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Processed Red Meat and the Risks Associated with High Consumption in Brazil

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Meat and its derivatives are products of high nutritional value and are widely used in people's diets. However, red meat derivatives have a high lipid content and during storage they produce toxic compounds such as malondialdehyde. In addition, they undergo salting processes and this greatly increases sodium consumption in the final diet.

The objective of this work is to analyze the content of chlorides and malonaldehydes in cured red meats and to relate it to the emergence and/or increase in the incidence of some diseases. Nineteen different types of cured red meat derivatives were analyzed for chlorides, lipids and malonaldehydes using official methodologies. The malonaldehyde (MDA) content ranged from 3.82 to 0.31 mg MDA/Kg of meat. The chloride content in the products ranged from 10.05 to 0.18 g. 100 g^{-1}, with a meatball brand having the highest value among the tested products. The percentage of lipids ranged from 15.82 to 1.42%. The exaggerated intake of chlorides, lipids and malonaldehydes coub beemergence and/or aggravation of several diseases, therefore, it is necessary to inform the population about the reduction in the consumption of these products as a preventive measure against illness.

Keywords: processed meat, malonaldehydes, chlorides, lipids and risks

1. Introduction

Red meat is an important and widely used constituent in the human diet, as it is a source of proteins, fatty acids, minerals (Borges *et al*., 2020a) and micronutrients such as vitamins A and B, zinc and iron (Boada; Henríquez- Hernández; Luzardo, 2016; Pereira; Vicente, 2013). In addition to these, it still has other components that make up its nutritional composition, such as omega 6 and omega 3 fatty acids (ω6:ω3) (Delgado- Pando *et al*., 2018; Cook, Appel; Whelton, 2016).

With the COVID 19 pandemic and a decrease in the population's income, processed meats have become a cheaper alternative to the consumption of animal proteins. Processed meats refer to meats that have undergone some type of process in order to improve flavor and preserve it. This transformation can occur through smoking, curing, salting, cooking and fermentation. Among the types of processing there are cured products that are characterized by the use of additives such as nitrates, nitrites, salt and sugar, which can result in improved taste, aroma and red color (Benevides; Nassu, 2020; IARC-WHO, 2015) which are the outstanding features of these products. Although these processes contribute to improving the sensory characteristics of these products, it should be noted that the frequent consumption of processed meat products is associated with the aggravation of many non-communicable diseases. Sodium chloride (Nacl), which is present in cured products and in daily diet on a voluntary basis, is directly linked to problems of arterial hypertension, cardiovascular diseases, stomach cancer, obesity, diabetes mellitus, atherosclerosis (INCA, 2020; Santos, 2013) and kidney disorders (Zang *et al*., 2022).

According to data provided by the Brazilian Institute of Geography and Statistics (IBGE), 20,745 people over 18 years old reported that they consume salt excessively (IBGE, 2013). Data indicate that arterial hypertension affects one in four adults in Brazil. The alert becomes even more worrying when 90% of men and 70% of women consume salt above average, and 85.1% of the adult population consider this excessive consumption to be appropriate (WHO, 2016).

The salt associated with heme iron unsaturated fatty acids, present in red meat, can favor the lipid oxidation process, resulting in some secondary products, such as maloaldehyde (MDA)

(Estévez *et al*., 2017). Lipid oxidation involves the oxidative deterioration of lipids containing carbon-carbon double bonds, and occurs in both triglycerides and tissue phospholipids (Zang *et al*., 2022; Huang; Ahn, 2019). Malondialdehyde is a biomarker of lipid oxidation (Tsikas, 2017). As it is a by-product of lipid oxidation, it can have some consequences for the product, such as changes in color, taste, odor and nutritional changes (Jiang; Xiong, 2016). It is also considered a mutagenic chemical compound and may contribute to the development of cancer (Perše, 2013).

Thus red and/or processed meats are directly associated with cardiovascular disease, obesity, type 2 diabetes and cancer. According to IARC, excessive consumption of processed meat can increase the risk of colon and rectal cancer (INCA, 2015). Chan *et al*. (2011) in their analysis of colorectal cancer, reported that in ten studies they found a relationship that consumption of 50 g per day of processed meat can increase the risk of colorectal cancer by 18%. The objective of this study is to analyze the content of chlorides, lipids and malonaldehydes in cured red meats and to relate it to the emergence and/or increased incidence of some diseases.

2. Materials and Methods

2.1 Materials

Samples of processed red meat derivatives were purchased in supermarkets in the city of Petrolina-PE. Nineteen types of processed cured red meat were analyzed (nine brands of hamburger, three brands of pepperoni sausage, three brands of meatballs and four brands of Italian-style salami) from different commercial brands. Samples were stored in a refrigerated environment, at a temperature of 4 °C until the moment of analysis. Samples were individually ground in a meat grinder at the time of analysis and analyzed within 15 days.

2.2 Methods

2.2.1 *Chloride Content in Cured Products*

The quantification of chlorides in the samples was carried out in two stages: obtaining and quantifying ash (minerals) and chloride analysis. Mineral residue was determined by the gravimetric method with incineration of the samples (5 g) in a muffle heated to 450 ºC until obtaining white ashes. Two drops of nitric acid solution (1 + 9) were added to the ash to facilitate dissolution and 10 mL of heated distilled water. Samples were homogenized and filtered in a 250 mL Erlemeyer flask. The pH of the solution was adjusted to 5.5 using calcium carbonate directly in the beaker. 1 mL of 5% potassium chromate solution was used as an indicator and the samples were titrated with 0.1M silver nitrate solution until the appearance of a brick-red color (IAL, 2008). All tests were performed in triplicate. Concentration of chlorides in the mineral residue was calculated using equation 1:

$$\% \text{ Nacl} = V \times N \times f \times 0.0585 \times 100/P2 \text{ (Eq. 1)}$$

Where: V= volume of the 0.1 N silver nitrate solution used in the titration, in mL; N= normality of the 0.1N silver nitrate solution; f= correction factor of 0.1 N silver nitrate solution; P1= sample mass, in grams; P1=mass of mineral residue; 0.0584= milliequivalent-gram of sodium chloride.

2.2.2 MDA-TBA Detection in a UV-VIS Spectrophotometer

MDA in meat products has been detected by the TBA assay using spectrophotometry (Mendes et al., 2009). MDA was extracted from the samples using a 5% TCA solution. Samples of the meat product (5 g) were homogenized with 18 mL of 5% TCA solution, 0.5 mL of 0.15% BHT in ethanol and 2 mL of 0.5% sulfanilamide solution using a glass rod for 30 seconds.

The homogenate was centrifuged at 2090 rpm/g for 15 min. 2 ml of the supernatant was removed and transferred in triplicate to test tubes where 2 ml of 0.08M TBA were added. The tubes were capped, vortexed for 10 seconds, heated in a water bath at 100 °C for 50 minutes, cooled to room temperature and the absorbance of the MDA-TBA read in a spectrophotometer at 532 nm. The 5% TCA solution was used as a blank to zero the instrument. The number of TBARS and results quantified using a calibration curve of 1,1,3,3-tetraethoxypropane (TEP) at concentrations of 0.02-0.09. The concentration of MDA in the samples was expressed in milligrams of MDA per kilogram of meat product (mg MDA kg^{-1} of meat product) by calculating the number of TBA in 2 mL used in the tests, converting the concentrations to milligrams and, below, the corresponding results for 1 kg of meat product.

2.2.3 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 ($N = 3$) and data expressed as mean ± standard deviation. The results were compared using Tukey test to identify the existence of significant differences between the test results, with a significance level of 95% for each parameter evaluated.

3. Results and Discussion

Table 1 shows the results obtained in the tests to quantify malonaldehyde, chlorides in cured red meat derivatives. It can be seen that the content of malonaldehyde (MDA) ranged from 3.82 to 0.31 mg MDA/Kg of meat. Although there werevariations between the commercial brands studied, it can be observed that the sausages and hamburgers presented the highest levels of the analyzed compound. The chloride content in the products ranged from 10.05 to 0.18 g. 100 g^{-1}, with a meatball brand having the highest value among the tested products. The lipid content ranged from 15.82 to 1.42%.

Cured meat products such as sausages, hams, bologna, hams, paio, presented are widely consumed due to their nutritional value (proteins, lipids), affordable price (Borges *et al*., 2019; Borges *et al*., 2020c). Although these products bring nutritional benefits, they should not be consumed in excess due to the high content of lipids, sodium and maloaldehyde that can contribute to illness and aggravation of pre-existing diseases. The association of consumption of red meat and processed products and diseases has been made in several studies and show concern and need to alert the population on this subject.

According to Torres and Okani, (1997) TBARS values above 1.59 mg of malonic aldehyde /

kg of sample can cause damage to the consumer's health. Some products analyzed, such as some brands of hamburgers, all sausages showed higher levels than the aforementioned maximum recommendation, which can be a source of danger for consumers. It is worth noting that lipid oxidation increases with the amount of lipids and with the ratio between polyunsaturated fatty acids (PUFAs) and saturated fatty acids (SFAs) and occurs during meat processing and storage (Bertolin; Joy; Branco, 2019).The longer the product is stored, the greater the possibility that the lipids will generate malonaldehyde. In addition, products such as meat derivatives already have a high content of lipids that contribute to their sensory characteristics, which only exacerbates the problem.

The lipid content ranged from 1.29 to 18.91%, with meatballs and salami showing the highest levels. Borges, Negreiros and Paiva (2020) analyzing meat derivatives such as chicken sausages, pepperoni sausages, hams, Italian-style salami, paios, hamburgers, loins and bologna found lipid levels ranging from 48.35 to 10.43%. Bertolin; Joy; Branco, (2019) analyzing pork, chicken, beef, beef, chorizo, sausage, frankfurter sausage, cooked ham and beef burger found fat contents of 31.8 to 0.95%. Chorizo (31.8%), sausage (19.3%) and hamburger (7.16%) had the highest percentages. In Brazilian legislation there are established values of fat for the formulation of meat products. The maximum value of total fat in raw beef hamburgers is 23%, 18% in meatballs and 30% in sausages (BRASIL, 2000).

Although all products are within the recommended values, it is necessary to take into account the World Health Organization's recommendation on the consumption of foods rich in fats and the damage to the health of the population. In late 2015, the International Agency for Research on Cancer (IARC) published a study commissioned by the WHO, on assessing the association of cancer with consumption of red meat or processed meat. This study analyzed, through 22 researchers from 10 countries, several studies that relate a higher risk of developing cancer with the consumption of sausages. The report delivered by IARC characterizes sausages as group 1 on the risk scale for developing cancer. This information says that this food is related to the development of cancer, mainly intestinal, pancreas and prostate. In this study, the meat heme group associated with lipid peroxidation were associated with the aforementioned cancer initiation or spread (INCA, 2015; IARC-WHO, 2015; Lancet Oncology, 2015).

The consumption of saturated and trans fats is directly linked to cardiovascular disease (CVD), due to the elevation of LDL cholesterol, so it is recommended to replace saturated fat with mono and polyunsaturated fats, as a means of reducing the risks of the disease (Santos *et al*., 2013). The chloride values ranged from 10.05 to 0.18 g. 100 g $^{-1}$ in the tested products. With the exception of the salami studied, all products analyzed showed significant chloride values. Borges and collaborators (2020b) when quantifying sodium levels in 38 types of cured products such as sausages, paios, Italian salami, hamburgers, bologna, hams, inferior hams and hot dog sausages found levels ranging from 31.01 to 2, 47 g. 100 g $^{-1}$ in the mineral residue.

Table 1. Lipid oxidation, lipids and sodium chloride content through meat derivatives.

sample	Product	TBARS (mg MDA/Kg meat)	Lipids (%)	Chlorides in Nacl (g/100 g)
1	Hamburger A	1.40^{d} ± 0.03	3.02^{j} ± 0.18	4.38^{b} ± 0.15
2	Hamburger B	1.19^{e} ± 0.00	4.95^{h} ± 0.28	3.57g ± 0.16
3	Hamburger C	1.46^{d} ± 0.02	5.39^{g}± 0.12	3.87^{d} ± 0,12
4	Hamburger D	2.21^{c} ± 0.00	4.68^{h} ± 0.85	3.41^{h} ± 0.59
5	Hamburger E	1.77^{c} ± 0.00	2.66^{j} ± 0.77	4.09^{c} ± 0.90
6	Hamburger F	1.11^{de} ± 0.04	3.62^{i} ± 0.52	4.16^{c} ± 0.87
7	Hamburger G	0.39^{h} ± 0.00	1.29^{l} ± 0.20	4.38^{b} ± 0.11
8	Hamburger H	2.26^{c} ± 0.03	1.42^{l} ± 0.05	3.47^{h} ± 0.65
9	Hamburger I	2.87^{b} ± 0.01	1.42^{l} ± 0.03	3.12^{i} ± 0.15
10	Pepperoni sausage A	3.82^{a} ± 0.02	6.74^{g} ± 0.02	3.10^{i} ± 0.15
11	Pepperoni sausage B	3.67^{a} ± 0.03	6.04^{f} ± 0.03	2.95^{j} ± 0.03
12	Pepperoni sausage C	2.76^{b} ± 0.01	4.67^{h} ± 0.02	3.57^{g} ± 0.15
13	Meat-ball A	0.95^{f} ± 0.03	15.82^{b} ± 0.03	3.74^{f} ± 0.05
14	Meat-ball B	0.88^{f} ± 0.02	15.19^{b} ± 0.05	3.14^{i} ± 0.29
15	Meat-ball C	0.52^{g} ± 0.04	15.51^{a} ± 0.03	10.05^{a} ± 0.11
16	Salami A	0.17^{i} ± 0.01	12.77^{c} ± 0.22	0.22^{l} ± 0.01
17	Salami B	0.31^{h} ± 0.01	12.29^{d} ±0.41	0.19^{l} ± 0.01
18	Salami C	1.11^{de} ± 0.01	18.91^{a} ± 0.05	0.19^{l} ± 0.01
19	Salami D	1.04^{f} ± 0.01	10.27^{e} ± 0.18	0.18^{l} ± 0.01

*Values expressed as mean ± standard deviation followed by equal lowercase letters in the same columns do not differ statistically at the 5% level (Tukey's test). No. TBARS measured within the maximum 15 days of laboratory storage.

Salt is an important additive in the food industry because, in addition to contributing to the flavor, it favors the conservation of these products, as it reduces water activity and, consequently, reduces microbial deterioration. In addition, iodized sodium chloride is an extremely important vehicle present in the diet, as it helps to combat iodine deficiency, which can cause health problems such as endemic goiter (WHO, 2008; WHO, 2012). It is also known as a contributor to lipid oxidation along with oxygen exposure, refrigeration and other processing techniques.

However, these data found are worrying because the consumption of a single of these products already exceeds or reaches the sodium limits recommended by health agencies. According to the World Health Organization (WHO, 2006), the maximum daily recommendation for sodium per person is 2000 mg and at least 3,510 mg of potassium. Table salt has 40% sodium, so the amount of salt per capita that can be ingested daily is 5 g. Therefore, it is recommended that only 3 g, which is equivalent to 2 level teaspoons, should be added to food in the preparation of meals daily. Which leads us to infer that a person consuming 100 grams of any of the analyzed products would already consume almost the maximum amount of sodium recommended by Organs competent bodies in 2006. The World Health Organization (WHO), the European Union (EU) have developed strategies to reduce sodium chloride (NaCl) consumption in the population (WHO, 2006; Council of the European Union, 2010).

In 2012, the WHO strongly recommended a reduction in sodium intake to less than 2 grams per day or less for adults to lower blood pressure and therefore the risk of pressure-related disorders in adults and children (WHO, 2016). According to the Ministry of Health, daily salt consumption by Brazilians is twice that recommended by the WHO, reaching 12 g/day. this happens because sodium is present in industrialized foods, such as sausages and in daily food, increasing the risk of high blood pressure (Castilho, 2019).

Sodium chloride (Nacl) is present in cured products and in the daily diet on a voluntary basis, it is directly linked to problems of arterial hypertension, cardiovascular diseases and stomach cancer (INCA, 2020). According to data provided by the Brazilian Institute of Geography and Statistics (IBGE), 20,745 people over 18 years old reported that they consume salt excessively (IBGE, 2013).

Another alarming situation is the fact that foods rich in sodium can increase risk of stomach cancer (INCA, 2020), in addition to bringing other health consequences such as cardiovascular disease, high blood pressure, obesity, diabetes mellitus and atherosclerosis (Santos, 2013; WHO, 2012). Data indicate that arterial hypertension affects one in four adults in Brazil. The alert becomes even more worrying when 90% of men and 70% of women consume salt above average, and 85.1% of the adult population consider this excessive consumption to be appropriate (WHO, 2016). The estimate for new cases of stomach cancer among men and women is 13,360 new cases in men and 7,870 for women, which corresponds to 12.81% for every 100,000 men and 7.34% for every 100,000 women. years from 2020 to 2022 (INCA, 2020).

This concern has motivated dietary reformulation to reduce salt, sugar, fat content and has been included in nutrition action plans in many EU countries and the world. This implementation of the national food reform has been generally suggested by the Ministries of Health followed by the Ministries of Agriculture and supported by national and local agencies, public research institutes and NGOs that implement programs (Belc *et al*., 2019). Many authors have done research and indicate the importance and/or alternatives to reduce the fat content, lipid oxidation (Lopez-Pedrouso *et al*., 2021; Liberty; Dehghannya; Ngadi, 2019; Belc *et al*., 2019) and sodium in meat foods (Douglas *et al*., 2021; Franca *et al*., 2022; Zhang *et al*., 2022; Raybaudi-Massilia *et al*., 2019).

3. Conclusions

Due to their affordable value, meat derivatives are part of most people's diet. However, the tests indicate a high content of lipids (15.82 to 1.42%), chlorides (10.05 to 0.18 g. 100 g-1) and malondialdehydes (3.82 to 0.31 mg MDA/Kg of meat) in the tested products. In six products, the malondialdehyde content exceeded the limit considered safe for consumption. 13 of the products reviewed had chloride levels that exceeded the current World Health Organization recommendation, which is currently 3 grams. The products analyzed regardless of the brand had a high lipid content, which can contribute to several diseases. These data show that it is necessary to inform the population about precautions with the consumption of industrialized meat products, as all these constituents can contribute to the aggravation and/or development of several non-communicable diseases.

References

Belc, N., Smeu, I., Acri, A., Vallauri, D., & Flynn, K. (2019). Reformulating foods to meet current scientifific knowledge about salt, sugar and fats. *Trends in Food Science & Technology*, *84*, 25-28. https://doi.org/10.1016/j.tifs.2018.11.002

Benevides, S. D., & Nassu, R. T. (2022). Tree of Knowledge, court hearers, [s.d]. Available in:<https://www.agencia.cnptia.embrapa.br/gestor/ovinos_de_corte/arvore/CONT000g3izohks02wx5ok0tf2hbweqanedo.html> Acessed in 21/09/2022

Bertolín, J. R., Joy, M., & Blanco, M. (2019). Malondialdehyde determination in raw and processed meat products by UPLC-DAD and UPLC-FLD. *Food Chemistry*, *298*, 125009. https://doi.org/10.1016/j.foodchem.2019.125009

Boada, L. D., Henríquez-Hernández, L. A., & Luzardo, O. P. (2016). The impact of red and processed meat consumption on cancer and other health outcomes: Epidemiological evidences. *Food and Chemical Toxicology*, *92*, 236-244. http://doi.org/10.1016/j.fct.2016.04.008

Borges, J. G., & Dantas, L. L. D. S. (2019). Chemical nutritional composition of commercial meat derivatives. *International Journal of Current Multidisciplinary Studies*, *5*(12), 1177-1181.

Borges, J. G., Negreiros, P. F., & Paiva, E. R. A. (2020). Frequent ingestion of animal fat and risks associated with consumption. *International Journal of Development Research*, *10*(07), 37686-37689. https://doi.org/10.37118/ijdr.19367.07.2020

Borges, J. G., Santana, L. L. D. S., Carvalho, R. C., & Mota, C. M. C. (2020b). Quantification of choride and sodium in cured meat products. *International Journal os Engineering Science Invention (IJESI), 9*(2), 51-55.

Borges, J. G., Santana, L. L. D. S., Carvalho, R. C., Mota, C. M. C., & Prado, K. A. C. (2020a). Contents of Sodium Nitrite and Sorbat in Commercial Meat Derivatives. *International Journal of Multidisciplinary and Current Research, 8*(1), 1-4(a).

Brazil. (2000). Ministry of Agriculture and Supply (MAPA). Normative Instruction No. 4, of March 31, 2000. Technical regulation for establishing the identity and quality of mechanically separated meat (cms) from poultry, cattle and swine. Available in:<https://www.defesa.agricultura.sp.gov.br/legislacoes/instrucao-normativa-sda-4-de-31-03-2000,662.html>. Access in: 25/08/2022

Castilho, Ingrid, Hypertension is diagnosed in 24.7% of the population, according to the Vigitel survey, 2019. Ministry of Health. Available em:<https://antigo.saude.gov.br/noticias/agencia-saude/45446-no-brasil-388-pessoas-morrem-por-dia-por-hipertensao>. Access in: 21/09/2020.

Chan, D. S. M., Lau,R., Aune, D., Vieira,R., Greenwood, C. D., Kampman, E., & Norat, T. (2011). Red and processed meat and colorectal cancer incidence: Meta-analysis of prospective studies. *PLoS ONE, 6*(6). https://doi.org/10.1371/journal.pone.0020456

Cook, N. R., Appel, L. J., & Whelton, P. K. (2016). Sodium intake and all-cause mortality over 20 years in the trials of hypertension prevention. *Journal of the American College of Cardiology, 68*(15), 1609-1617. https://doi.org/10.1016/j.jacc.2016.07.745

Council of the European Union(2010). Notices from European union institutions, bodies, offices and agencies. Council conclusions of 8 June 2010 on ‘Action to reduce population salt intake for better health’ — adoption of the conclusions. 2010/C 305/04. Off. J. Eur. Union C 305/5. Available in: http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2010:305:0003:0005:EN:PDF, Access in: 6August 2021

Delgado-Pando, G., Fischer, E., Allen, P., Kerry, J. P., O'Sullivan, M. G., & Hamill, R. M. (2018). Salt content and minimum acceptable levels in whole muscle cured meat products. *Meat Science, 139*, 179-186. https://doi.org/10.1016/j.meatsci.2018.01.025

Douglas, P., Saldana, E., Lorenzo, J. M., Pateiro, M., Dominguez, R., Dos Santoa, B. A., … & Campagnol. P. C. B. (2021). Low-sodium dry-cured rabbit leg: A novel meat product with healthier properties. *Meat Science, 173*, 108372. https://doi.org/10.1016/j.meatsci.2020.108372

Estévez, M., Li, Z., Soladoye, O. P., & Van-Hecke, T. (2017). Health Risks of Food Oxidation. *Advances in Food and Nutrtion Research, 82*, 45-81. https://doi.org/10.1016/bs.afnr.2016.12.005

Fellendorf, S., O'Sullivan, M. G., & Kerry, J. P. (2016). Impact of ingredient replacers on the physicochemical properties and sensory quality of reduced salt and fat black puddings. *Meat Science, 113*, 17-25. https://doi.org/10.1016/j.meatsci.2015.11.006

Franca, P. A. P., Duque-Estrada, P., Fonseca e Sá, B. F., Van Der Goot, A. J., & Pierucci, A. P. T. (2022). Meat substitutes - past, present, and future of products available in Brazil: changes in the nutritional profifile. *Future Foods*, *5*, 100133. https://doi.org/10.1016/j.fufo.2022.100133

Huang, X., & Ahn, D. U. (2019). Lipid oxidation and its implications to meat quality and human health. *Food Science and Biotechnology*, 1-11. https://doi.org/10.1007/s10068-019-00631-7

IAL. (2008). Ial, Institute Adolfo Lutz. *Physical-chemical methods for food analysis*. 4. ed. São Paulo. 1020 p.

IARC. (2015). Carcinogenicity of consumption of red and processed meat. *The Lancet Oncology*, *16*, 1599-1600. https://doi.org/10.1016/S1470-2045(15)00444-1

IARC-WHO. (2015). Iarc Monographs Evaluate Consumption of Red Meat and Processed Meat**.** Available in: https://www.iarc.fr/en/mediacentre/pr/2015/pdfs/pr240_E. Pdf. Access at: 04 nov. 2023.

IBGE. I Brazilian Institute of Geography and Statistics. National Health Survey, 2013. Available at: <https://sidra.ibge.gov.br/tabela/4388#resultado >National Cancer Institute. Estimate 2020. Synthesis and comments, 2020. Available at: 22/04/2023.

INCA. (2015). WHO classifies processed meats as carcinogenic. Available at: http://www2.inca.gov.br/wps/wcm/connect/agencianoticias/site/home/noticias/2015/oms_classifica_carnes_processadas_como_cancerigenas. Access in: 03 nov. 2022

INCA. National Cancer Institute. Estimate 2020. Synthesis and comments, 2020. Available at: <https://www.inca.gov.br/estimativa/sintese-de-resultados-e-. Available at: 18/09/2020

Jiang, J., & Xiong, Y. L. (2016).Natural antioxidants as food and feed additives to promote health benefits and quality of meat products: A review. *Meat Science*, *120*, 107-117. https://doi.org/10.1016/j.meatsci.2016.04.005

Lancet Oncology. (2015). Carcinogenicity of consumption of red and processed meat. *Lancet Oncology*. *16*(16), 1599-1600.

Liberty., Dehghannya, J., & Ngadi, M. O. (2019). Effective strategies for reduction of oil content in deep-fat fried foods: A review. *Trends in Food Science & Technology*, *92*, 172-183. https://doi.org/10.1016/j.tifs.2019.07.050

Lopez-Pedrouso, M., Lorenzo, J. M., Gullon, B.; Campagnol, P. V. B., & Franco, D. (2021). Novel strategy for developing healthy meat products replacing saturated fat with Oleogels. *Current Opinion in Food Science*, *40*, 40-45. https://doi.org/10.1016/j.cofs.2020.06.003

McAfee, A. J., McSorley, E. M., Cuskelly, G. J., Moss, B. W., Wallace, J. M. W., Bonham, M. P., & Fearon, A. M. (2010). Red meat consumption:An overview of the risks and benefits. *Meat Science*, *84*, 1-13. https://doi.org/10.1016/j.meatsci.2009.08.029

Mendes, R., Cardoso, C., & Pestana, C. (2009). Measurement of malondialdehyde in comparison study between HPLC methods and the tradicional Spethopotometric. *Food Chemistry*, *122*(4), 1038-1045.

Pereira, P. M. DE C. C., & Vicente, A. F. DOS R. B. (2013). Meat nutritional compositionand nutritive role in the human diet. *Meat Science*, *93*(3), 586-592. https://doi.org/10.1016/j.meatsci.2012.09.018

Perše, M. (2013). Oxidative stress in the pathogenesis of colorectal cancer: Cause or consequence? *BioMed Research International*, 2013. https://doi.org/10.1155/2013/725710

Raybaudi-Massilia, R., Mosqueda-Melgar, J., Rosales-Oballos., Y., Citti de Petriconed, R., Frágenas, N. N., Zambrano-Durán, A., … & Urbin, G. (2019). New alternative to reduce sodium chloride in meat products: Sensory and microbiological evaluation. LWT-*Food Science and Technology*, *108*, 253-260. https://doi.org/10.1016/j.lwt.2019.03.057

Santos, R. D., Gagliardi, A. C. M., & Lottenberg, A. M. P. (2013). I Guideline on fat consumption and cardiovascular health. *Brazilian Archives of Cardiology*, *100*(1), 1-40.

Torres, E. A. F. S., & Okani, E.T. (1997). TBA test - Rancidity in food. *National Meat Magazine*, *243*, 68-76 (In Portuguese).

Tsikas, D. (2017). Assessment of lipid peroxidation by measuring malondialdehyde (MDA) and relatives in biological samples: Analytical and biological challenges. *Analytical Biochemistry*, *524*, 13-30. https://doi.org/10.1016/j.ab.2016.10.021

WHO. (2006). World Health Organization. Reducing salt intake in populations. Report of a WHO Forum and Technical Meeting. WHO Forum on Salt Reduction Consumption in Populations: Paris, France. 978 92 41595377. Available at: <http://www.who.int/dietphysicalactivity/Salt_Report_VC_april07.pdf> Access in: 10/09/2021

WHO. (2008). World Health Organization. Salt as a vehicle for fortification: report of a WHO expert consultation. *Reportof a WHO Expert Consultation*, 1-36.

WHO. (2012). World Health Organization. Guideline: Sodium Intake for Adults and Children. Guideline: Sodium Intake for Adults and Children. *WHO Guidelines Approved by the Guidelines Review Committee. Geneva*.

WHO. (2016). World Health Organization. Reduce sodium intake to reduce high blood pressure and risk of cardiovascular disease in adults. Available in: <http://www.who.int/elena/titles/sodium_cvd_adults/es, Access in: 21 /09/2021.

Zhang , Y., Guo , X., Peng, Z., & Jamali, M. A. (2022). A review of recent progress in reducing NaCl content in meat and fish products using basic amino acids. *Trends in Food*

Science & Technology, *119*, 215-226. https://doi.org/10.1016/j.tifs.2021.12.009

Zhang, W., Xiao, S., & Ahn, D. U. (2013). Protein Oxidation: Basic Principles and Implications for Meat Quality. *Critical Reviews in Food Science and Nutrition*, *53*(11), 1191-1201.https://doi.org/10.1080/10408398.2011.577540