be pointed out that the presence of Pb fragments in the gastrointestinal tract could also constitute a source of chronic exposure (Madsen et al., 1988). Nowadays, consuming wild game meat that contains high concentrations of Pb is considered a significant additional source of exposure, especially for some sub-groups of the population (hunters and their families, children, etc.). This can have possible health implications if we consider what we now know about the toxicity of this metal (Johansen et al., 2001) (Haldimann et al., 2002) (Bjerregaard et al., 2004) (Hunt et al., 2009) (Tsuji et al., 2009) (EFSA, 2010) (Knott et al., 2010) (Pain et al., 2010) (Mateo et al., 2011) (Sevillano et al.,

2011) (Taggart et al., 2011). In contrast, Jarzynska and Falandysz (2011) found that Pb concentrations in muscle tissue, the liver and the kidneys of deer was below the limits established by the European Union (EU, 2006) and just 5% of the muscle samples taken exceeded 0.1 mg/kg wet weight, mainly due to the use of Pb ammunition. In accordance with the Pb concentrations found in this study and assuming a 50-100 g/day consumption of muscle, liver or kidney, it was concluded that game meat consumption (deer) would have no health implications.

3. Control of lead in wild game meat within the European Union

The Regulation (EC) No 853/2004 (EU, 2004), laying down specific hygiene rules for food of animal origin, does not apply to hunters who directly supply the end consumer with small quantities of wild game or wild game meat, nor does it apply to hunters who sell to local retailers that supply directly to the end consumer.

On the other hand, wild game is indeed included under the Directive 96/23/EC (EU, 1996), which requires that Member States implement national plans to monitor animal residues and their animal products and establishes residues to be determined and species to sample. Within these plans, heavy metals should be sampled in the tissue of cows, sheet, goats, pigs, and horses as well as in poultry, aquiculture animals, milk, rabbit meat, farmed game meat, wild game meat and honey.

The Decision 97/747/EC (EU, 1997) fixes the levels and frequencies of sampling in wild game meat. The samples are taken at the game handling establishment or at the hunting location itself and the minimum number of samples to be taken each year is established in order to analyse chemical element residues.

In Spain, the Integrated National Waste Plan (PNIR) falls under the regulation of the Royal Decree 1749/1998 (Real Decreto, 1998), which establishes the control measures applicable to certain substances and their residues in live animals and their products. The Decree also brings together the criteria of Directive 96/23/EC and Decision 97/747/EC.

The PNIR involves targeted sampling in which samples are taken in view of detecting any illegal treatment or ensuring that the maximum limits for veterinary medication residues or the maximum levels of pesticides and pollutants are adhered to. Sampling is geared towards animals whose characteristics (species, gender and age) make the probability of finding residues higher. Such a focus differs from random sampling which aims to bring together statistically significant data for evaluating consumer exposure to a certain substance for example.

In addition, suspect sampling is carried out when legislation has not been adhered to, illegal treatment is suspected, the veterinary medication withdrawal periods have not been respected or when the official control agent sees fit.

In accordance with the Directive 96/23/EC, the Member States should annually provide information regarding the results of residue control plans to the European Commission, which will then inform each Member State of residue control plan development in the European Union. Therefore, annual summaries of the results are published on the webpage of the Directorate General for Health and Consumers (DG SANCO, 2012). However, this information only brings together cases in which the legislation is not adhered to and does not make reference to the quantities recorded in each sample.

As there are no maximum limits to the chemical elements in wild game, it is assumed that the criteria applied by EU Member States for reporting of a non-compliance in game meat is the same as the criteria for meat (muscle) and for the offal of cows, sheep, pigs and poultry (0.10 and 0.50 mg/kg wet weight respectively in the case of Pb). In others cases, according to the information available, it seems that an action level of 0.30 mg Pb/kg wet weight is used (Czech Republic).

Between 2005 and 2010 the number of non-compliances regarding Pb was clearly higher in wild game compared to other animal groups. Some countries that produce significant amounts of wild game, such as Germany and France, have not detected any non-compliance in relation to the presence of Pb in wild game meat throughout the same period. In Spain, out of the 18 non-compliances concerning Pb between 2005 and 2010 only two samples analysed in 2010 were related to game meat.

The information available in European Commission reports does not include the lead concentrations detected. Only in the case of some countries are concentrations or concentration ranges between 2005 and 2009 mentioned. Some samples have even reached Pb content levels of 282 mg/kg wet weight (Table 3).

Table 3. Lead concentrations in wild game samples of non-compliance appearing in the national residue plan reports for the period 2005-2009

Year and concentration (mg/kg wet weight)	Group	Country
2009		
0.74	Deer muscle	Austria
1.08	Deer muscle	Austria
48.00	Deer muscle	Czech Republic
3.14	Wild game	Ireland
0.515 to 0.778	Liver	Latvia
0.566 to 3.12	Kidney	Latvia
0.11 to 0.92	Muscle	Latvia
2008		
0.45-208.99	Deer, chamois, hare and wild boar muscle	Austria
5.72	Muscle	Ireland
2007		
0.78 to 6.95	Deer, hare and wild boar muscle	Austria
2006		
0.59 to 6.17	Fallow deer and wild boar muscle	Austria
0.4 to 9.9	Wild birds	Denmark
78	Deer	Denmark
0.68	Muscle	Romania
0.76	Muscle	Romania
1.64	Muscle	Romania
0.32	Muscle	Romania
0.68	Muscle	Romania
75.21	Muscle	Romania
0.13	Muscle	Slovenia
0.27	Muscle	Slovenia
0.31	Muscle	Slovenia
1.7	Muscle	Slovenia
3.6	Muscle	Slovenia
6	Muscle	Slovenia
24	Muscle	Slovenia
1.6	Partridge muscles	United Kingdom
2005		
1.2 to 282	Deer, hare and wild boar muscle	Austria
0.92	Muscle	Slovenia
1.51	Muscle	Slovenia
1.92	Muscle	Slovenia

Although the number of non-compliances in game meat detected in Spain is low, the number of samples taken each year is limited (Table 4). Therefore, based on this partial data, we cannot disregard the risk of the eventual presence of Pb to those who frequently consume wild game meat and wild game products. Furthermore, these samples generally do not come from pieces of game destined for self-consumption nor are they supplied directly in small amounts by hunters to the end consumer or local retail establishments that supply directly to the end consumer. In contrast, samples consist of pieces of large game that have been sent to game handling establishments for *post mortem* inspection and testing for trichina and infectious diseases, etc.

Table 4. Samples of wild game analysed in Spain for the purposes of targeted sampling of chemical elements from 2005 to 2009

Year	No. of samples
2005	35
2006	43
2007	40
2008	40
2009	55

4. Studies on the occurrence of lead in game meat

As well as the official controls conducted in the European Union, which are dealt with in the previous section, there have been many studies determining the Pb concentration in the muscle and offal of large and small game. The following table provides a summary of the results.

Table 5. The Pb content in wild game samples analysed in different studies

Species	Pb Content in mg/kg wet weight, except if stated otherwise	Reference
Wild boar, roe and deer	Muscle: 0.078-0.180 mg/kg Liver: 0.090-0.240 mg/kg Kidney: 0.080-0.360 mg/kg	(Falandysz, 1994) (Poland)
Roe, fallow deer, deer, pheasant, wild duck and hare	Muscle: 0.08-1.1 mg/kg Liver: 0.16 mg/kg Kidney: <0.05-0.33 mg/kg	(Doganoc and Gacnik, 1995) (Slovenia)
Birds (turkey, pheasant, partridge)	Liver: 6-25 mg/kg Up to 7,766 mg/kg in the "Chukar partridge"	(Kreager et al., 2008) (Canada)
Deer and wild boar	Kidney: 0.056-11.60 mg/kg Liver: 0.061-0.202 mg/kg Muscle: 1.04-3.38 mg/kg	(Bilandzic et al., 2009) (Croatia)
Deer and caribou	Deer (muscle and liver): 23-1,243 mg/kg (isolated values) Caribou: 1-5,726 mg/kg (isolated values)	(Tsuji et al., 2009) (Canada)
Pheasant, partridge, wood pigeon, grouse, eurasian woodcock	0.43-3.4 mg/kg (average value range for the different species included in this study)	(Pain et al., 2010) (Reino Unido)
Deer	Muscle: 0.18 mg/kg (dry weight) Liver: 0.17 mg/kg Kidney: 0.30 mg/kg (dry weight)	(Jarzynska et al., 2011) (Polonia)
Not specified	3.153 mg/kg Max: 867 mg/kg	(EFSA, 2010)
Partridge	2.55 mg/kg	(Mateo et al., 2011) (Spain)
Deer and wild boar	Deer (n=88): 0.322 mg/kg Wild boar (n=40): 1.357 mg/kg All (n=128): 0.645 mg/kg (weighted mean)	(Taggart et al., 2011) (Ciudad Real, Spain)
Deer and wild boar	Deer (n= 61): 0.326 mg/kg Wild boar (n=64): 1.291 mg/kg	(Sevillano Morales et al., 2011) (Córdoba, Spain)

From the official control data in Europe, the quantitative results are limited. Couple this with the special characteristics of the controls' design it means that the Pb content in game meat cannot be known with exact precision.

With regard to other studies (Table 5), it was found that Pb concentrations are generally higher than established limits for both large and small game. It should also be pointed out that samples differed greatly. This is probably due to the influence of those factors mentioned earlier that condition unequal distribution of Pb even in a single animal. In addition, given that the number of sampled animals in some studies is not very representative, it is difficult to estimate the average Pb content in game meat. The most reliable results for the whole of Europe are probably those brought together in the EFSA report (2010). However, this does not contain detailed information on the sampled species but rather uses 2,500 results from 19 Member States (no data from Spain).

In Spain in recent years studies have been carried out on Pb content in large and small game. In large game, Taggart et al. (2011) analysed the Pb content in the muscles of 88 deer and 42 wild boars shot with Pb ammunition during hunts in Ciudad Real province between 2005 and 2006. Average content in deer muscle stood at 0.322 mg Pb/kg (n=88) and was 1.357 mg Pb/kg (n=40) in wild boars (excluding extreme values). Although all animals were shot with lead ammunition, game shot in the "mining area" always displayed a higher Pb concentration compared to those shot in the "control area". For example, the average concentration in wild boars from the mining area was 1.77 mg Pb/kg compared to the 0.266 mg Pb/kg found in those captured in the control area. Taking into consideration all the analysed samples as a whole (excluding extreme values), the average Pb content stood at 0.645 mg/kg (n=128).

In a similar study, Sevillano Morales et al. (2011) determined Pb concentration in the muscles of deer (n=61) and wild boar (n=64) shot in different areas of Cordoba province between 2003 and 2006. Average concentration in deer muscle was 0.326 mg Pb/kg and 1.291 mg Pb/kg in wild boars. These results are very similar to those found in Ciudad Real province by Taggart et al. (2011).

Regarding small game, Mateo et al. (2011) published the results from a study of Pb content in 64 partridges captured in Albacete province. The presence of pellets was confirmed by X-ray in 56 of the animals analysed. This implied that each animal had an average of 4.2 pellets. The average concentration was 2.55 mg Pb/kg (n=128) taking into consideration that both breasts of each animal were analysed. Pain et al. (2010) found average values of 1.12 mg Pb/kg (n=26) in partridges.

If we analyse the results in Table 5, we can see how average Pb concentrations are always higher in birds than in large game species. This is also the case throughout Spain. Such findings are logical if we bear in mind the type of ammunition used in both cases. Cartridges with pellets are used in small game hunting, which contaminates the meat to a greater extent. Bullets are used in large game hunting which disperse less throughout the animal's body compared to pellets. However, some large game actually showed the highest extreme values.

In terms of EFSA data (2010), the average estimated concentration (3.15 mg Pb/kg wet weight) is quite higher than that found in Spain. But, we do not know what type of species have been used in the EFSA study and it is thus difficult to determine the cause of such differences.

In summary, the Pb content in the samples analysed in Spain that we are going to use for the purposes of evaluation would be 2.55 mg Pb/kg (n=128) for partridges (Mateo et al., 2011). For deer and wild boar we have data from two studies (Sevillano Morales et al., 2011) (Taggart et al., 2011) both of which are quite similar. Considering the collection of results from both studies we are left with the following:

a) Deer (n=149): 0.323 mg Pb/kg wet weight.

b) Wild boar (n=104): 1.316 mg Pb/kg wet weight.

We must point out that we only have results for three species of wild game and we do not have any information regarding other species that are also hunted and consumed by the Spanish population.

Risk assessment associated with lead in game meat

1. Exposure assessment

Game meat consumption

Haldimann et al. (2002) established a daily consumption of 50 g (based on a weekly consumption of 2.2 portions, each of 159 g). Jarzynska and Falandysz (2011) also established a deer meat consumption of 50-100 g/day to make their risk estimation. Kosnett (2009) considered a consumption of 2-5 portions/ week (141 g/portion for adults and 100 g/portion for children between 3 to 5 years). This amounts to an intake of 40-100 g/day for adults and 14.3-71.4 g/day for children.

Iqbal et al. (2009) surveyed 742 people (aged 2-92 years of age) in North Dakota (USA). Some 80.8% said that they eat wild animal meat, 98.8% of which came from hunting. Out of those surveyed, 47.3% ate deer 1 to 3 times per week and in 90.3% of cases portion sizes were around 57 g. This means that consumption was between 8.14 g and 24.42 g per day. Out of those participating in the survey, 70.2% said that they ate "other game meat" <1 time/week but portion sizes remained the same at 57 g. This implies a daily consumption of 8.14 g (assuming a consumption of once per week), a figure that was also obtained for game birds. On the whole, this means that the average daily consumption of game meat was 24.42-40.7 g/day.

In the EFSA study (2010), it is assumed that weekly game meat consumption is 200 g, which implies a daily consumption of 28 g. This figure applies to those with specific diets, namely the population who consume game meat. As for the population in general, it should be mentioned that game meat makes up just 0.2% (SAF) at most of all meat consumed.

In Spain, according to the National Survey of Spanish Dietary Intake (ENIDE) conducted by AESAN (2011), the average consumption of large game meat is 0.18±4.77 g/person/day. Figures for partridge and quail stand at 0.31±5.50 g/person/day and those for rabbit are 3.24±16.81 g/person/day. However, in the case of partridges, quail and rabbits the survey makes no distinction between farm bred and wild animals. For the group of "only consumers", the findings are as follows: 45.69±62.66 g/person/day (large game), 65.60±48.54 g/person/day (partridge, quail) and 59.6±43.01 g/person/day (rabbit). It must also be taken into account that game meat can be consumed in meat-based products (*pâté*, cured meat and cured sausage, etc) for which there is no information available. In any case, the information included in the ENIDE survey does not include children nor does it contain specific information on subgroups such pregnant women.

If we solely consider ENIDE's data and then add the contribution of the food groups, the following results would be obtained:

a) General population (adults): average consumption of 3.73 g/person/day.

b) "Only consumers" (adults): average consumption of 170.89 g/person/day.

It must be borne in mind that in the ENIDE study the percentage of game meat consumers is very low (0.4% for game meat, 0.47% for partridge and quail and 5.43% for rabbit). In fact, large game meat consumption figures referred to 12 people, partridge and quail figure referred to 14 people and the figure for rabbit referred to 163 people. But, regarding the latter it is probable that most of the rabbits have come from a farm. Therefore, in our opinion the consumption data collected in the survey are only slightly representative of actual game meat consumption amongst the Spanish population.

Sevillano Morales et al. (2011) carried out a survey in Andalusia on large game meat consumption over a period of 12 months. Out of the 301 people surveyed, 199 stated that they eat game meat (deer and wild boar). Some 15% of consumers ate just deer and 14% ate just wild boar, whereas 71% ate both. Within the most representative group (consumers of both types of meat), consumption amongst both "hunters" and "non-hunters" is shown in the Table 6.

Table 6. Wild game consumption (deer and wild boar) in a survey carried out in Andalusia (n=199)

	Deer/wild boar consumption (g/person/day)	
	Hunters	**Non-hunters**
Average	12.5/10.46	7.81/4.27
Maximum	73.1/82.2	137/13.69
P95	53.2/43.59	17.45/13.69
Minimum	1.83/1.83	0.35/0.35
Average Consumption (deer+wild boar)	**22.96**	**12.08**
P95 Consumption (deer+wild boar)	**96.79**	**31.14**

Source: (Sevillano Morales et al., 2011).

Sevillano Morales et al. (2011) found that large game meat consumption was lower than in the ENIDE survey (AESAN, 2011). But, given the number of participants, it would be fair to say that the information brought together by Sevillano Morales et al. (2011) is more reliable. Nonetheless, once again we are dealing with incomplete information given that data make exclusive reference to large game (deer and wild boar). Although these two animals are eaten the most, other game is eaten too. In this sense there is no information relating to small game consumption but if we assume that partridge, quail and rabbit (small game) consumption can be similar to that of large game, total average consumption would stand at approximately 45-50 g/person/day. This amount falls in line with the range that has too been calculated by other authors (Table 7).

Table 7. Game meat consumption according to different source

Reference	Game meat consumption (g/person/day)
(Haldimann et al., 2002)	50
(Jarzynska y Falandysz, 2011)	50-100
(Kosnett, 2009)	40-100
(Iqbal et al., 2009)*	24.4-40.7
(EFSA, 2010)	28
ENIDE (AESAN, 2011)	170.89
(Sevillano Morales et al., 2011)*	45-50

*Data considered to be the most reliable due the representativeness of the survey.

Estimation of the "Exposure Dose" or the "Estimated Daily Intake"

Based on an average consumption of 50 g/person/day and Pb content in those samples analysed in Spain of 2.55 mg Pb/kg (n=128) in partridges, 0.323 mg Pb/kg in deer (n=149) and 1.316 mg Pb/kg in wild boar (n=104), the average daily intake of Pb due to game meat consumption can be calculated according to the following:

a) One option would be calculate the weighted mean of the three available results (deer, wild boar and partridge) according to the number of samples for each case and the Pb concentration. Therefore, average concentration for game meat in general would be 1.34 mg Pb/kg (assuming that deer, wild boar and birds are eaten in the same quantities).
   In this approach, daily Pb intake from game meat consumption would be 0.05 kg/day x 1.34 mg/kg = 0.067 mg Pb/person/day. This is the equivalent of 67 µg Pb/person/day (1.12 µg Pb/kg b.w./day, for an adult weighing 60 kg).

b) A second option would be take into consideration the Pb content in each one of the three types of game meat and the percentage of total consumption for each one. We do not have data to hand in Spain to make such an estimation given that the ENIDE survey does not specify what corresponds to game meat within the bird and rabbit groups. If we take data compiled by Iqbal et al. (2009) on the proportion by which deer, wild boar and other (birds) are consumed, in the worst of cases the proportion lies at 3:1:1 (deer: wild boar: birds) and in our case would correspond to approximately 30 g of deer: 10 g of wild boar: 10 g of birds.
   The daily intake for this approach would be:
   - Deer: 0.030 kg/day x 0.323 mg/kg = 0.0097 mg/day.
   - Wild boar: 0.010 kg/day x 1.316 mg/kg = 0.013 mg/day.
   - Birds: 0.010 kg/day x 2.55 mg/kg = 0.025 mg/day.

   This involves a daily Pb intake of 0.0097 + 0.013 + 0.025 = 0.048 mg/person/day (48 µg Pb/person/day), which is the equivalent of 0.8 µg Pb/kg b.w./day for an adult weighing 60 kg.

In summary, daily Pb intake due to game meat consumption can be estimated at 48-67 µg Pb/day (0.8-1.12 µg Pb/kg b.w./day for an adult weighing 60 kg).

In Spain, dietary Pb intake (excluding that from game meat consumption) has been studied throughout the country. Results indicate that lead is consumed at a rate of between 28.4 and 574 µg Pb/person/day (Cuadrado et al., 1995) (Falcó et al., 2005), with an average of 48 µg Pb/person/day (Rubio et al., 2004).

2. Risk characterisation

The ENIDE survey offers little information on "only game meat consumers". In fact, out of the 3,000 people surveyed the percentage of "game meat consumers" is minute (0.4% for game meat, 0.47% for partridge and quail and 5.43% for rabbit meat, despite not knowing whether meat is from hunting or farming). If we then take into account daily Pb intake due to game meat and its derivatives (Table 1), it is clear that game meat consumption for the general population does not pose any problem. Nonetheless the negative effects of this type of meat cannot be dismissed in the case of those who regularly eat it. According to EFSA (2010) dietary exposure to Pb when taking into account all foods is 0.36-1.24 µg Pb/kg b.w./day for the general population in Europe (with an average body weight of 60 kg) and 0.73-2.43 µg Pb/kg b.w./day for high consumers. In the case of specific diets, such as game meat consumers, daily intake can reach 1.98-2.44 µg Pb/kg b.w./day, which amounts to a considerable increase compared to the base rate. The EFSA (2010) estimates that a daily consumption of 28 g of game meat would provide 1.47 µg Pb/kg b.w./day. **According to our data, in Spain due to game meat consumption there has been an increase of 0.8-1.12 µg Pb/kg b.w./day. This figure is practically identical to that of Europe in general.**

Until very recently, the accepted PTWI for Pb (WHO, 2000) was 25 µg Pb/kg b.w./week, which results in a daily intake of 3.6 µg Pb/kg b.w./day. In accordance with this criteria and considering the average European dietary intake (EFSA, 2010) of 0.36-1.24 µg Pb/kg b.w./day, given the amount of game meat consumed, **in Spain dietary intake could vary between 1.16 µg Pb/kg b.w./day (32.2% of the PTWI) and 2.36 µg Pb/kg b.w./day (65.5% of the PTWI)**. For high consumers it could reach 3.56 µg Pb/kg b.w./day (98.9% of the PTWI). However, such an approximation is no longer considered valid nowadays. In 2010, the EFSA's Panel on Contaminants in the Food Chain (CONTAM) evaluated the risk of Pb exposure and identified neurotoxicity in child development, cardiovascular effects and nephrotoxicity in adults as critical effects (EFSA, 2010). Likewise, it concluded that the current PTWI of 25 µg Pb/kg b.w./week (3.6 µg Pb/kg b.w./day) was no longer adequate. The reason for this was that there was no evidence to support the existence of a threshold for the critical effects caused by Pb. The CONTAM Panel established that a more accurate approximation for risk assessment in the case of Pb was to use the Margin of Exposure (MOE). The best way of obtaining information on human exposure to Pb and its toxic effects is to measure Pb content in the blood. Therefore, the benchmark dose was calculated from the Pb concentrations in the blood (µg/l) found in dose-response tests on chronic effects in humans with the lowest confidence limit (BMDL) as a point of reference for critical effect characterisation. Daily Pb intake values were then calculated (µg Pb/kg b.w./day) in terms of neurotoxicity in development (children between 1-3 years) $BMDL_{01}$, 12 µg/l (0.5 µg Pb/kg b.w./day); cardiovascular effects (increased systolic pressure) in adults $BMDL_{01}$, 36 µg/l (1.5 µg Pb/kg b.w./day); chronic kidney effects (reduced glomerular filtration and an increase in serum creatinine) $BDML_{10}$, 15 µg/l (0.63 µg Pb/kg b.w./day).

$BMDL_{01}$ is defined as "the lower limit of a one-sided 95% confidence interval of the daily dose (BMD; µg Pb/kg b.w./day) which produces a 1% increase in the controls being affected in a certain way, coming from a mathematic model of the experimental data". In the case of $BMDL_{10}$ the increase stands at 10%.

The MOE is calculated by dividing the BMDL for each considered effect, which has been converted into an intake value, between the respective estimated daily intake (1.16-2.36 µg Pb/kg b.w./day, according to our calculations) (Table 8).

Table 8. "Margin of Exposure" (MOE) estimations for game meat consumers (adults weighing 60 kg)

	Spain Present assessment [a]		**EFSA (2010) Average Consumer** [b]	
Estimated daily intake µg Pb/kg b.w./day	**1.16**	**2.36**	**1.98**	**2.44**
$BMDL_{01}$ µg Pb/kg b.w./day Cardiovascular effects	1.5	1.5	1.5	1.5
MOE Cardiovascular effects	**1.29**	**0.63**	**0.76**	**0.61**
$BMDL_{10}$ µg Pb/kg b.w./day Kidney effects	0.63	0.63	0.63	0.63
MOE Kidney effects	**0.54**	**0.27**	**0.32**	**0.26**

[a]Consumption of 50 g/day and [Pb]=0.323, 1.316 and 2.55 mg/kg for deer, wild boar and partridge respectively.
[b]Consumption of 28 g/day and [Pb]=3.15 mg/kg.

As shown in Table 8, the values obtained for the MOE are very similar to those calculated by EFSA 2010) for game meat consumers amongst the population of Europe.

The CONTAM Panel (EFSA, 2010) concluded that a MOE ≥10 would be enough to avoid any substantial risk of significant toxic effects. Furthermore, even with an MOE ≥1 the risk would be very low, and if the MOE stood at <1 negative effects would not be unlikely in some consumers.

Therefore, bearing in mind the results taken from data available in Spain and based on the assumptions that were made previously, there is indeed the possibility of risk to those consumers who have a diet rich in game meat, especially those who fall under the category of high consumers. More specifically, risk involves kidney effects.

Uncertainties

Upon evaluating the situation in Spain with regard to Pb in game meat and the possible management measures, the following uncertainties have been detected:

1. Sample representativeness. As European legislation does not establish any maximum limit for game meat, there is no concrete data on its Pb content. The PNIR includes game meat but only deals with the number of non-compliances. This report therefore has had to take into consideration the data published by authors in scientific journals. But, it must not be forgotten that the available data only corresponds to samples of deer, wild boar and partridge. Obviously, game meat in Spain encompasses others species such as rabbit, hare, quail, etc. whose Pb content is unknown yet could still be consumed in great quantities.

2. Consumption. Although the latest food survey carried out by AESAN in Spain (AESAN, 2011) is without a doubt the most comprehensive in terms of the dietary habits of the Spanish population, data for game meat is not very representative. Out of the 3,000 people surveyed, only 12 said that they eat large game meat. There was a section named "partridge/quail" but only 14 participants said they eat this type of small game. Rabbit meat was eaten by 163 participants. However, it is clear that the majority of the game meat consumed by the participants of the survey (partridge, quail, rabbit) comes from farms and not from hunting in the wild. In view of this, game meat consumption data in the ENIDE survey is clearly lacking for the purposes of the requested evaluation. Identical to the case of Pb content, this meant that consumption data had to be drawn from investigatory studies. Although they used a considerable number of participants, they only deal with large game meat consumption and not small game meat, which in Spain could be just as or even more significant amongst the population. Thus for the purposes of the evaluation we have had to make an estimation based on studies from other countries despite that fact that they may not represent the current situation in Spain.

Lead ammunition alternatives

Other materials like copper (which is not as toxic as lead), steel, bismuth and tungsten have began to be used as an alternative.

1. Steel

Steel pellets are 30% lighter and significantly harder than their Pb counterparts. Given that the collision energy of a steel pellet is less than that of a Pb pellet, it has been stated that the number of injured birds instead of killed birds can be increased. Their disadvantages include the fact that steel could be a potential risk to the environment due to their chromium content, which could reach 27% (FERA, 2010).

2. Tungsten

The use of tungsten and its environmental effects on the soil biota and plants has been assessed. When tungsten fragments mix with the earth in quantities exceeding 1%, bacterial components reduce, fungal biomass increases and more worms die *(Eisenia foetida)* (FERA, 2010). However, a recent studied has confirmed that even high bullet densities (with a tungsten content of 96%) pose little risk to the environment. For example, in 2009 the United States Fish & Wildlife approved the use of a tungsten alloy for duck hunting (US Fish & Wildlife Service, 2009).

3. Bismuth

Bismuth is another alternative to Pb but it is weak and a small amount of tin needs to be added to it. In relation to its toxicity, experimental studies were performed on mice in which five pellets were placed in the peritoneal cavity. Traces of bismuth were found after four and nine weeks in the kidney tubules and the nervous system yet they had no adverse effects. Furthermore, another study based on administering bullets (tungsten, bismuth and tin compounds) by mouth to farms ducks showed that the only adverse effect was the erosion of gizzards. Even still, there were no alterations in consumption habits, anomalies for a physiological point of view, weight loss or mortality (FERA, 2010).

4. Copper

Unlike Pb, copper is an essential micronutrient. However, it can be toxic in high quantities. In the case of mammals copper is generally not toxic as we have an efficient homeostatic mechanism. Unlike mammals though, copper can be extremely toxic for the aquatic biota including fish (Flemming and Trevors, 1989).

Regarding its use in ammunition, traces of copper can at times be present in pellets and it is used to cover lead bullets. Regarding copper bullets, Oltrogge (2009) indicates that although they expanded upon impact with the animal to facilitate death, they do not break into fragment. As a result, the risk of contaminating the meat is reduced.

Establishing a maximum limit for game meat

As we have already indicated, game meat in Spain is frequently consumed by hunters and their families not just during hunting season (August-February) as catches can be frozen and eaten throughout the year. In addition, special permits can be issued as a way of controlling rabbit and wild boar populations. This means that the hunting season is often be extended over most of the year (Mateo et al., 2011). Likewise, nowadays it is much more common to see this type of meat on offer in restaurants, supermarkets and butchers. It is also often promoted as a healthy alternative to intensely farmed animals (Taggart et al., 2011).

Various studies (Mateo et al., 2007) (Pain et al., 2010) (Taggart et al., 2011) have shown that there are some discrepancies today as to what constitute safe consumption levels of farm animals (chicken, beef, pork, etc.) and wild game. The lack of any European Union regulation on game meat can imply a potential risk of the toxic effects of Pb for game meat consumers (Taggart et al., 2011). These same authors highlight that little information is known about Pb content in the muscles of hunted game, which means that it is difficult to assess the risk that this type of food involves.

European food safety regulations are based on keeping contaminants (like Pb) "as low as possible" in such a way that foods with unacceptable residue levels cannot be marketed (EU, 1993). Taggart et al. (2011) point out that hunting should no longer be considered a minority activity. They claim that in accordance with the basic food safety principles of the European legislation, Pb content should be considered a priority for policy makers in order to protect the health of citizens, particularly hunters and their family and friends, pregnant women or woman of a child-bearing age and children, regardless of the size of these groups compared to the population in general.

In line with those studies carried out in the United Kingdom, Pain et al. (2010) suggest that game meat should be specifically covered by European regulations.

Despite the fact that establishing specific maximum limits for game meat would be desirable, we believe that it would not solve the problem of potential risk to those who consume it. Firstly, information on Pb content and game meat consumption is lacking. We then must add this to the undeniable fact that there are great differences between Pb content not just between large and small game but also amongst the same animal. The latter is due to the type of ammunition used, the greater or lesser extent of Pb fragmentation and the distance of the meat being consumed to the exact place of impact. Secondly, establishing maximum limits would serve little purpose as official control of such foods would be ineffective given that most of it is eaten directly by hunters and their families. Naturally, this meat does not pass through the normal distribution channels for other foods subject to regulation.

Therefore, more than just establishing specific maximum limits for different types of game meat and its derivative products, we feel that more emphasis should be placed on other aspects that can be implemented more easily. Specific recommendations should be put in place for consumers of this type of meat and the Governing bodies should act in a certain way.

Conclusions and recommendations of the Scientific Committee

Conclusions

1. The large and small wild game catches analysed in Spain show higher average Pb content than the maximum limits established by the EU for meat and offal in general (although this regulation does not specify game meat). This lead content is similar to that found in other countries and in Europe as a whole according to the latest study carried out by EFSA (2010).
2. It is a proven fact that wild game meat is consumed in Spain although it is more frequently eaten by hunters and their families not just during hunting season (August-February) as catches can be frozen and eaten throughout the year. However, we must not forget that game meat and its derivative products appear in the diet of the general population as they are eaten in restaurants (cured sausage or *pâté*).
3. As we can see from the information available on lead content in game meat and the figures concerning its consumption by the general population, the situation in Spain is practically identical to that found by EFSA for the population of Europe as a whole. However, we cannot disregard the fact that those who adults have a diet rich in game meat can experience some negative effects.
4. Regarding managing measures that could be taken for wild game meat, establishing specific limits would not be an adequate solution. Firstly this is due to the great differences in Pb content (even within the same animal), and secondly because official controls for such food would not be effective enough, as most of this meat is consumed directly by the hunters and their families, without going through the usual distribution channels for foods that are subject to regulations.
5. In this Committee's opinion, in light of the situation in Spain, the most appropriate measure regarding the consumption of wild game meat contaminated with Pb as a result of using Pb ammunition would be to reduce the risk of toxic effects. This would be done following specific recommendations for consuming and preparing food for population groups that consume this type of meat, and encouraging the banning of Pb ammunition and/or replacing it with existing alternatives.

Recommendations

Different organisations along with different authors have devised some recommendations regarding the consumption of this type of meat (CDPHE, 2008) (Tsuji et al., 2009) (BfR, 2010) (CDEP, 2011), with which we completely agree.

Furthermore, the Regulation (EC) No 853/2004, which aims to preserve certain hunting traditions while still ensuring that game meat is harmless, recommends that training should be provided for those hunters that supply the market with wild game meat for human consumption. In this respect, it suggests that training should be given in areas, amongst others, such as sources of environmental pollution or other factors that could affect public health when consuming wild game meat.

Below are a series of recommendations that, in our opinion, are important in protecting the health of wild game meat consumers:

- Children under 6 years of age, pregnant women and women who plan on getting pregnant should avoid eating the meat of game that has been shot with lead ammunition. This is because the lead fragments cannot be removed from the meat completely safely. Also, these population groups are more sensitive to the health effects of lead to such an extent that even small ingested quantities can be harmful. Lead can mainly affect the CNS in terms of the development of small children when it is present in lower concentrations than those that can cause adverse effects.
- In adults, wild game meat consumption should be limited to a maximum of one portion per week (approx. 150 g).
- Campaigns should be promoted that provide wild game meat consumers with relevant information on precautions to consider when preparing and cooking the meat so that lead exposure is reduced.
- When it comes to eating the meat, the area around the place where the ammunition entered the animal should be cut away. This is because the lead fragments can disperse around the visible wound. Damage, discoloured or dirty meat should be removed along with pieces that contain fur, vegetation remains, visible bones or lead fragments. With regard to washing the meat, although it can reduce Pb content in the tissue around the wound, studies have shown that lead can spread from highly contaminated areas to other areas.
- In the case of minced meat, the mincer should be cleaned regularly, preferably before it is used on another animal. This is due to the fact that lead is a soft metal and can be minced along with the meat. Therefore, a whole batch of minced meat would become infected.

Other actions that Governing bodies must take:

- Wherever possible, limiting the use of lead ammunition in favour of other available alternatives should be promoted. The presence of Pb in wild game meat can be eliminated by using lead-free ammunition or reduced by using certain types of ammunition. In general terms, rapid expansion bullets fragment more than controlled expansion bullets. This means that the meat becomes more infected with lead.
- Official control of wild game meat (large and small) should be reinforced as much as possible.
- Adequate information should be obtained to be able to correctly assess the risk to those who consume wild game meat. Comprehensive studies must therefore be carried out to obtain more precise and representative information on lead content in all the types of game meat and its derivative products consumed in Spain. These studies would also serve to complete the information available on this type of consumption not just amongst the general population but amongst those groups considered to be more exposed to higher consumption or especially sensitive to the toxic effects of lead (child and pregnant women).

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