

Occurrence of Foreign Matter in Food: Applied Identification Method - Association of Official Agricultural Chemists (AOAC) and Food and Drug Administration (FDA)

E. C. Mattos, V. S. M. G. Daros, R. Dal Col, A. L. Nascimento

Abstract—The aim of this study is to present the results of a retrospective survey on the foreign matter found in foods analyzed at the Adolfo Lutz Institute, from July 2001 to July 2015. All the analyses were conducted according to the official methods described on Association of Official Agricultural Chemists (AOAC) for the micro analytical procedures and Food and Drug Administration (FDA) for the macro analytical procedures. The results showed flours, cereals and derivatives such as baking and pasta products were the types of food where foreign matters were found more frequently followed by condiments and teas. Fragments of stored grains insects, its larvae, nets, excrement, dead mites and rodent excrement were the most foreign matter found in food. Besides, foreign matters that can cause a physical risk to the consumer's health such as metal, stones, glass, wood were found but rarely. Miscellaneous (shell, sand, dirt and seeds) were also reported. There are a lot of extraneous materials that are considered unavoidable since are something inherent to the product itself, such as insect fragments in grains. In contrast, there are avoidable extraneous materials that are less tolerated because it is preventable with the Good Manufacturing Practice. The conclusion of this work is that although most extraneous materials found in food are considered unavoidable it is necessary to keep the Good Manufacturing Practice throughout the food processing as well as maintaining a constant surveillance of the production process in order to avoid accidents that may lead to occurrence of these extraneous materials in food.

Keywords—Food contamination, extraneous materials, foreign matter, surveillance.

I. INTRODUCTION

THE concept of Food Safety is linked to the reduction of natural hazards associated with the incidents that might occur during the processing phase and are globally recognized.

In order to reduce such occurrences and the impact of attacks to the food system practices denominated Food Defense have been created, they are still under development and are not globally recognized yet.

Mattos EC is scientific researcher at the Microscopy Department of Instituto Adolfo Lutz, Santo Andre, SP, Brazil (phone: 55 11 49901267; e-mail: ecmattos@ial.sp.gov.br).

Daros VMSG is director of Instituto Adolfo Lutz, Santo Andre, SP, Brazil (e-mail: daros@ial.sp.gov.br).

Dal Col R is scientific researcher at the Chemical Department of Instituto Adolfo Lutz, Santo Andre, SP, Brazil (e-mail: dalcol@ial.sp.gov.br).

Nascimento AL is biologist at the Microscopy Department of Instituto Adolfo Lutz, Santo Andre, SP, Brazil (e-mail: alnascimento@ial.sp.gov.br).

The issue of product contamination by foreign substances such as insect's fragments, rigid pointed and sharp objects that can damage the consumer's health is also related to Food Safety.

Extraneous materials are any foreign substances in foods that are associated with objectionable conditions or practices in production, storage, or distribution of foods. Extraneous materials include: (a) filth or objectionable matter contributed by animal contamination (rodent, insect, or bird matter) or unsanitary conditions; (b) decomposed material or decayed tissues due to parasitic or nonparasitic causes; and (c) miscellaneous matter (sand, soil, glass, rust, or other foreign substances). Bacterial contamination is excluded from these substances [1].

Many types of extraneous material may be present in foods. Extraneous material that is associated with food may include bone fragments, hair or feathers from animal products. Stones, rocks and dirt are commonly found in foods that are grown close to the soil like fruits and vegetables. Metal is a common physical hazard that can be introduced anywhere along the food chain from field to consumer, but is most commonly associated with processing activities such as cutting, slicing, or grinding operations. Extraneous material can be introduced by anything that comes in contact with the food (e.g., from the person that handles the food or during transportation or storage). Jewelry and personal items are common physical contaminants that may be present due to poor food handling. Extraneous material which originates from packaging or containers (e.g., glass would be included in this area of concern) [2].

In general, there are three health concerns usually associated with physical hazards (often referred to as extraneous material):

- 1) Physical injury to the lips, inside the mouth, teeth, tongue, throat, esophagus, stomach, colon
- 2) Choking
- 3) Product Tampering

Foreign materials in foods are a real concern to the food processor, not only in terms of the consumer complaints that arise, but as an important factor in the effective implementation of the company's food safety program, particularly the Hazard Analysis Critical Control (HACCP) system [3].

In order to reduce particles contamination in all types of food and to guarantee high output of safety and high quality products it is necessary surveillance and identification of the foreign matter.

The detection methodology to identify and isolate all the variety of contaminants includes general optical microscopy, polarized light microscopy, and electronic microscopy [4].

The aim of this paper is to present the main findings of foreign matters in food analyzed by Public Health Laboratory Adolfo Lutz Institute, Santo Andre, Sao Paulo, Brazil, in order to comply with Healthy Surveillance Department and General Consumers request.

II. MATERIAL AND METHODS

A retroactive data survey was conducted considering the findings of foreign matters in food and beverages for the period of July 2001 to July 2015 by Laboratory.

The procedures were conducted according to the official methods of Association of Official Agricultural Chemists (AOAC) or Food and Drug Administration (FDA) [5], [6].

To improve results interpretation, food products and foreign matter have been divided into groups as described below:

Food: Group 1 – flour and flour-based products, cereal (bakery and pasta); Group 2 - grains; Group 3 – meat products, fish and fish-based products; Group 4 – chocolate and candy; Group 5 – condiments and tea; Group 6 – tomato-based products; Group 7 – coffee; Group 8 – Processed foods; Group 9 – milk and milk-based products; Group 10 – water; Group 11 – beverage; Group 12 – canned products; Group 13 - vegetables; Group 14 – supplements and sugar free products.

Foreign matter: Group A - Live infestations (insects, larvae and mites); Group B - dead insects, insect fragments, feces, webs, dead larvae, dead mites; Group C - rodent hair and excrement; Group D – animal and/or human hair; Group E - fungus; Group F - amorphous substance, carbonized particle; Group G - impurities (shells, sticks, seeds, dirty); Group H - insects considered vectors and their fragments (Blattodea, Diptera) and other animals; Group I - various materials such as metal, plastic, stone, elastic, nylon, glass, wood, cellulose; Group J - green algae; Group K - parasites; Group L - barbules

III. RESULTS AND DISCUSSION

Tables I and II present the main results of the study, which demonstrated that flours, cereals and derivatives such as baking and pasta products were the types of food where foreign matters were found more frequently (28%) followed by condiments and teas (18%). The main types of foreign matters found were fragments of stored grains insects, its larvae, nets, excrement, dead mites and rodent excrement (34%). Foreign matters that can cause a physical risk to the consumer's health such as metal, stones, glass, wood were rare (8%). Findings of extraneous materials such as, shell, sand, dirt and seeds were noticed as well (14%).

Unavoidable extraneous material may occur in food as a by-product of the processing system or as something inherent to the product itself. Items such as stems in blueberries,

microscopic airborne debris, dirt on potatoes, or minute insect fragments in figs are common examples of unavoidable extraneous matter [2].

TABLE I
THE OCCURRENCE OF FOREIGN MATTERS RESULTS BY GROUPS

Group	Condemn Samples Quantity
1 - flour and flour-based products	198
2 - grains	21
3 - meat products, fish and fish-based products	41
4 - chocolate and candy	48
5 - condiments and tea	130
6 - tomato-based products	48
7 - coffee	102
8 - processed foods	13
9 - milk and milk-based products	57
10 - water	39
11 - beverage	16
12 - canned products	3
13 - vegetables	1
14 - supplements and sugar free products	2

TABLE II
FOREIGN MATTERS FINDINGS RESULTS

Group	Condemn Samples Quantity
A - Live infestations (insects, larvae and mites)	46
B - dead insects, insect fragments, feces, webs, dead larvae, dead mites	270
C - rodent hair and excrement	115
D - animal and/or human hair	34
E - fungus	40
F - amorphous substance, carbonized particle	54
G - impurities (shells, sticks, seeds, dirty)	107
H - insects considered vectors and their fragments (Blattodea, Diptera) and other animals	28
I - various materials such as metal, plastic, stone, elastic, nylon, glass, wood, cellulose	64
J - green algae	1
K - parasites	2
L - barbules	7

This work demonstrated that the highest percentage of foreign matter found were those named as unavoidable, especially insects, fragments, webs and stools, as Fig. 1.

Insects can infest grains and seeds such as peanuts, sunflower, wheat, maize, oats and others. The deterioration of seeds mass and beans by insect activity associated with the presence of moisture, enable fungal growth and mycotoxin production [7].

Critical levels for some classes of contaminants have been determined and indicate what levels of foreign matter are considered safe. Stored product pest (SPP) may be source of indirect contamination of stored commodities, by pesticide residues (> MRLs) of chemical treatment by protectants. Direct contamination includes physical, microbial and chemical (toxins, carcinogens and allergens) arthropod contaminants. Parts of arthropod bodies, exuviae and feces are physical contaminants whose safe levels are regulated by Defect Action Levels (DALs) in USA [8].

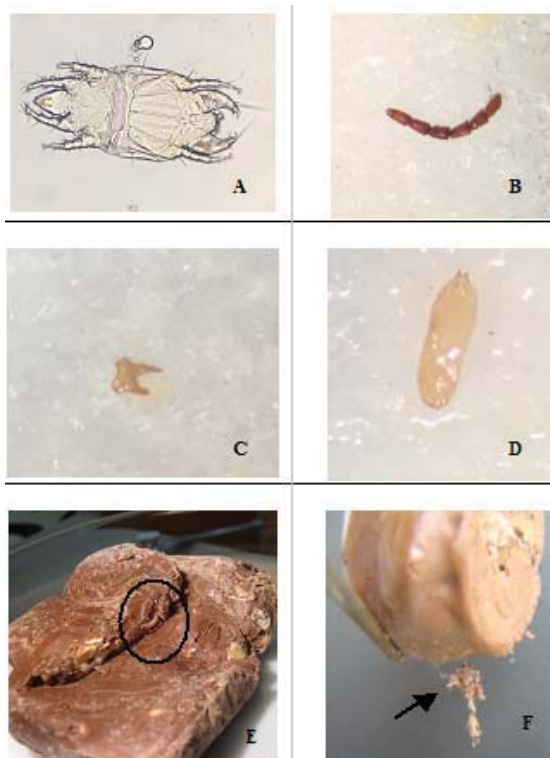


Fig. 1 Unavoidable foreign matters findings: (A) - mites; (B) - fragments and insects' antenna; (C) - fragment terminal of larvae; (D) - insect larvae; (E) - insect live larvae in chocolate; (F) - webs and excrement of insects in chocolate candy

In the case of contamination by foreign materials derived from the wheat grains, particularly, milling industries are equipped to minimize this contamination, as prior to grinding the grains undergo a rigorous cleaning process. However, when the grains have internal infestation adult insects and / or their immature forms, and it is not possible to eliminate this type of infestation they will be milled along with the grain, therefore, flour from these grains is contaminated with insect fragments [9].

The evidence of contamination of processed food for insects is usually due to the presence of small fragments of the exoskeleton, but whole adult insects and larvae may appear; findings of other contaminants such as dust mites and rodents' hair may also appear [9].

Some species of *Acarina*, *Blattodea*, *Coleoptera*, *Lepidoptera*, and *Psocoptera* may cause allergic reactions in humans exposed to remnants of their bodies. No critical levels are available for contamination of food agro-commodities by allergens of arthropods [8]. Thus, the presence of insects in stored grains cannot be ignored and must be controlled, always keeping best practices of manufacturing and storage.

Among the foreign matter considered inevitable, it is worth to mention the presence of rodent's hair as the presence of this kind of filthy demonstrate the rodent contact with the food, which are considered vectors of important diseases pathogens such as salmonellosis, leptospirosis, murine typhoid and, more

recently, mice (*Peromyscus maniculatus*) have been associated to a pulmonary syndrome produced by hantavirus.

The 10 years' period research carried out by [10] demonstrated that 2.5% of the samples presented rodent's hair, which is below the (15%) found in the present study.

Other paper reported high occurrence of foreign matter findings in food as [11] where samples of guava, strawberry and grape jams were analyzed to determine the presence of filth and mold filaments and 80% of the samples presented at least one extraneous material. The extraneous materials found were mold filaments, insect fragments, mites, non-edible plant parts (leaves and stems), maggots, a whole insect, a nylon thread, a piece of plastic material, and a metallic particle.

Similar to [11], [12] conducted research with 30 samples of fresh minas-type cheese from 10 commercial brands, all registered in the Brazilian Food Sanitary Inspection, and reveal that 100% of the samples presented foreign matter and filth, including, in greater amounts, burnt matter (32.4%) and synthetic (5.5%) and vegetable (2.6%) material fragments and, in smaller amounts, sand grains, macroscopic fragment of synthetic origin and human hair.

Reference [13] analyzed macroscopically and microscopically, from January 2001 to June 2007, 80 food samples and the results revealed that 27.5% had insects, their stages of development, fragments and secretions; 25.0% fungi and yeast; 8.7% carbonized material or caramelized substance; 5.0% rodents (hair and excrements); 3.7% parasites (nematodes); 3.7% sensory changes; 2.5% pig hair; 2.5% presence of lizard; 1.3% unidentified fatty substance; 1.3% non-edible plant; 1.3% bovine hair and tick; 1,3% human hair.

It is important to mention that foreign matter causes repugnance even when it is not associated with health hazard, it also displays quality deviations, and failures in the implementation of GMPs and should those responsible for the contamination implement effective measures of control, monitoring throughout production chain to avoid loss, consumers' rejection, and ensure the attainment of safe food.

Avoidable extraneous material is generally less tolerated than unavoidable because it is preventable. It consists of foreign matter which should not be present if proper GMPs are followed. Avoidable extraneous material may come in many different forms such as small glass fragments, pieces of plastic, chunks of rubber, pieces of jewellery, feather barbules, animal debris or any other unrelated foreign material [2].

Fig. 2 demonstrates avoidable foreign matters findings in a variety of analyzed food. This type of physical contamination is a global issue that the food industry has not been able to eliminate completely. According to [14], in the UK, physical contamination accounted for 8 percent of all food incidents, or 118 cases, in 2013. In Australia and New Zealand, 120 food recalls were issued from 2004 to 2013 due to foreign material contamination. In the U.S., the FDA issued 18 food recalls for foreign material from January 2013 to September 2014. The Canadian Food Inspection Agency tracked 21 total cases of extraneous materials in food to date in 2014, two of which warranted issuing public warnings.

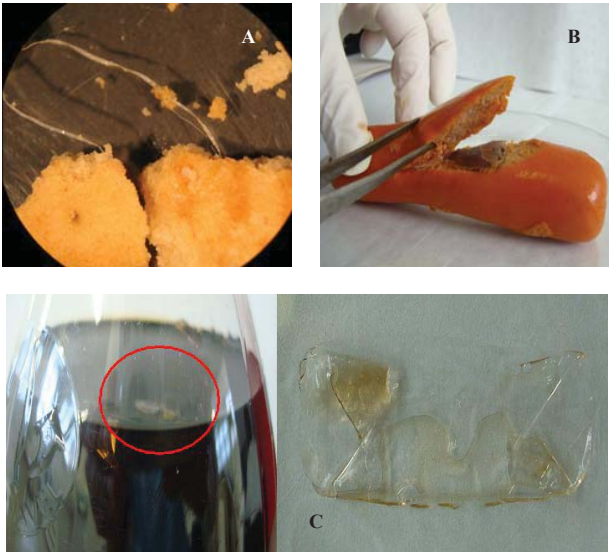


Fig. 2 Avoidable foreign matters findings in food: (A) synthetic fibers in cookies dough; (B) paper in sausage; (C) plastic in soda beverages

According to a passive surveillance system through which FSIS receives consumer complaints on agency-inspected product (i.e., representative of only what consumers or state health departments have called in to report), of 1,309 complaints reported from 2001 to September 2002, 331 were related to foreign materials (25%). About 6% of those cases resulted in injury. The most common materials were identified as metal, glass and plastic [3].

In this study, the incidence of the presence of foreign matter that can place physical risk to consumer health was low (about 8%), however this value is relative to the analyzes performed by a Public Health Laboratory that meets the demand of a population 2.5 million and cannot be compared to the data from Brazil as a whole, which has an estimated population of 190 million inhabitants [15].

It's hard to tell if the foreign matter is a hazard or not. This is demonstrated by the example of physical hazards from foreign objects such as pieces of metal or glass in food. The factors that must be evaluated may include size, ability to pierce, risk groups (e.g. children, elderly), the intended use of the product, probable contamination sources and detection viability and control [16].

Government agencies have determined that characteristics of the foreign material contaminants also are important when assessing how hazardous such inclusions. For example, the U.S. Food and Drug Administration (FDA) has been monitoring injuries resulting from foreign materials since 1972. Over a 25-year period, the agency evaluated 190 cases involving hard or sharp foreign materials in foods. The agency has developed criteria for determining whether a product is adulterated and could cause injury. Only hard or sharp foreign objects that measured 7 mm to 25 mm were determined to be hazardous. Objects less than 7 mm were determined to be too small to cause injury and those greater than 25 mm were so

large that the agency felt that there was little chance of a consumer eating the food. Clearly, other characteristics such as the concentration and number of inclusions also have an impact on whether the physical contaminant is a food safety issue or a consumer perception issue [3]. Furthermore, according to the Consumer Product Safety Commission, spherical objects smaller than 1.75 inches in diameter are considered hazardous for children less than 3 years of age as they may cause damage to the digestive system and suffocation [17].

Following an assessment of health risks conducted by the FDA regarding a survey on the presence of foreign matter in food, objects with size 1-6 mm could pose an imminent but limited danger. The document also states glass was the most frequently found material in food and lesions in the throat and mouth were most frequently reported.

On the presence of bones fragments in food, the Food Safety and Inspection Service (FSIS) concluded that bone particles smaller than 1 cm are considered to be without risk to health, particles of 1 to 2 cm are low risk and particles larger than 2 cm have the potential to be a safety hazard and may cause injury. The presence of foreign matter other than bone may represent a potential hazard and should be considered case by case basis, regardless of their size.

Reference [18], in his publication entitled Regulatory action criteria for filth and other extraneous materials, concluded that any sharp object size equal to or greater than 7 mm would be considered a health hazard.

Brazilian legislation that deals with the presence of macroscopic and microscopic foreign matter in food and beverage considers contrary to the norm foods that presents hard or sharp objects, equal to or greater than 7 mm (measured at the largest size), which can cause consumer injuries, such as bone fragments, metal, wood and hard plastic splinter; rigid objects with diameters equal to or greater than 2 mm (measured from the largest to the smallest dimension), such as stone, metal, teeth, whole or fragmented core, glass fragments of any size or shape and plastic films that may cause damage to consumers' health [19].

The Food Safety and Inspection Service maintains a program of the Consumer Complaint Monitoring System (CCMS) it is a passive surveillance system designed to document and track all consumer complaints that are reported to the Food Safety and Inspection Service.

The health actions concerning food issue in Brazil, as well as allegations of irregularities in products and facilities are decentralized, thus the supervision of facilities and products is attributions of the municipal health authorities, district and state.

The presence of foreign matters in food represents a disregard the legislation that guarantee consumer's protection which can generate litigation [20].

There is even a growing interest in forensic investigation of electronic microscopy, which allows identification of the presence of foreign material and forensic entomology, where the insect development stage can provide important data for investigations [20].

IV. CONCLUSION

Microscopic analysis provides an important tool for evaluating conditions and inadequate practices during the stages of production, storage and distribution of food.

The research led to the conclusion that although foreign matters found in greater amounts are considered unavoidable it is necessary to maintain a strict quality control throughout the food processing, as well as constant surveillance to prevent the occurrences of filth that might pose a risk to the population health.

REFERENCES

- [1] S.S. Nielsen, "Examination of Foods for Extraneous Materials", *Food Analysis Laboratory Manual - Food Science Texts Series*, 2010, pp. 137-143.
- [2] Canadian Food Inspection Agency. Physical Hazard, 2013. Available at <http://active.inspection.gc.ca/rdhi-bdrid/english/rdhi-bdrid/introe.aspx?i=8>
- [3] R.F. Stier. "The Dirty Dozen: Ways to Reduce the 12 Biggest Foreign Materials Problems", *Food Safety Magazine*, Jun/Jul 2003.
- [4] J.T. Stasny, F.R. Albright, R. Graham, "Identification of foreign matter in foods", *Scan Electron Microsc.*, Pt 3, pp. 599-610, 1981.
- [5] Association of Official Analytical Chemists (AOAC), "Official methods of analysis of AOAC", 2010.
- [6] Food and Drug Administration – FDA, *Technical Bulletin Number 5, Macroanalytical Procedures Manual*. Washington DC: Center for Food Safety and Applied Nutrition, 1984, ch V.
- [7] S. Aquino, M.R. Potenza, "Análise da micobiota associada à entomofauna em rações a granel para animais domésticos", *Arq. Inst. Biol.*, vol.80, no.2, pp.243-247, Apr/Jun 2013.
- [8] V. Stejskal, J. Hubert, "Arthropods as sources of contaminants of stored products: an overview", *9th International Working Conference on Stored Product Protection*, 2006. Available at <http://spiru.cgahr.ksu.edu/proj/iwcsspp/pdf2/9/kps92.pdf>
- [9] C.H.B. Vargas, A.A. Almeida, "Identificação dos insetos infestantes de alimentos através da micromorfologia de seus fragmentos", *Revta bras. Zool.*, vol. 13, no.3, pp. 737 -746, 1996.
- [10] É.R.A. da Silva, M.H. Martini, "The presence of rodent hair in food: a risk of human health", *9th International Working Conference on Stored Product Protection*, 2006. Available at <http://spiru.cgahr.ksu.edu/proj/iwcsspp/pdf2/9/6216.pdf>
- [11] T.B. Morais, A.C.B. Diegues, D.M. Sigulem, "The use of light microscopy in a study of extraneous matter and authenticity of guava, strawberry and grape jams", *Food Control*, vol. 15, no. 6, pp. 497-499, 2004.
- [12] T.B. de Souza, A.G. da Cruz, M.R. L. Moura, A.C. M. Vieira, A.S. Sant'Ana, "Microscopic quality indicators of Minas Frescal cheese", *Food Control*, vol. 19, no. 1, pp. 71-75, 2008.
- [13] V.S. Lirio, I.S. Mantesso, C.S.C. Dias, R.J. Carneiro, J.A. Mazzocatto, J.C. Melão, M.I. Augusto, M.A.B. Nojosa, E.P. Cruz, M.A.M. Ferreira, "Avaliação microscópica de alimentos comercializados na cidade de São Paulo", *XXI - RAIB - Reunião Anual do Instituto Biológico*, Instituto Biológico, São Paulo: Secretaria de Agricultura e Abastecimento, vol. 70, pp. 107-216, 2008.
- [14] J. Mason, "Foreign Material Contamination in Food", *NSF International Supply Chain Assurance Division*, 2015. Available in http://www.aig.com/Jan-2015-NSF-Article_3171_659050.html
- [15] Instituto Brasileiro de Geografia e Estatística - IBGE, 2010. Available at <http://www.ibge.gov.br/home/estatistica/populacao/censo2010/default.sh>
- [16] Codex Alimentarius, "Discussion Paper on proposed draft guidelines for evaluating objectionable matter in food", *JOINT FAO/WHO Food Standards 52 Programme*, Codex Committee on Food Hygiene, 34th Session, Bangkok, Thailand, 8- 13 October, 2001.
- [17] D.P. Goldman, "The Physical Hazards of Foreign Materials", *Food Safety and Inspection Service - FSIS*, 2002. Available at <http://www.fsis.usda.gov/OPPDE/rdad/FRPubs/02033N/ThePhysicalHazardsofForeignMaterials.pdf>. Access in 28 Aug 2015.
- [18] A.R. Olsen, S.A. Knight, G.C. Ziobro, "Macroanalytical Procedures Manual", revised edition, FDA Tech. Bull. No. 5., U.S. Food and Drug Administration, Washington, DC, 1998.
- [19] Brasil. Agência Nacional de Vigilância Sanitária - ANVISA. Resolução RDC nº 14 de 28 de março de 2014. Dispõe sobre matérias estranhas macroscópicas e microscópicas em alimentos e bebidas, seus limites de tolerância e dá outras providências. Diário Oficial (da) República Federativa do Brasil. Brasília, DF, nº 61, Seção 1, pp. 58, mar 2014.
- [20] P.M.L. Germano, A.B. Boanova, M.I.S. Germano, "Consumers' right: larva in a bombom results in reparation due to moral injuries", *Revista de Direito Sanitário*, v. 10, no. 2, pp. 166-182, Jul/Oct, 2009.