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Study of the Main Types of Beverages Adulteration Seized in the City of Recife – Brazil

Estudo dos Principais Tipos de Adulterações em Bebidas Apreendidas na Cidade do Recife – Brasil

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Abstract. In this paper we analyzed expertise reports between 2010 and 2014 of forensic analyses used to discover beverages adulteration in the city of Recife. This research was performed by consulting reports copies at general file sector performed of the Institute of Criminalistics Prof. Armando Samico (ICPAS). It was made Principal Component Analysis (PCA) of adulteration types of Recife Political-Administrative Regions (PAR), to establish the most common incidence of adulteration by city areas. It was found a total of 295 analyzes in beverages. Among these, 71% were in alcoholic beverages, 18% in non-alcoholic beverages and 11% in bottled water. Regarding the adulteration patterns, 41% corresponded to the presence of foreign bodies, 27% showed fungal presence, 17% were being sold outdated, 6% had organoleptic changes, 5% were white expertise and 4% of the products did not correspond to that shown on the label. Through the PCA, it was found that in the Southwest region of Recife occurred more cases of presence of foreign bodies and non-corresponding products, while in the South region occurred more fungal presence and organoleptic change. Although the Center, North, West and Northwest regions do not have a statistically significant type of adulteration, consumption of adulterated beverages may cause risks to consumer health from ingesting toxic substances due to either degradation or presence of microorganisms and foreign bodies.

Keywords: Beverage adulteration; Forensic toxicology; Public health.

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Resumo. Neste trabalho foram analisados laudos periciais entre 2010-2014 de análises forenses utilizadas para descobrir adulterações em bebidas na cidade do Recife. Esta pesquisa foi realizada consultando as cópias dos laudos no setor de arquivo geral do Instituto de Criminalística Prof. Armando Samico (ICPAS). Foi feita Análise de Componentes Principais (ACP) dos tipos de adulteração pelas Regiões Político-Administrativa (RPA) do Recife, para estabelecer a incidência das adulterações mais comuns por áreas da cidade. Foi encontrado um total de 295 análises em bebidas. Destas 71% foram em bebidas alcoólicas, 18% em bebidas não alcoólicas e 11% em água engarrafada. Em relação às adulterações 41% corresponderam a presença dos corpos estranhos, 27% apresentaram presença de fungos, 17% estavam sendo vendidos fora do prazo de validade, 6% tinham alteração sensorial, 5% foram perícias inconclusivas e 4% o produto não correspondia ao que mostrado no rótulo. Através da ACP foi constatado que na região Sudoeste do Recife ocorreram mais casos de presença corpos estranhos e produtos não correspondentes, na região Sul ocorreu mais presença fungos e alterações sensoriais. Embora as regiões Centro, Norte, Oeste e Noroeste não possuíam algum tipo de adulteração estatisticamente significantes. Consumo de bebidas adulteradas pode causar riscos para a saúde dos consumidores por ingestão de substâncias tóxicas devido à degradação ou presença de microrganismos ou a presença de corpos estranhos.

Palavras-chave: Contaminação de alimentos; Toxicologia Forense; Saúde Pública.

1. Introduction

Quality of food and beverages has become a worldwide problem that is increasingly important to detect the arrival of adulterated or lower quality products on market[1]. Food authenticity involves most of food products, in particular beverages[2]. To sell beverages, there are parameters that must be performed according to specific legislation, such as identification, quality, hygiene, production, and specifications regarding product composition, packaging and labeling[3].

Development of different techniques to establish the authenticity of foods and beverages has significantly enhanced with increasing consumer awareness. This also becomes companies' interest, which does not wish an unfair competition from unscrupulous companies who earn economic benefits through fraudulent practices observed in industries[3]. Definitive and effective authentication of food products require the use of highly sophisticated analytical techniques as

adulteration perpetrators employ adulteration and forgery methods that are increasingly hard to find[3].

Adulteration consists in modifications either in a part or in the whole product, and may be accidental in the process of production, storage failures or deliberately made. These modifications can cause serious health problems for consumers by emergence of toxic chemicals, production of toxins by microorganisms, or ingestion of foreign bodies[4,5]. Usually adulterations happen by production or storage faults, but there are people who act with a bad intent in an attempt to incriminate companies or businesses as a way to obtain financial benefits[6].

There are many problems reported in the literature on beverages adulteration involving presence of foreign bodies and contamination by microorganisms. Analysis of 77 herbal teas sold for individual use showed that most of mint teas, 62.5%, contained rodent bristle, while 71.4% of chamomile teas had insect fragments[7]. Survey of milk marketed in dairy farms in the South Region of Brazil revealed that 50% of samples of raw milk and 33.3% of pasteurized milk collected samples showed bacterial contamination by total and fecal coliforms, main causes of food toxic infections[8].

Brazilian wines analyzed of a 2003 crop showed Ochratoxin A in concentrations higher than 2.0 µg.L-1 in 7.4% of white wines and in 6.25% of red wines[9]. Usually Ochratoxin A found in grapes are produced by Aspergillus niger and Aspergillus cabonarius[10]. Ochratoxin A is a nephrotoxic, teratogen and mutagenic mycotoxin and may have hepatotoxic effects[11].

In 100 samples of soft drinks that were collected randomly from outlets in the Southeast region of Brazil by Sanitary Surveillance, Zygosacharomyces rouxii, Rhodotorula mucilaginous and Criptococus albidus yeast fungi were found. Presence of Zygosacharomyces rouxii among the yeasts is relevant because it is considered an osmophillic yeast and is often associated with deterioration of processed foods[12].

Beverage adulterations are litigations that can generate a criminal prosecution and punishment if adulteration is proven. There are several techniques used to try to detect if adulteration has occurred and whether it was by accident or not. The forensic police is the competent state institution to carry out criminal skills through forensic experts[13] .

Given the importance of the topic, this study determined the main adulteration patterns found in beverages seized by the Forensic police in the city of Recife and established what are the possible health issues that may occur due to the consumption of this type of product related to the kind of adulteration.

2. Methods

2.1.Background

It was analyzed all reports copies of beverages seized in the city of Recife between the years 2010 and 2014 by the Forensic police. Analyses were performed at general file sector of Institute of Criminalistics Prof. Armando Samico (ICPAS) by authorization of the head of criminalistics laboratory unit with the approval of ICPAS manager. Analyzes of alcoholic and non-alcoholic beverages were included. The parameters evaluated were: label, violation of the cover, volume of liquid, color, odor, presence of foreign bodies, °Brix (for sugary drinks), carbon dioxide (CO2) content (for carbonated drinks) and expiration date.

2.2.Analyses

It was identified in report copies analyzed which techniques were used to determine the type of beverage adulteration. These techniques are briefly described below.

Torque test consists in evaluating clamping force used in screw cover. This test is used to determine whether bottles with screw caps were opened and closed subsequently probably to insert a foreign object or to modify the content of the product. The test is performed using a torquemeter Medtec Model TTG15[14].

Pass/not-pass test consists in passing metal cover of container lid in two holes. So-called “pass” hole the cover must pass because it has the exact diameter of the cap. In called “not-pass” hole the cover should not pass because it has a smaller diameter than the cover. If the cover does not pass the “pass” hole it is an indicative of violation, because it was opened and dilated. If the cover passes through the “not-pass” hole it is also an indicative of violation because it has been opened and replaced, being compressed beyond the value set at factory[14].

The UV lamp test involves exposing the seal on the cover of beverage to a UV lamp (SP Labor Model 97620-08) with wavelength 254 nm, observing the

luminescence of the words “Indústria Brasileira”. This test is used to check if the drink is original or fake[14].

The CO2 content test was accomplished with an equipment called aerometer (Zahm & Nagel Series 6000) which evaluated CO2 concentration in carbonated beverages such as beer, sparkling wines, soft drinks and carbonated water. The equipment has a needle which pierces the container lid where CO2 escapes and the pressure is measured by a pressure gauge. The equipment also has a thermometer, because the solubility of gases is proportional to temperature. Pressure and temperature obtained was compared and correlated in a frame obtaining CO2 dissolved in the liquid. The test was used in conjunction with the torque and pass/not-pass tests. If the bottle has been opened, the concentration of CO2 must be less than that described by the manufacturer. This is usually associated with inclusion of foreign bodies, modified content and proliferation of microorganisms because it leads to a pH increase[14].

The °Brix test is performed to measure total soluble solids content. To perform this test, it was used an IMPAC refractometer (model IPB62T 46 to 82% Brix). Variations in total soluble solids amount may indicate a different composition from that informed in the label, this can be related to outdated product or modified composition[14].

Organoleptic analysis consists of visual and olfactory assessment. Visual assessment seeks to observe presence of a foreign object or dirt. Olfactory assessment seeks to perceive whether the smell of the drink is its characteristic smell or if it has some adulterated odor as acid, metallic, sour or rot. These analyses are indicative of bad maintenance, storage or fraud[14].

2.3.Statistics

Data of adulteration were crossed with the location where the complaint occurred through principal component analysis (PCA) to establish incidence areas where they are the most common specific adulteration patterns. PCA is a mathematical procedure which uses orthogonal transformation to convert a set of observations of variables possibly correlated to a set of variables linearly uncorrelated called principal components. The number of principal components is less than or equal to the number of original variables. The main components are guaranteed to be independent only if the data are normally distributed (jointly). This analysis is used

as a tool for exploratory data analysis and for making predictive models. The PCA can be obtained by eigenvalue decomposition of a covariance matrix (or correlation) or by singular value decomposition of a data matrix, usually after centering (and normalizing or use Z-scores) a data matrix for each attribute. The PCA results are generally discussed in terms of score components also called factor scores (the processed variable values correspond to a particular data point). PCA is the simplest of the true eigenvector by multivariate analysis. Often, its operation can be taken as an indicative of the internal structure of the data in a way that best explains the variance in the data[15].

The PCA is used to promote a linear transformation on the data so that the resulting data from this processing have its relevant components in the first dimensions, in so-called principal axis. The transformation matrix used to calculate the PCA consists of a matrix whose columns are eigenvectors of the data estimated covariance matrix. The eigenvectors of this matrix in fact form a new base that follows the data variation. The PCA, therefore, consists in a basis change. One of the eigenvectors properties is that they are perpendicular (orthogonal) to each other. This property is important because it makes it possible to express the data in two dimensions, instead of multiple dimensions.

The city of Recife has six Political-Administrative Regions (PAR), which correspond to regional offices, where are installed decentralized administrative units of different organs of the Recife City Hall. These PAR were used to be correlated to adulteration patterns. It was also examined whether the type of adulteration may cause any health problem to consumers, aiming to raise awareness about the risks of consuming adulterated drinks.

Data were entered into spreadsheets (Microsoft Excel®) for comparison of seizures by year and adulteration pattern found. Data were also inserted into StatSoft Statistica 10® program to perform PCA and to correlate PAR of Recife to the type of adulteration.

3. Results

During the period from 2010 to 2014, it was carried out 295 expertises on beverages. Among the beverages that were analyzed, 71% were non-alcoholic, 18% were alcoholic and 11% were bottled water. For non-alcoholic beverages analyzed, 47% were soft drinks, 33% included milk and dairy products, 19% were

juices and 1% was classified as others (energy drinks, sports drinks, etc.). Among the alcoholic beverages analyzed, 84% were beers, 10% were whiskies and 6% were vodkas. Regarding adulteration patterns, 41% corresponded to presence of foreign bodies, 27% showed fungal presence, 17% were being sold outdated, 6% had some type of sensory change, 5% were inconclusive expertise (refers to the situation where it was not possible to find the adulteration element) and 4% had a product inside the container not corresponding to that presented on the label.

Applying PCA, it was correlated six PAR of the city of Recife with the adulteration patterns, and a scatter plot was established (Figures 1a and 1b). The map of the city was made for a better visualization of the PAR correlation with the adulteration patterns (Figure 1c). The first principal component (PC1) is the variables (adulteration patterns) and the second principal component is the highest variance of the variables. In this analysis it is possible to observe where certain type of adulteration is more common for a region in the city.

Observing PCA scatter plots variables arrangement (adulteration patterns) over the first principal component (PC1) models 42.08% of the variance in the data matrix (Figure 1a). Outdated products are on the left side of the graphic while other adulteration patterns are on the right side of the graphic. This means that other adulteration patterns are more associated to each other than to the outdated products. Another important fact is that the outdated products are below 0.5 and it is not considered statistically significant. Thus, it can be inferred that PC1 models the most common adulteration patterns, sensory changes and fungal presence have the greatest weight on PC1. The second principal component (PC2) models 31.7% of the information, showing a possible link between cases of non-corresponding products with presence of foreign bodies in one group and fungal presence and sensory changes in another group.

As seen in Figure 1b, center, north, west and northwest regions are located in the graphic region which does not have statistically significant type of adulteration. These regions may not be associated with any specific pattern of adulteration. In Figure 1b can still be identified that the southwest region is located in a graphic region where there is a great deal of influence of presence of foreign bodies and non-corresponding products, being the most common adulteration patterns of that PAR. The south region is close to the area of organoleptic changes and fungal presence influence, this shows that it is more common to find

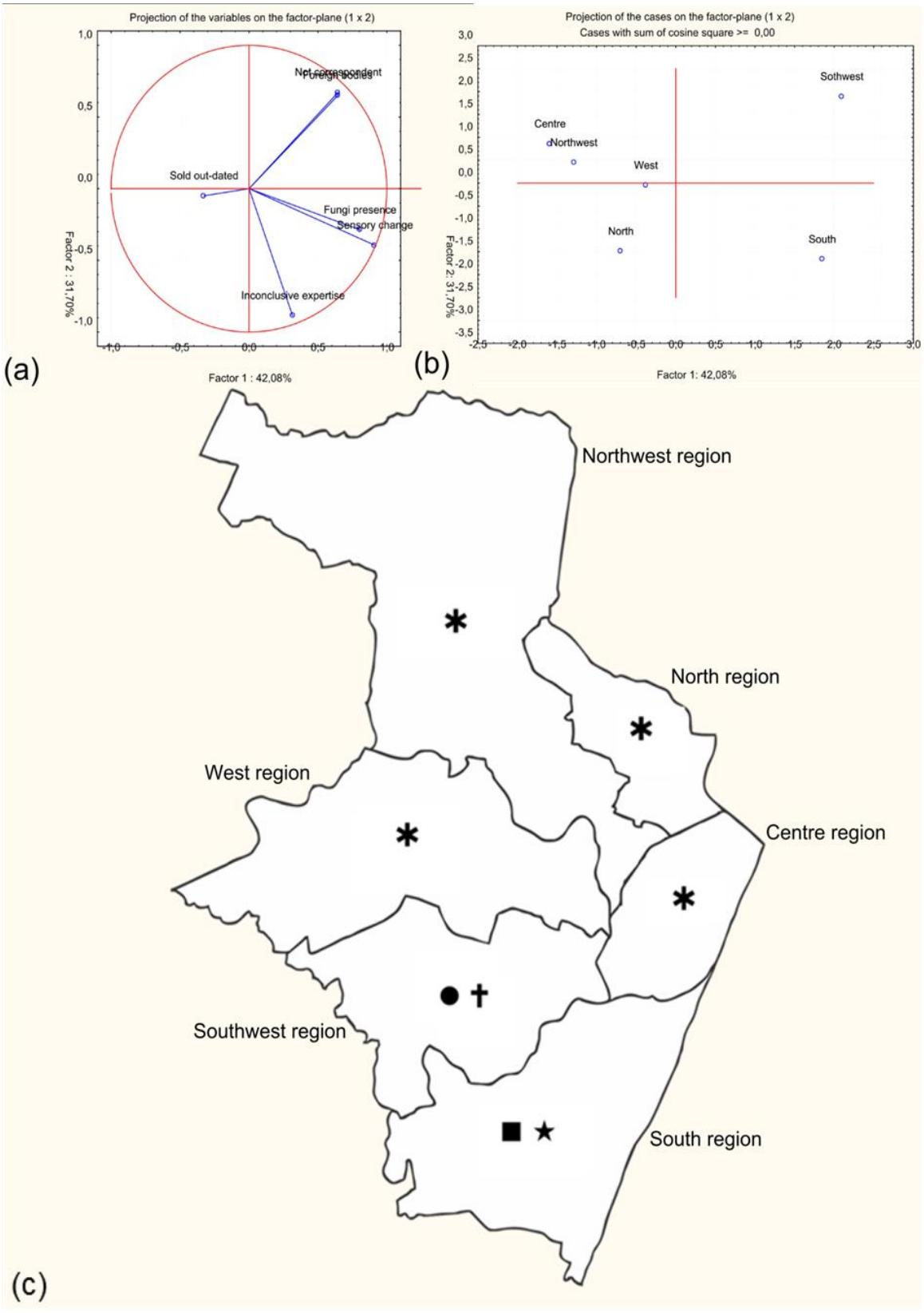

Figure 1. PCA scores plot (a) and loadings plot (b) and a map of the city of Recife (c) of correlated PARs to the adulteration patterns in beverages (● Foreign bodies; ✝ Non-corresponding; ■ Fungal presence; ★ Sensory change; ✱ No statistical association).

these adulteration patterns in that PAR. There was no PAR in the graphic scores under inconclusive adulteration influence, being this kind of adulteration low related to any PAR.

4. Discussion

Most of beverages analyzed are non-alcoholic (71%), in which 47% were soft drinks. As the preference of the Brazilian population is cola-type soft drinks (50.9%)[16], this can justify intentional adulterations. Since cola-type soft drinks have a dark color, it is difficult to visualize the adulteration.

Beer is the most alcoholic beverage analyzed (84%) and also the most consumed by the Brazilian population (61%)[16]. The ease of finding this type of beverage and its widespread use justifies the large amount of expertise in this product.

Beer packaging constitutes an amber glass bottle, and cola-type soft drinks are dark products. In both situations it is easy to add some foreign body like a stone, straw or other plastic material, small animals or parts of them, being a type of adulteration that can be caused by production failures or people acting with a bad intention. Regarding beer, it is also easy to replace the liquid content by other content as water[17]. This is also true for the Tetra Pak® packaging, in which the joints can be detached and subsequently re-glued. This situation can be arbitrarily done as a way of trying to process beverage corporations to obtain financial profits.

Presence of foreign bodies in beverages can cause serious health problems if ingested. Normally, foreign body ingestion occurs more often in children due to the lack of perception. These foreign bodies can cause lung or bronchi infections, emphysema, atelectasis or trigger an asthmatic process[18].

Fungal presence can occur for many reasons such as storage at elevated temperature, packaging flaws allowing entry of air, marketing beyond stipulated validity period, especially in milk and dairy products. According to the literature, the main fungal contaminants in beverages are: Saccharomyces cerevisiae, Hansenula anomala, Kloeckera apiculata, Pichia membranaefaciens, Rhodotorula mucilaginous, Zygosaccharomyces bailli, Candida zeylanoides and Aspergillus sp.12 All these fungi are yeast excepting Aspergillus sp, which has septa hyphae form. A particularity of Aspergillus sp is the ability to produce ochratoxin A.[11]

Fungal presence, independent of its kind, demonstrates that the product does not fit for human consumption according to Brazilian law[19].

Outdated products may have organoleptic changes in their color, odor, flavor and texture, besides favoring proliferation of microorganisms[20]. Usually, when the product does not correspond to that described on the label, it may have been replaced by another one with a bad intention or had production failure and was filled by clean water or any disinfecting product[21].

Southwest region of the city of Recife has intense retail and wholesale trade, where also many distributors circulate. This region is where the Food Supply Center of the state (Ceasa-PE) is located. As purchase and sale of food products in this region is intense, this type of adulteration becomes more common[22], especially for sales in wholesale and also by people acting with a bad intention trying to get a higher profit on sales or trying to get some financial profit.

In the South region there were more problems with fungal presence and organoleptic changes. This region has a large retail with presence of the two largest malls of the city and three hypermarkets and several other food sales establishments such as delicatessens, emporiums and several bars and restaurants. Poor packaging inventory may lead to fungal appearance and organoleptic changes[23], which may be associated to fungal presence.

Despite the multivariate analysis did not explain center, north, west and northwest regions adulteration, these regions have an intense commerce and services. As many establishments sell other products in addition to food products, it ends up not having a care in shelf products replacement, which may lead to this kind of situation.

One of the main problems encountered in the development of this study was the lack of material in the literature on the subject, making difficult a comparison with other locations or adulteration patterns.

5. Conclusion

By analysis of all forensic reports copies of beverages seized in the city of Recife between the years 2010 and 2014 by the Forensic police, it was given eight adulteration patterns of beverages in the city of Recife. Such patterns correspond to presence of foreign bodies and non-corresponding products as indicated on the label, most commonly found in the southwest region of the city, fungal presence

and sensory changes, most commonly found in the south region of the city and outdated products and inconclusive expertises without association with no specific region of the city. North, northwest, west and center regions, showed no correlation with any kind of adulteration in particular.

Factors such as proximity to food distribution centers, presence of many trading posts of food in a given region, type of commerce practiced in a given region may explain the prevalence of each type of adulteration by Recife city PAR. Adulterations can cause serious health problems in the consumer due to the presence of pathogenic microorganisms and toxins, in addition to the consumer acquires a non-corresponding to desired product. Some people act with a bad intention causing adulteration arbitrarily as a way to try to process the Production Company or distributor to obtain financial profit. Expertise is essential to establish the kind of adulteration and if it was intentionally made or happened by accident due to production failure.

References

1. Egito AS, Rosinha GMS, Laguna LE, Miclo L, Girardet JM, Gaillard JL. Método eletroforético rápido para detecção da adulteração do leite caprino com leite bovino. Arq Bras Med Vet Zootec. 2006; 58:932-939. http://dx.doi.org/10.1590/S0102-09352006000500032

2. Fügel R, Carle R, Schieber A. Quality and authenticity control of fruit purées, fruit preparations and jams – a review. Trends Food Sci Tech. 2005; 16:433-441. http://dx.doi.org/10.1016/j.tifs.2005.07.001

3. Reid LM, O'donnell CP, Downey G. Recent technological advances for the determination of food authenticity. Trends Food Sci Tech. 2006; 17:344-353. http://dx.doi.org/10.1016/j.tifs.2006.01.006

4. Juneja VK, Sofos JN (2009) Pathogens and toxins in foods: challenges and interventions. ASM Press, Washington; 2009. 524p.

5. Ikenberry SO, Jue TL, Anderson MA et al. Management of ingested foreign bodies and food impactions. Gastrointest Endosc. 2001; 73:1085-1091. http://dx.doi.org/10.1016/j.gie.2010.11.010

6. Spink J. Safety of Food and Beverages: Risks of Food Adulteration. In: Motarjemi Y, Moy G, Todd E (ed) Encyclopedia of Food Safety, Volume 3: Foods, Materials, Technologies and Risks. Academic Press, East Lansing; 2013. pp 413-416.

7. Sá LV, Dias CSC, Araújo ES, Braga MAS, Neves DVDA, Oliveira VMR, Jonke LAC. Qualidade microscópica de chás: comparação com parâmetros legais. Hig Aliment. 2001; 15:27-32.

8. Silva VAM, Rivas PM, Zanela MB, Pinto AT, Ribeiro MER, Silva FFP, Machado M. Avaliação da qualidade físico-química e microbiológica do leite cru, do leite pasteurizado tipo A e de pontos de contaminação de uma granja leiteira no RS. Acta Sci Vet. 2010; 38:51-57.

9. Vanderlinde R, Pedruzzi I, Dutra SV, Adami L, Marcon AR, Boscato GM, Orlandin A. Ocratoxina A em vinhos e sucos de uva. In: X Congresso Latino-Americanos de Viticultura e Enologia. Annals, Bento Gonçalves-RS; 2015. p 337.

10. Welke JE, Hoeltz M, Noll IB. Aspectos relacionados à presença de fungos toxigênicos em uvas e ocratoxina A em vinhos. Ciênc Rural. 2009; 39:2567-2575. http://dx.doi.org/10.1590/S0103-84782009005000201

11. Khoury A, Atoui A (2010) Ochratoxin A: General Overview and Actual Molecular Status. Toxins. 2010; 2:461-493. http://dx.doi.org/10.3390/toxins2040461

12. Morais VAD, Madeira JEGC, Dias EC, Boncompagni AC, Gonçalves RCP, Carvalho E. Avaliação microbiológica de amostras de refrigerantes comercializados no Estado de Minas Gerais. Rev Inst Adolfo Lutz. 2003; 62:1-4.

13. Espíndula A. Perícia criminal e cível: Um visão geral para peritos e usuários da perícia, 4th edn. Millennium Editora, Campinas; 2013. 512p.

14. Velho JA, Geiser GC, Espindula A. Ciências Forenses: Uma Introdução às Principais Áreas da Criminalística Moderna. Campinas: Editora Millennium, 2012.

15. Hill T, Lewicki P. Statistics: Methods and Applications. Tulsa: StatSoft, 2005.

16. Cervieri-Júnior O, Teixeira-Junior JR, Galinari R, Rawet EL, Silveira CTJ (2015) O setor de bebidas no Brasil. BNDES. https://web.bndes.gov.br/bib/jspui/bitstream/1408/3462/1/BS%2040%20O%20setor%20de%20bebidas%20no%20Brasil_P.pdf. Accessed 26 Jun 2015.

17. Bouckley B. Judge throws out watered-down Budweiser beer fraud claims against Anheuser-Busch. Beveragedaily.com. 2014. http://www.beveragedaily.com/Regulation-Safety/Judge-throws-out-watered-down-Budweiser-beer-fraud-claims. Accessed 26 Jun 2015

18. As AB, Yusof AM, Millar AJW. Food foreign body injuries. Int J Pediatr Otorhi. 2012; 76:20-25. http://dx.doi.org/10.1016/j.ijporl.2012.02.005

19. Brazil. Civil House. Sub-head for legal affairs. Decree nº 6.871, June 4 of 2009. Regulates the Law nº 8.918, July 14 of 1994. OD 06/05/2009. http://www.planalto.gov.br/ccivil_03/_Ato2007-2010/2009/Decreto/D6871.htm. Accessed 26 Jun 2015.

20. Tsiros M, Heilman, CM. The Effect of Expiration Dates and Perceived Risk on Purchasing Behavior in Grocery Store Perishable Categories. J Marketing. 2005; 69:114-129. http://dx.doi.org/10.1509/jmkg.69.2.114.60762

21. McKay C, Scharman EJ. Intentional and Inadvertent Chemical Contamination of Food, Water, and Medication. Emerg Med Clin N Am. 2015; 33:153-177. http://dx.doi.org/10.1016/j.emc.2014.09.011

22. Edwards M. Food hygiene and foreign bodies. In: Lelieveld HLM, Holah J, Napper D (ed) Hygiene in Food Processing – Principles and Practice, 2nd edn. Woodhead Publishing, Cambridge; 2014. pp 441-464. http://dx.doi.org/10.1533/9780857098634.3.441

23. Wani AA, Singh P, Langowski HC. Food Technologies: Packaging. In: Motarjemi Y, Moy G, Todd E (ed) Encyclopedia of Food Safety, Volume 3: Foods, Materials, Technologies and Risks. Academic Press, East Lansing; 2013. pp 211-218.