Quality Assurance and Safety of Crops & Foods, 2019; 11 (7): 623-629
SPECIAL ISSUE*: Scientific trends of global food laws and regulations*

Food additives used in Brazilian meat products: compliance with current national legislation

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Received: 15 August 2018 / Accepted: 19 September 2019

RESEARCH ARTICLE

Abstract

Based on information declared on the label, 192 meat products available on the local market were evaluated in relation to the presence of food additives. A total of 40 substances declared as food additives were found in the present study. Among the additives with a numerical acceptable daily intake (ADI), sodium nitrite, carmines, and pentasodium triphosphate were the most reported. Considering the substances with a not limited or not specified ADI, the most cited additives were sodium erythorbate, monosodium L-glutamate, and sodium lactate. The highest number of food additives per product was found in sausages, salami, Bologna and frankfurters. All food additives declared on the labels were permitted for use in the category of products in which they were found, with few exceptions. Some irregularities were also observed regarding the form of declaration of the additives in the labels. Ensuring that additives are used properly is important to improve the quality and safety of food and to minimise potential risks to human health.

Keywords: labelling, regulation, food safety, sodium nitrite

1. Introduction

According to the Food and Agriculture Organization of the United Nations (FAO), meat can be part of a balanced diet contributing valuable nutrients, such as protein, vitamins, and minerals that are beneficial to health and essential for growth and development. Further processing of meat offers the opportunity to add value, reduce prices, improve food safety and extend the shelf-life (FAO, 2014). It is expected that the world meat production double by 2050, especially in developing countries, which provides a significant opportunity for livestock farmers and meat processors in these countries. Nevertheless, increasing livestock production and the safe processing and marketing of hygienic meat and meat products represent a big challenge (FAO, 2016).

The quality and safety of meat products is a topic that has received much attention during the last few years. Many studies have correlated the high intake of processed red meats with a risk of colorectal cancer, stroke, coronary heart diseases and diabetes. Moreover, the addition of foreign proteins and/or the use of food additives in meat products have raised some concerns. Therefore, meat authenticity and safety are issues of primary importance, considering that the worldwide consumption of these products is increasing and that consumers are more aware and informed, tending to demand safer and healthier products (Arisseto-Bragotto *et al.*, 2017; Iammarino *et al.*, 2017).

Food additives have been used for millennia and have many advantages and benefits, including preservation, improving flavour or appearance, and preventing ingredients from separating (EU, 2017). The safety of food additives has been assessed by international committees, such as the Joint FAO/WHO Expert Committee on Food Additives (JECFA) and the European Food Safety Authority (EFSA), and an acceptable daily intake (ADI) is derived to protect the consumer (Van Loco *et al.*, 2015). These assessments are also the basis of national regulations, which establish the

conditions under which the use of additives is considered to be safe, including permitted food categories and maximum levels of use.

In Brazil, the regulation of additives for food manufacturing is attributed to the Ministry of Health (*Ministério da Saúde*) / National Health Surveillance Agency (*Agência Nacional de Vigilância Sanitária* – ANVISA). A variety of information is required for the regulatory process, including safety considerations, technological needs, the proposed maximum limit of use, and the estimated intake of the additive. The legislation is positive, which means that an additive can only be used when indicated in the specific legislation for the food category, with their functions and maximum limits. Currently, food additives are grouped into 23 functions and all used substances must be declared in the list of ingredients by their functional class followed by their full name or international numbering system (INS) number (ANVISA, 1997, 2002; Arisseto-Bragotto *et al.*, 2017).

When used in accordance with their legal requirements, food additives improve the quality and safety of food. Moreover, ensuring that additives are used properly is important to minimise potential risks to human health (EU, 2017). Therefore, the aims of this work are: (1) to give an overall and current picture of the use of food additives in the Brazilian industry of meat products; (2) to evaluate compliance with national legislation in this area; and (3) to identify priority studies on the most used substances for this category of foods.

2. Materials and methods

Labels of 192 meat products available in the main supermarkets from the city of Campinas, SP, Brazil, were photographed from January to March 2017 and evaluated in relation to the use of food additives based on the information declared by manufacturers. The sampling included all processed meat products found in the commercial establishments visited and comprised imported and locally produced foods. All food additives declared by manufacturers and the number of labels in which the substances were cited were registered. This approach permitted a comparison between different products within the same category and between similar products from different producers. In order to allow an evaluation of compliance with the current national legislation, the products were divided into five categories according to Regulation no. 1004 of December 11th 1998 (ANVISA, 1998).

It was observed whether the additives found in the products were permitted in the respective categories, according to: the Regulation no. 1004 of December 11th 1998 that assigns additive functions, additives and their maximum limits of use for category 8 – meat and meat products (ANVISA, 1998); the Resolution RDC no. 179 of October 17th 2001 that approves the extension of use of sodium tripolyphosphate and sodium carboxymethylcellulose as stabilisers in meat products (ANVISA, 2001); and the Resolution CNS/MS no. 04 of November 24th 1988 that approves the use of silicon dioxide, propylene glycol and polysorbate 80 (Brasil Ministry of Health, 1988). The compliance with the form that the additive is declared on the label was also assessed according to Resolution RDC no. 259 of September 20th 2002 that approves the technical regulation on packaged food labelling (ANVISA, 2002).

3. Results and discussion

A total of 40 substances declared as food additives was found in the evaluated labels. In two products (one dry-cured sausage and one Vienna), the use of haemoglobin natural colour was reported. However, no records of this substance were found in the Regulation no. 1004 (ANVISA, 1998) and in the Codex General Standard for Food Additives (CAC, 2018). Therefore, out of 40 substances declared in the products, 39 can be considered as food additives. According to Figure 1, 20 substances were additives with a numerical ADI (Figure 1A) and 19 were additives with a not limited or not specified ADI (Figure 1B).

Among the additives with a numerical ADI (Figure 1A), the following functional classes were found: colours (INS 120, 150d, 160b, 160c(ii)), preservatives (INS 202, 211, 235, 250, 251, 252), stabilisers (INS 339i, 339ii, 450i, 450iii, 450v, 451i, 451ii, 452i), emulsifiers (INS 433), and humectants (INS 1520). The most used colour, preservative and stabiliser were, respectively, carmines (INS 120; 112 labels), sodium nitrite (INS 250; 156 labels) and pentasodium triphosphate (INS 451i; 81 labels).

Maximum levels of use are set for food additives with a numerical ADI. These substances must be used in accordance with their legal requirements in order to avoid potential risks to health. Some of these compounds may be associated to adverse effects and represent a concern to consumers. Nitrites and nitrates, for example, may lead to the formation of N-nitrosamines, which are considered carcinogenic (IARC, 2010). The intake of phosphates has been associated with an increase on phosphorus consumption, which could cause changes in bone structure (Premaor and Brondani, 2016). As for carmines, the main concern is the possibility of allergic reactions in hypersensitive individuals (Takeo *et al.*, 2018).

Considering the additives with a not limited or not specified ADI (Figure 1B), the following functional classes were found: colours (INS 150a, 162), acids (INS 260, 270, 330, 575), antioxidants (INS 300, 301, 315, 316), acidity regulators (INS 325, 331iii), thickeners (INS 407, 412, 415), anticaking agents (INS 551), and flavour enhancers

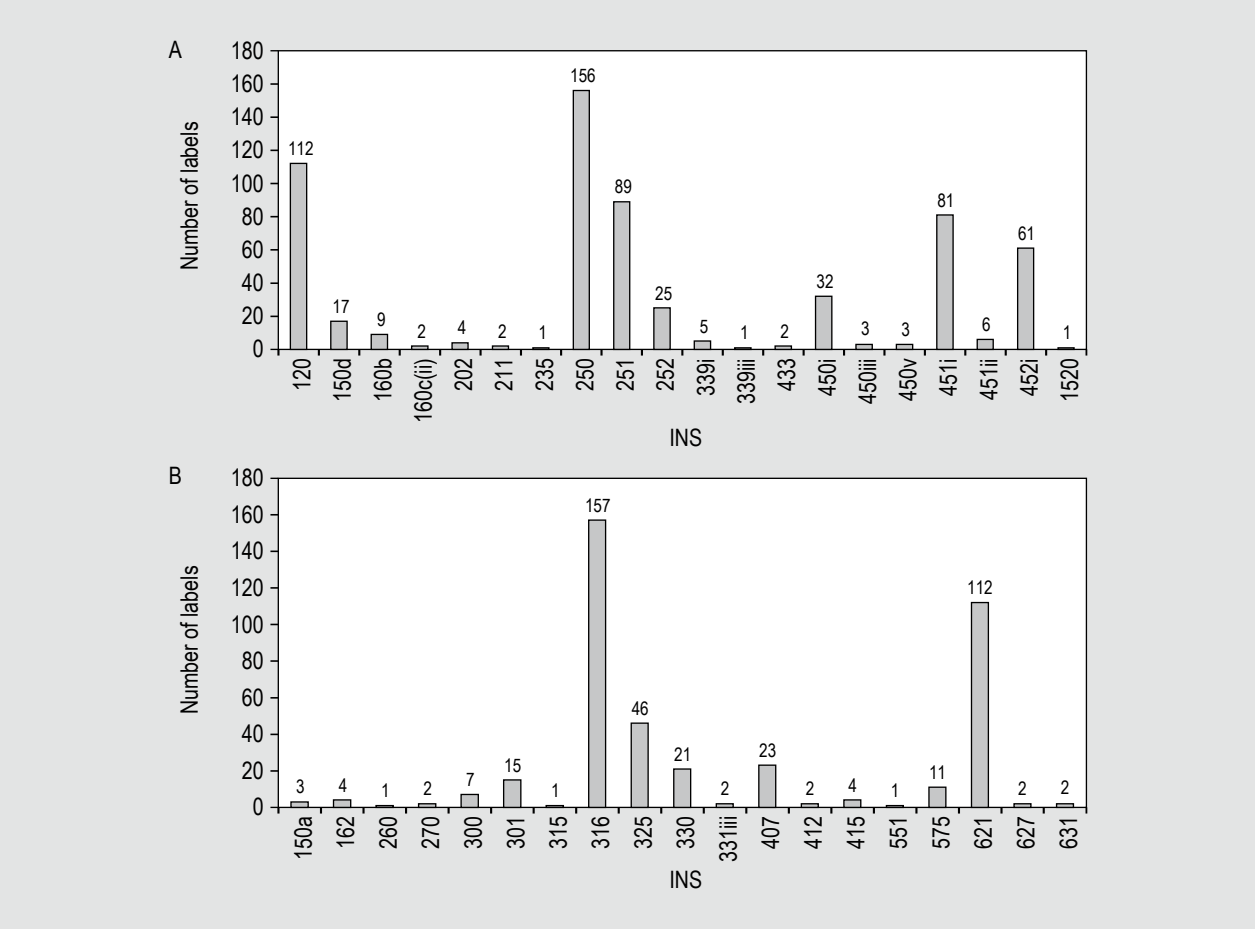

Figure 1. Additives found in the evaluated samples: (A) additives with a numerical acceptable daily intake (ADI); (B) additives with a not limited or not specified ADI.

(INS 621, 627, 631). The most used additives were sodium erythorbate (INS 316, antioxidant; 157 labels), monosodium L-glutamate (INS 621, flavour enhancer; 112 labels), and sodium lactate (INS 325, acidity regulator; 46 labels).

Food additives with a not limited or not specified ADI may be used according to Good Manufacturing Practices (GMP), i.e. as *quantum satis* (amount necessary to achieve the desired technological effect). This means that, on the basis of available data (chemical, biochemical, toxicological and other), the total daily intake of the substance, arising from its use at the levels necessary to achieve the desired effect and from its acceptable background in food, does not represent a hazard to health (IPCS, 2008). In the present study, the only exceptions were observed for thickeners (INS 407 – carrageenan, INS 412 – guar gum, INS 415 – xanthan gum), for which maximum levels are set by Regulation no. 1004 (ANVISA, 1998).

Table 1 reports the 10 most used additives in the category of 'fresh processed meat products'. Sodium erythorbate and sodium polyphosphate were observed in at least one label of each type of product included in this category. The highest number of food additives was found in seasoned meats and sausages and the product with the lowest number of additives was meatball. Sodium lactate, sodium nitrite and sodium nitrate were only used in seasoned meat and sausage, which are usually stored under refrigerated temperatures. Meatball, hamburger, *quibe* and chicken nuggets are generally frozen and some of them are pre-fried.

The most used additives in the category of 'dried, cured and/or aged meat products' are shown in Table 2. The only additives cited in at least one label of each type of product included in this category were sodium nitrite and sodium nitrate. It was observed that some products also contained potassium nitrate. The highest number of food additives was found in salami and pepperoni and the product with the lowest number of additives was jerked beef. It is important to mention that some labels (four of jerked beef and three of dry-cured ham) did not report the use of antioxidants such as sodium erythorbate and sodium ascorbate, which is important to minimise the formation of N-nitrosamines in these products.

Table 1. Number of labels containing the most used additives in fresh processed meat products (n=54).[1]

Function	Additive	INS	Products (total number of labels)					
			Meatball (3)	Hamburger (7)	*Quibe* (3)	Seasoned meat (10)	Sausage (28)	Chicken nuggets (3)
Acidifier	Citric acid	330	–	1	1	3	5	–
Acidity regulator	Sodium lactate	325	–	–	–	4	12	–
Antioxidant	Sodium erythorbate	316	3	2	3	10	28	3
Colour	Carmines	120	–	1	–	1	27	1
	Caramel IV	150d	–	3	–	1	2	–
Flavour enhancer	Monosodium L-glutamate	621	1	4	–	10	19	3
Preservative	Sodium nitrite	250	–	–	–	6	28	–
	Sodium nitrate	251	–	–	–	4	22	–
Stabiliser	Sodium polyphosphate	452i	1	2	1	8	11	2
	Pentasodium triphosphate	451i	1	4	1	2	14	1

[1] Non-cured, non-dried, non-fermented processed meat (comminuted, in whole pieces or cuts), pre-fried or not, frozen or not, in edible casings or not, breaded or not, to be cooked before consumption.

Table 2. Number of labels containing the most used additives in dried, cured and/or aged meat products (n=64).[1]

Function	Additive	INS	Products (total number of labels)							
			Coppa (4)	Bacon (9)	Jerked beef (7)	Sausage (5)	Pork paté (3)	Pepperoni (4)	Dry-cured ham (9)	Salami (23)
Antioxidant	Sodium erythorbate	316	1	9	3	5	3	3	–	19
	Sodium ascorbate	301	2	–	–	–	–	1	6	4
Colour	Carmines	120	–	–	–	3	2	2	–	10
Flavour enhancer	Monosodium L-glutamate	621	1	1	–	3	1	2	–	10
Preservative	Sodium nitrite	250	3	9	7	5	3	4	6	20
	Sodium nitrate	251	2	4	6	1	1	2	1	10
	Potassium nitrate	252	–	–	–	2	–	2	8	11
Stabiliser	Pentasodium triphosphate	451i	–	5	–	4	1	1	–	8
	Disodium diphosphate	450i	–	–	–	1	–	2	–	13
	Potassium polyphosphate	452ii	–	–	–	–	–	1	–	9

[1] Non-heat treated processed meat (comminuted, in whole pieces or cuts), in edible casings or not.

For the category of 'cooked meat products', the most used additives are shown in Table 3. Sodium erythorbate, monosodium L-glutamate, sodium nitrite and sodium polyphosphate were found in at least one label of each type of product included in this category. Bologna and frankfurter showed the highest number of food additives.

Table 4 reports the most used additives in the category of 'salted meat products'. Sodium erythorbate, sodium nitrite and sodium nitrate were observed in at least one label of each type of product included in this category. Pork offals were the products with the lowest number of additives. It has also been observed that three products (two pork cuts and one pork offal) mentioned the use of sodium nitrite but did not report the use of antioxidants.

The most used additives in the category of 'preserves' are shown in Table 5. Sodium erythorbate, monosodium L-glutamate, sodium nitrite, pentasodium triphosphate and sodium polyphosphate were declared in at least one label of each type of product of this category. The highest number of additives was observed in Vienna, and two samples of corned beef mentioned the use of sodium nitrite but did not report the use of antioxidants.

Table 3. Number of labels containing the most used additives in cooked meat products (n=47).[1]

Function	Additive	INS	Products (total number of labels)						
			Apresuntado (3)	Ribs (2)	Sausage (10)	Bologna (11)	Turkey breast (3)	Ham (4)	Frankfurter (14)
Acidity regulator	Sodium lactate	325	–	–	5	4	1	3	9
Antioxidant	Sodium erythorbate	316	3	2	9	9	3	4	14
Colour	Carmines	120	3	–	7	7	3	4	9
Flavour enhancer	Monosodium L-glutamate	621	3	1	9	8	2	4	14
Preservative	Sodium nitrite	250	3	1	10	11	3	4	14
Stabiliser	Sodium nitrate	251	–	1	5	5	1	–	6
	Pentasodium triphosphate	451i	2	–	7	7	1	2	12
	Disodium diphosphate	450i	–	–	4	5	–	–	6
	Sodium polyphosphate	452i	2	1	1	3	2	2	5
Thickener	Carrageenan	407	3	1	–	1	1	2	2

[1] In edible casings or not, smoked or not.

Table 4. Number of labels containing the most used additives in salted meat products (n=12).[1]

Function	Additive	INS	Products (total number of labels)		
			Pork cuts (7)	*Feijoada* meats (2)	Pork offals (3)
Acidity regulator	Sodium lactate	325	1	2	–
Antioxidant	Sodium erythorbate	316	5	2	2
Colour	Carmines	120	1	2	–
	Caramel IV	150d	1	1	–
Flavour enhancer	Monosodium L-glutamate	621	1	2	–
Preservative	Sodium nitrite	250	6	2	3
	Sodium nitrate	251	5	2	3
	Potassium sorbate	202	2	–	–
Stabiliser	Pentasodium triphosphate	451i	3	1	–
	Sodium polyphosphate	452i	–	2	–

[1] Heat-treated or not, to be desalted before consumption.

In relation to the compliance with the national regulation, all food additives declared on the labels were permitted for use in the category of products in which they were found, except haemoglobin natural colour (used as colour in one dry-cured sausage and one Vienna) and silicon dioxide (used as anticaking agent in one chicken nuggets). As already mentioned, no regulation concerning the use of haemoglobin natural colour was found. As for silicon dioxide, Resolution CNS/MS no. 04/1988 (Brasil Ministry of Health, 1988) approves its use in curing salts (associated with potassium or sodium nitrate/nitrite and potassium or sodium ascorbate, used as preservative/colour retention agent), but not as anticaking agent.

Moreover, some irregularities were observed regarding the form of declaration of the additives on the labels, since Resolution RDC no. 259/2002 (ANVISA, 2002) requires that food additives be declared in the list of ingredients by their functional class followed by their full name or INS number. Table 6 shows the irregularities found in relation to the form of declaration of the additives in the labels.

Considering the most reported food additives (sodium nitrite, sodium nitrate, sodium erythorbate, monosodium L-glutamate, carmines, pentasodium triphosphate, sodium polyphosphate, sodium lactate, citric acid, and carrageenan) and current legislation of different countries,

Table 5. Number of labels containing the most used additives in preserves (n=15).[1]

Function	Additive	INS	Products (total number of labels)		
			Corned beef (3)	*Fiambre* (5)	Vienna (7)
Antioxidant	Sodium erythorbate	316	1	5	7
Colour	Carmines	120	–	2	4
Flavour enhancer	Monosodium L-glutamate	621	2	5	4
Preservative	Sodium nitrite	250	3	5	7
Stabiliser	Pentasodium triphosphate	451i	1	3	3
	Sodium polyphosphate	452i	2	2	5
Thickener	Carrageenan	407	3	–	3

[1] Canned products.

Table 6. Irregularities found in relation to the form of declaration of the additives in the labels.

Category	Products	Irregularity
Fresh processed meat products	Sausage	Functional class of monosodium L-glutamate was not declared.
	Sausage	Functional class of monosodium L-glutamate was not declared.
	Chicken nuggets	Functional class of guar gum was not declared.
Dried, cured and/or aged meat products	Jerked beef	No functional classes were declared.
	Pepperoni	Functional class of glucono-delta-lactone was not declared.
	Salami	Wrong INS number of monosodium L-glutamate.
	Salami	Wrong INS number of monosodium L-glutamate.
Cooked meat products	Sausage	Name and INS number of colours were not declared, only the functional class.
	Sausage	Name and INS number of colours not declared, only the functional class.
Salted meat products	*Feijoada* ingredients	Caramel IV was declared as a natural colour.
Preserves	*Fiambre*	Functional class of monosodium L-glutamate and polysorbate 80 were not declared.

it was observed that the main substances used in Brazilian meat products are also permitted in Canada (HC, 2018), European Union (EU, 2008), Japan (JFCRF, 2018) and USA (FDA, 2018). Some differences may arise from the fact that the same substance can be regulated as an additive in a country and as an ingredient in another one. As an example, monosodium L-glutamate is regulated as a food additive in Brazil, but it is considered a flavour enhancing ingredient in Canada.

Other divergences can be observed regarding the maximum limits allowed for the use of additives in different countries. Table 7 shows a comparison of the amounts permitted in different countries for sodium nitrite, the most used

Table 7. Maximum permitted levels of sodium nitrite in meat products (g/100 g).

Country	Maximum levels (g/100 g)	Comments	Reference
Brazil	0.015	Permitted in all meat products categories.	ANVISA (1998)
Canada	0.012-0.020	The lowest level (0.012 g/100 g) is permitted only in bacon.	HC (2018)
European Union	0.005-0.018	Various restrictions/exception described.	EU (2008)
Japan	0.007	Meat products.	JFCRF (2018)
USA	0.020	Alone or with sodium nitrate as a preservative and colour fixative in smoked, cured salmon, shad and sablefish; or in meat curing preparations for home curing of meat and meat products.	FDA (2018)

additive with maximum limits. As can be seen, permitted amounts varied from 0.005 to 0.020 g/100 g. The lowest level is established for some products in the European Union, while the highest ones are set in Canada and USA. In many countries, the maximum levels are above the provisions established by the Codex Alimentarius (0.080 g/100 g) (CAC, 2018).

4. Conclusions

An overall and current picture of the use of food additives in the Brazilian industry of meat products was reported in the present work. A total of 40 substances declared as food additives was found in the evaluated labels of 192 commercialised products. The most reported food additives were sodium nitrite, sodium nitrate, sodium erythorbate, monosodium L-glutamate, carmines, pentasodium triphosphate, sodium polyphosphate, sodium lactate, citric acid, and carrageenan. It could be observed that most of the substances have been used in accordance with the regulations in force. Some irregularities were observed with respect to the form of declaration on the label. Divergences can be observed regarding the maximum limits allowed for the use of additives in different countries, as it was demonstrated for sodium nitrite, which reflects a disharmony between different legislations. It is important to emphasise that no laboratory analysis was performed in the present study to verify the authenticity of the data declared on the labels and the compliance with maximum limits permitted for each additive. However, the study may be useful for future inspection and monitoring actions.

Conflict of interest

The authors declare that there are no conflicts of interest.

References

Agência Nacional de Vigilância Sanitária (ANVISA), 1997. Regulation No. 540 of October 27th 1997 (Portaria No. 540, de 27 de outubro de 1997). Diário Oficial da União, Poder Executivo, Brazil.

Agência Nacional de Vigilância Sanitária (ANVISA), 1998. Regulation No. 1004 of December 11th 1998 (Portaria No. 1004, de 11 de dezembro de 1998). Diário Oficial da União, Poder Executivo, Brazil.

Agência Nacional de Vigilância Sanitária (ANVISA), 2001. Resolution No. 179 of October 17th 2001 (Resolução RDC No. 179, de 17 de outubro de 2001). Diário Oficial da União, Poder Executivo, Brazil.

Agência Nacional de Vigilância Sanitária (ANVISA), 2002. Resolution No. 259 of September 20th 2002 (Resolução RDC No. 259, de 20 de setembro de 2002). Diário Oficial da União, Seção 1, No. 184, pp. 33-34.

Arisseto-Bragotto, A.P., Feltes, M.M.C. and Block, J.M., 2017. Food quality and safety progress in the Brazilian food and beverage industry: chemical hazards. Food Quality and Safety 1(2): 117-129.

Brasil Ministry of Health, 1988. Resolution CNS/MS No. 04 of November 24th 1988 (Resolução CNS/MS No. 04, de 24 de novembro de 1998). Diário Oficial da União, Poder Executivo, Brazil.

Codex Alimentarius Commission (CAC), 2018. General standard for food additives. CODEX STAN 192-1995, Revision 2018. Available at: https://tinyurl.com/y3p48bb7.

European Union (EU), 2008. Regulation (EU) No. 1333/2008 of the European Parliament and of the Council of 16 December 2008 on food additives. Official Journal of the European Union L 354: 16-33.

European Union (EU), 2017. Official control of food additives and smoke flavourings. Overview report. Available at: https://tinyurl.com/y4a782mg.

Food and Agriculture Organization of the United Nations (FAO), 2014. Meat consumption. Animal production and health. Available at: http://www.fao.org/ag/againfo/themes/en/meat/background.html.

Food and Agriculture Organization of the United Nations (FAO), 2016. Meat and meat products. Animal production and health. Available at: http://www.fao.org/ag/againfo/themes/en/meat/home.html.

Food and Drug Administration (FDA), 2018. Food additive status list. Available at: https://www.fda.gov/food/ingredientspackaginglabeling/foodadditivesingredients/ucm091048.htm.

Health Canada (HC), 2018. List of permitted preservatives (lists of permitted food additives). Available at: https://tinyurl.com/yahn4u3c.

Iammarino, M., Marino, R. and Albenzio, M., 2017. How meaty? Detection and quantification of adulterants, foreign proteins and food additives in meat products. International Journal of Food Science and Technology 52: 851-863.

International Agency for Research on Cancer (IARC), 2010. Ingested nitrate and nitrite, and cyanobacterial peptide toxins. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans 94: 1-454.

International Programme on Chemical Safety (IPCS), 2008. Risk characterization. Principles and methods for the risk assessment of chemicals in food. Available at: http://www.who.int/foodsafety/chem/risk_characterization.pdf.

Japan Food Chemical Research Foundation (JFCRF), 2018. Standards for use of food additives. Available at: http://www.ffcr.or.jp/en/upload/StandardsforUseofFoodAdditivesfeb2018_2.pdf.

Premaor, M.O. and Brondani, J.E., 2016. Nutrição e saúde óssea: a importância do cálcio, fósforo, magnésio e proteínas. Revista AMRIGS 60: 253-263.

Takeo, N., Nakamura, M., Nakayama, S., Okamoto, O., Sugimoto, N., Sugiura, S., Sato, N., Harada, S., Yamaguchi, M., Mitsui, N., Kubota, Y., Suzuki, K., Terada, M., Nagai, A., Sowa-Osako, J., Hatano, Y., Akiyama, H., Yagami, A., Fujiwara, S., and Matsunaga, K., 2018. Cochineal dye-induced immediate allergy: review of Japanese cases and proposed new diagnostic chart. Allergology International 67(4): 496-5050. https://doi.org/10.1016/j.alit.2018.02.012

Van Loco, J., Vandevijvere, S., Cimenci, O., Vinkx, C. and Goscinny, S., 2015. Dietary exposure of the Belgian adult population to 70 food additives with numerical ADI. Food Control 54: 86-94.