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Contents of Sodium Nitrite and Sorbat in Commercial Meat Derivatives

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Abstract

Meats are essential for human health, are excellent sources of various proteins and minerals. Use of additives such as nitrite, sodium sorbate helps in microbial control, development of attractive sensory characteristics in meat and meat derivatives. Aim of this work was to quantify levels of nitrite and sodium sorbate in meat products derivatives. Additives were extracted from trademarks of different meat derivatives, analyzed by UV / Vis absorption spectroscopy, quantified using sorbic acid and nitrite calibration curves. Sodium nitrite content ranged from 0.001-0.230 g 100g^{-1}, sodium sorbate ranged from 0.02 to 0.11 g 100 g^{-1}. In both tests' values were found in disagreement with Brazilian legislation for meat products showing importance of reducing consumption of these products due to health hazards associated with these products.

Keywords: *Sodium nitrite; Sodium sorbate; Meat derivatives; Toxicity; Legislation.*

Background

Meats are foods with high protein content, varied nutritional composition, high acceptance among world population (Borges & Santana, 2019). To diversify its products meat industry makes use of various preservation methods such as salting, smoking, use of curing salts, most used being nitrite and sodium sorbate. Sodium nitrite has several functions in meat derivatives such as developing color and flavor in products, destroying proteolytic species such as *Clostridium botulinum*, keeping microbiologically safe products (Zang *et al*., 2018; Nikodinoska *et al*., 2019). Nitrites have additional functions in meat as they help prevent oxidation and lipid rancidity, guarantee a bright red color, a typical flavor of cured products (Sebranek & Bacus, 2007).

Although nitrites are widely used in meat industry, are efficient in their proposed functions, they are classified by International Agency for Cancer Research as potentially carcinogenic agents (IARC, 2010). This is because in acidic environment such as stomach, nitrite binds amines and amides forming nitrosamides, nitrosamines that are carcinogenic, is associated with increased risk of gastric, esophageal, nasopharyngeal, bladder cancer, among others. (Sun, Mi, Lee, Shin, & Sung, 2007; Authority, 2010; Hospital, Hierro, Stringer, & Fernández, 2016; Zang *et al*., 2018; Nikodinoska *et al*., 2019).

Both Brazilian and European legislation authorize addition of sodium nitrite and nitrate in meat derivatives. In Europe, maximum levels of 0.15 g 100 g^{-1} $NaNO_2$ and 0.30 g 100 g^{-1} $NaNO_3$ were accepted (European Commission, 2011). In Brazil, sodium or potassium nitrite, used alone or in combination, maximum allowed limit is 0.15 g 100g^{-1} of cured meat product, except beef jerky, infant food, expressed as nitrite ion (BRAZIL, 1998). These values remain unchanged in Brazil but in Europe were valid until May 2018, when a maximum level of nitrite in fermented salami of 0.10 mg 100 g^{-1} was approved (European Commission, 2018). Acceptable Daily Intake (ADI) for nitrite, established according to Joint Expert Committee on Food and Agriculture (JECFA), is 0-0.06 mg Kg^{-1} body weight, for nitrate is 0 -3.7 mg kg^{-1} body weight. Both should not be consumed by children less than 3 months of age (FAO, 2013; Oliveira, 2015).

Sorbates (sorbic acid, its sodium, potassium and calcium salts) are considered GRAS (Generally Recognized as Safe) additives, are therefore of great importance, are widely used by food, animal feed, cosmetic, pharmaceutical industries (Sofos, 1989). In Brazil, in case of food, sorbic acid, its salts can be used as preservatives, antimicrobials, stabilizers, antioxidants in a wide variety of products (BRASIL, 1998). In general, sorbate is considered an effective conservative. It has effective action against pathogenic, spoilage microorganisms in meat products, especially when used in combination with nitrite (Sofos, 1989). IDA for sorbic acid, its sodium and potassium salts, established according to JECFA, is 0-25

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mg Kg $^{-1}$ body weight (FAO, 2013). Use of sodium, potassium and calcium sorbate in cured meat is permitted under Brazilian law, with a maximum limit of 20 mg 100 g^{-1} meat, for external use only, surface treatment, for use in combination or alone, expressed as sorbic acid (BRAZIL, 1998). Aim of this work was to quantify nitrite and sodium sorbate contents in meat products derivatives.

Materials and Methods

Study site

Physicochemical analyzes of meat products were performed at General Chemistry and Analytical Laboratories of Federal University of Valley of São Francisco, Petrolina, Pernambuco, Brazil. Samples of meat derivatives were purchased in cities of Petrolina-PE and Juazeiro-BA. Petrolina is a municipality in state of Pernambuco, located in São Francisco Valley region, neighboring municipalities of Juazeiro and Sobradinho. Located at 380 meters altitude, latitude 9 ° 23 '39' 'South, longitude 40 ° 30' 35 '' West. Juazeiro is a city in state of Bahia. Neighboring municipalities of Petrolina and Sobradinho, Juazeiro is 5 km south-east of Petrolina. Located at 369 meters altitude, latitude: 9 ° 26 '18' 'South, longitude: 40 ° 30' 19 '' West.

Samples of commercial meat derivatives

Thirty-three types of meat products were purchased (six hamburgers, two loins, four salami, seven hams, eight bologna, four ham, and two turkey breasts) from different brands. Preservation was carried out in a refrigerated environment at 4 °C. Samples were individually ground in a meat grinder at time of analysis.

Determination of sodium nitrite by UV / Vis absorption spectroscopy

Sodium nitrite quantification test was performed in two steps: obtaining meat extracts, quantification by UV / Vis absorption spectroscopy. Extraction was performed based on official methodology described by the Adolfo Lutz Institute. (2005). Triturated and homogenized samples (10 g) were added with 5% (w / v) sodium tetraborate solution (5 mL), distilled water (50 mL). After manual stirring, samples were taken to a water bath (70 °C) with frequent stirring (15 min), cooled to room temperature, added with 5 mL of 15% (w / v) potassium ferrocyanide solutions and acetate solution 30% (w / v) zinc. After stirring, samples were allowed to stand for 30 min and were filtered on filter paper. Extracts were collected in plastic bottles, frozen until moment of use. Nitrite determination was based on diazotation reaction with 0.5% (w / v) sulfanilamide in acidic medium, followed by reaction with alpha-naphthylethylenediamine hydrochloride (NED reagent) 0.5% (w / v). Each extract was prepared in triplicate and its absorbance was read in visible region at 540 nm in a spectrophotometer (Nova Instruments, model 1600UV) (IAL, 2005). To quantify nitrite content in samples, a sodium nitrite calibration curve was constructed in range 0.32 to 2.4 µg mL^{-1} ($y = 0.3296X + 0.0807$, $R^2 = 0.9595$).

Determination of sodium sorbate by absorption spectroscopy UV / Vis

Extractions were performed based on methodology described by Cecchi. (1988). Crushed and homogenized samples (1 g) were added with 30 mL of absolute ethanol, shaken in SK 180-Pro shaker for 30 min. They were then filtered on filter paper, extracts collected in a volumetric flask. Extracts were obtained in triplicate, on day the analyzes were performed, to avoid ethanol evaporation, possible alteration of results. Determination of sorbate is made by UV / Vis absorption spectroscopy, reading at 255 nm. Extracts obtained were diluted (1:10) for identification and quantification. To quantify sorbate content in samples, a sodium sorbate calibration curve was constructed in range of 0.25-3.3 µg mL^{-1} ($y = 0.2955x - 0.0197$, $R^2 = 0.9987$). Absorbances were read on a spectrophotometer (Nova Instruments, model 1600UV). All extracts were analyzed in triplicate.

Statistical analysis

Statistical analysis was performed by One-way ANOVA, using the STATISTICA® 7.0 program, values considered significant with $p> 0.05$. All determinations were performed in triplicate ($N = 3$), data were expressed as average ± standard deviation. Results were compared using Tukey test to identify significant differences between test results, with a significance level of 95% for each parameter evaluated.

Results and Discussion

Results of quantitation of nitrite and sodium sorbate content in meat products are described in Table 1. When analyzing sodium nitrite content levels ranged from 0.001-0.230 g 100g^{-1}, among samples, it is noted that only 19 of 33 samples analyzed were in accordance with Brazilian legislation exceeding maximum allowed values. This data is worrying in view of toxicity of this additive, potential danger of sodium nitrite ingestion to health of population. These data already serve as indicative for population to change eating habits with a reduction in consumption of red meat, its derivatives, aiming at maintaining health.

Chetty *et al*. (2019) in analyzing nitrite and nitrate content in meat samples from Fiji, found nitrate contents ranging from 0.00 to 0.124 g 100 g^{-1}, while for nitrite rates from 0.00 to 0.164 g 100 g $^{-1}$. These are below maximum level proposed by European Union legislation, but above limit set by Food Standards Australia and New Zealand.

Table 1: Sodium nitrite and sorbate content in commercial meat derivatives

Samples	Sodium nitrite (g $100g^{-1}$)	Sodium sorbate (g $100g^{-1}$)
Braz. legislation	0.015 g. $100g^{-1}$	0.02 g.100 g^{-1}
Hamburguer A	$0.023^{a} \pm 0.01$	$0.09^{c} \pm 0.01$
Hamburguer B	$0.021^{c} \pm 0.01$	$0.09^{c} \pm 0.00$
Hamburguer C	$0.021^{c} \pm 0.01$	$0.11^{a} \pm 0.01$
Hamburguer D	$0.019^{e} \pm 0.01$	$0.09^{c} \pm 0.01$
Hamburguer E	$0.019^{e} \pm 0.01$	$0.09^{c} \pm 0.01$
Hamburguer F	$0.020^{d} \pm 0.01$	$0.09^{c} \pm 0.01$
Loin A	$0.015^{h} \pm 0.00$	$0.03^{h} \pm 0.00$
Loin B	$0.015^{h} \pm 0.00$	$0.10^{b} \pm 0.01$
Sirloin A	$0.018^{f} \pm 0.00$	$0.03^{h} \pm 0.00$
Sirloin B	$0.020^{d} \pm 0.00$	$0.02^{i} \pm 0.01$
Salami A	$0.020^{d} \pm 0.00$	$0.04^{g} \pm 0.01$
Salami B	$0.019^{e} \pm 0.00$	$0.04^{g} \pm 0.01$
Salami C	$0.020^{d} \pm 0.00$	$0.09^{c} \pm 0.01$
Salami D	$0.019^{e} \pm 0.00$	$0.03^{h} \pm 0.00$
Ham A	$0.011^{j} \pm 0.00$	$0.02^{i} \pm 0.01$
Ham B	$0.011^{j} \pm 0.00$	$0.07^{e} \pm 0.01$
Ham C	$0.006^{m} \pm 0.00$	$0.06^{f} \pm 0.01$
Ham D	$0.003^{n} \pm 0.00$	$0.06^{f} \pm 0.01$
Ham E	$0.001^{p} \pm 0.00$	$0.08^{d} \pm 0.01$
Ham F	$0.002^{o} \pm 0.00$	$0.06^{f} \pm 0.01$
Ham G	$0.006^{m} \pm 0.00$	$0.08^{d} \pm 0.01$
Lower ham A	$0.018^{f} \pm 0.00$	$0.03^{h} \pm 0.00$
Lower ham B	$0.012^{i} \pm 0.00$	$0.03^{h} \pm 0.00$
Lower ham C	$0.017^{g} \pm 0.00$	$0.02^{i} \pm 0.00$
Lower ham D	$0.007^{l} \pm 0.00$	$0.02^{i} \pm 0.00$
Mortadella A	$0.021^{c} \pm 0.00$	$0.02^{i} \pm 0.00$
Mortadella B	$0.022^{b} \pm 0.00$	$0.10^{b} \pm 0.01$
Chicken Mortadella C	$0.019^{e} \pm 0.00$	$0.02^{i} \pm 0.00$
Mortadella D	$0.001^{p} \pm 0.00$	$0.02^{i} \pm 0.01$
Mortadella E	$0.001^{p} \pm 0.00$	$0.02^{i} \pm 0.00$
Mortadella F	$0.006^{m} \pm 0.00$	$0.02^{i} \pm 0.00$
Mortadella G	$0.001^{p} \pm 0.00$	0.02 ± 0.00
Mortadella H	$0.006^{m} \pm 0.00$	$0.03^{h} \pm 0.00$
Turkey breast light A	$0.011^{j} \pm 0.00$	$0.02^{i} \pm 0.00$
Smoked turkey breast B	$0.011^{j} \pm 0.00$	$0.02^{i} \pm 0.00$

* Values expressed as average ± standard deviation followed by equal lowercase letters in same columns do not differ statistically at 95% significance level (Tukey test).

Bahadoran *et al*. (2016) found mean values of nitrate and nitrite in fresh, processed meat from 5.56 to 19.4 mg 100 g^{-1}, from 2.93 to 13.9 mg 100 g $^{-1}$, respectively.

Lira *et al*. (2003) quantified residual nitrite in hams (0.0017 to 0.0035 mg 100 g^{-1}), mortadella (traits: 0.0003 to 0.0017 mg 100 g^{-1}), Tuscan sausage (0.0005 to 0.0016 mg 100 g^{-1}), smoked pepperoni sausage (0.0016 mg 100 g^{-1}). Pereira *et al*. (2012) evaluated nitrite and nitrate contents of cured salami, ham, bacon, sausage samples in Araraquara, Sao Paulo region using capillary electrophoresis. Results from both Lira *et al*. (2003) and Pereira *et al*. (2012) of all samples were below limits established by Brazilian Legislation (BRASIL, 1998). Meat product legislation varies widely between countries, but effective enforcement ensures that these industries do not exceed values allowed by law, do not harm health of population.

Sodium sorbate values in samples ranged from 0.02 to 0.11 g 100 g^{-1}, which means that 23 of 33 samples analyzed disagree with Brazilian law. It is noteworthy that 14 samples had triple or more sorbate allowed by law. Oliveira *et al*. (2015) when analyzing sorbate in Brazilian meat products found for mortadella, contents ranging from 0.094 to 0.175 g 100 g^{-1}, values that also exceeded current laws similar to some samples of this study.

Although sodium sorbate is considered GRAS (Sofos, 1989), its use is only safe for population when added levels are within limits of law. Sorbate and nitrite, when present together at gastric pH, form a series of mutagenic, genotoxic species, including ethylnitrolic acid (ENA), 1.4-dinitro-2-methylpyrrole (NMP) (Hartman, 1983; Osawa & Namiki, 1982; Oliveira *et al*., 2015). In general, reaction of nitrite with sorbic acid can form mutagenic products at pH 3.5. C-nitro and C-nitrous compounds were main isolated mutagenic products (Sofos, 1989; Oliveira *et al*., 2015).

Conclusion

Sodium nitrite and sorbate are widely used in meat industry because of their antimicrobial function, for contributing to color and flavor of products. Sodium nitrite content ranged from 0.001-0.230 g $100g^{-1}$ between samples, only 19 of 33 samples analyzed were in accordance with Brazilian legislation exceeding maximum allowed values. Sodium sorbate values in samples ranged from 0.02 to 0.11 g 100 g^{-1}. Twenty-three of thirty-three samples analyzed disagree with Brazilian law. Toxicity, dangers of these additives, associated with non-compliance with levels established by law, show importance of reducing consumption of these products in order to prevent diseases.

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