Ciência Rural, Santa Maria, v.54:06, e20220550, 2024 http://doi.org/10.1590/0103-8478cr20220550

ISSNe 1678-4596
FOOD TECHNOLOGY

Better use of caiman *yacare* carcass and physical-chemical characterization of mechanically separated meat

Gilmar Borges de Paiva[1,2*] **Elisa Rafaela Bonádio Bellucci**[2] **Marco Antônio Trindade**[3] **Javier Teles Romero**[2] **Andrea Carla da Silva Barretto**[2]

[1]Instituto Federal de Educação, Ciência e Tecnologia de Mato Grosso (IFMT), 78.360-000, Campo Novo do Parecis, MT, Brasil. E-mail: gilmar.paiva@ifmt.edu.br. *Corresponding author.
[2]Departamento de Engenharia e Tecnologia de Alimentos, Universidade Estadual Paulista (UNESP), São José do Rio Preto, SP, Brasil.
[3]Departamento de Engenharia de Alimentos, Escola de Engenharia de Alimentos e Ciência Animal, Universidade de São Paulo (USP), Pirassununga, SP, Brasil.

ABSTRACT: The captive breeding of the Pantanal caiman (*Caiman yacare*) offers great potential for the full use of all the component parts of the animal. The meat is an option for human consumption with good sensory acceptance, the skin is valued on the international market and the carcass can be used for obtaining mechanically separated caiman meat (MSCM). This research evaluated the physical chemical parameters of mechanically separated meat obtained from caiman *yacare* carcass to improve its yield. The proximate composition, lipid oxidation, pH, total volatile bases (TVB) and color during storage under freezing at -18 °C for 90 days were all evaluated. The MSCM presented low lipid content, high protein content and good stability during storage under freezing for 90 days. These results demonstrated that MSCM can be used in the development of caiman meat products.
Key words: wild animal, exotic meat, oxidative stability, innovation.

Melhor aproveitamento da carcaça do jacaré e caracterização físico-química da carne separada mecanicamente

RESUMO: A criação em cativeiro do jacaré do Pantanal (*Caiman yacare)* oferece grande potencial para o aproveitamento integral de todas as partes componentes do animal. A carne é uma opção para consumo humano com boa aceitação sensorial, a pele é valorizada no mercado internacional e a carcaça pode ser utilizada para obtenção de carne de jacaré mecanicamente separada (CJMS). O objetivo deste trabalho foi avaliar os parâmetros físico-químicos da carne mecanicamente separada obtida da carcaça do jacaré do Pantanal para melhorar seu rendimento. A oxidação lipídica, pH, bases voláteis totais (TVB) e cor durante o armazenamento sob congelamento a -18 °C, foram avaliados por 90 dias. Além disso, foi avaliada a composição centesimal. A CJMS apresentou baixo teor de lipídios, alto teor de proteína e boa estabilidade durante o armazenamento sob congelamento por 90 dias. Esses resultados demonstram que a CJMS pode ser utilizada no desenvolvimento de produtos cárneos de jacaré.
Palavras-chave: animal selvagem, carne exótica, estabilidade oxidativa, inovação.

INTRODUCTION

Meat from the Pantanal caiman is considered an exotic meat and is highly valued in the consumer market, with low lipid and high protein content while still having an agreeable flavor. In Brazil, caiman meat for human consumption must come from legalized captive breeding (ROMANELLI et al., 2002; VICENTE NETO et al., 2006; CORDEIRO et al., 2022; SANCHES et al., 2023). This captive production provides two main products: the skin, which has high value on the international market, and the meat, with good acceptance on the internal market and brought to table through butchers, restaurants and hotels (VICENTE NETO et al., 2006; FERNANDES et al., 2017). In addition, residues from the slaughter of caiman can be used for the production of meat and bone flour (ALEIXO et al., 2002; GOMES & PHILIPPI, 2018). According to MEDEIROS et al. (2021), who studied the yield of the carcass of caiman *yacare* produced in the Pantanal in captivity, reported on the yield of animals with an average live weight of 6.5 kg ± 1.31 for male and female caiman *yacare*, where they found an average yield of 58.9% ± 3.86 for females and 60.4% ± 2.73 for male animals. Thus, to increase the yield and take advantage of the byproduct, mechanically separated caiman meat (MSCM) is an alternative to increase the yield. The MSCM is obtained by separating the meat adhered to the caiman carcass through a mechanical process of grinding and bone separation (GONÇALVES, 2011; WILHELM et al., 2022). The technology

Received 10.04.22 Approved 09.21.23 Returned by the author 12.14.23
CR-2022-0550.R3
Editors: Rudi Weiblen Rubén Domínguez

of obtaining mechanically separated meat has traditionally been explored for chicken and fish, as highlighted by GONÇALVES (2011). The scientific community has shown interest in investigating its technological properties for product development. HAĆ-SZYMAŃCZUK et al. (2019) evaluated the antioxidant and antimicrobial activity of oregano (*Origanum vulgare L.*) preparations during the storage of low-pressure mechanically separated chicken meat (BAADER meat). SÁ JÚNIOR et al. (2021) conducted a study on optimizing washing cycles for mechanically separated meat and the addition of corn starch in saramunete (*Pseudupeneus maculatus*) sausages. In a similar vein, other researchers developed sausages using mechanically separated Nile Tilapia (*Oreochromis niloticus Linnaeus*, 1758) enriched with pineapple (*Ananas comosus (L.) Merril*) fibers (FREITAS et al., 2022). However, in the context of MSCM, there remains a dearth of information in the scientific literature, underscoring the importance of studying its physical, physicochemical, and technological properties. The mechanically separated meat from caiman *yacare* carcass represents an innovation for food science and technology, considering its potential application for the elaboration of products derived from caiman meat, as well as in formulations of nuggets, emulsified sausages (ALTEMIO et al., 2021; PAIVA et al., 2021). Moreover, caiman meat in recent study described by PAIVA et al. (2021) showed that mechanically separated meat in nugget formulations presented microbiological parameters safe for product consumption. The objective of this research was to promote the better use of the caiman *yacare* carcass, characterize the physical-chemical parameters and analyze the frozen storage time effect.

MATERIALS AND METHODS

Raw material

The caiman carcasses were obtained from two Brazilian companies - Coocrijapan (Cáceres, Brazil) and Caimasul (Corumbá, Brazil), which are duly legalized for caiman breeding in captivity and slaughter. The MSCM was obtained using an HT-250 pulper for chicken and fish (Hightech, Chapecó, Brazil), with frozen carcass (approximately -5 ºC) and the temperature of MSCM freshly produced was 10 – 12 ºC. This process was performance in the Training Abattoir at the Fernando Costa Campus, São Paulo University (Pirassununga, Brazil). After obtaining the MSCM (39% yield), it was portioned in plastic polyethylene packages (500 g of MSCM) and frozen at -20 °C in an ultra-freezer (EcoClima, São Paulo, Brazil), in the same locale. Subsequently, the MSCM was transported to São Paulo State University (São José do Rio Preto, Brazil) for analysis.

Proximate composition and pH

Proximate composition analysis was carried out to determine moisture, ash, protein (AOAC, 2007) and lipid content (BLIGH, & DYER, 1959), in triplicate, and the results were expressed in g/100g. A digital pH meter (Tecnopon, Piracicaba, Brazil) equipped with a penetration glass probe and previously calibrated with two standard solutions (pH 4 and pH 7) at room temperature was used to determine pH of sample over 90 days of frozen storage. The samples are at room temperature too.

Lipid oxidation, total volatile bases and color parameters

The lipid oxidation was evaluated using the TBARS (thiobarbituric acid reactive substances) values according to VYNCHE (1970). The values were expressed as mg of malonaldehyde per kilogram of sample (mg MDA.kg $^{-1}$). The total volatile bases (TVB) were determined according to HOWGATE (1976). The color parameters were measured using a ColorFlex 45/0 colorimeter (Hunterlab, Virginia, USA), aperture 0.75, illuminant D65 and viewing angle 10°, linked to Universal software version 4.10 (Hunterlab, Virginia, USA). The samples were thawed during 2 hours at 4 ºC and 30 minutes at room temperature before this analysis, and ten measurements were taken in each point between 0 and 90 days of frozen storage. All the other analyses were performed after 0, 30, 60 and 90 days of frozen storage, in triplicate. The results of the all analysis of the two sample of MSCM, as they presented a low variation between them, were statistically analyzed observing the storage time.

Statistical analysis

Analysis of variance (ANOVA) was performed using the General Linear Model (GLM) procedure of the *Statistica* software, version 10.0 (Statsoft Inc., USA) and means were compared by the Tukey test ($P < 0.05$). Triplicate sampling x one treatment (MSCM) x four times of storage (0, 30, 60 and 90 days) were analyzed for pH, TBARS, TVB and instrumental color parameters (dependent variable). For statistical analysis, the raw meat material of each producer was considered as random term and storage time when the sampling occurred was considered a fixed effect.

RESULTS AND DISCUSSION

The MSCM presented 77.89 ± 1.39% moisture, 17.45 ± 0.43% protein, 2.43 ± 1.18% lipid, 2.23 ± 0.35% ash content and the yield was 39%. These results corroborated those obtained by SIMONCINI et al. (2020), who evaluated the “in natura” meat of captive-bred Caiman *latirostris*, where the results of humidity were 77.15% ± 0.39, protein 20.54 ± 0.26 and lipids 0.80% ± 0.33. Furthermore, the values found for moisture and protein in MSCM are higher than those found in mechanically separated meat (MSM) from other animal sources such as chicken (OLIVEIRA et al., 2014) and Nile tilapia (BERNADINO FILHO & XAVIER, 2019), while the lipid value was lower when compared with these same studies. There is nothing in the scientific literature about the characterization of MSCM. For the pH, the MSCM presented values between 6.52 and 6.64, which were similar to those found in MSM of pacu fish (*Piaractus mesopotamicus*) stored under freezing for 120 days (ZUANAZZI et al., 2016) and european sea-bass, golden, sea and rainbow trout stored under freezing for 90 days (SECCI et al., 2016). The gradual increase of pH can indicate protein degradation, with the production of substances such as ammonia and other amines (KIRSCHNI & MACEDO-VIEGAS, 2009) but this was not the case in this study.

The TBARS values increased (P < 0.05) over frozen storage time (Table 1), the highest value being found after 90 days of storage. The values varied between 0.261 to 0.505 mg of malonaldehyde/ kg of sample, lower values than those found by TRINDADE et al. (2008) in mechanically separated chicken meat stored at -18 °C for 99 days, and similar to those found in MCM chicken stored from 0 to 9 months under freezing (CEGIELKA et al., 2019). The lipid oxidation in meat and meat products is influenced by the amount of lipids and fatty acids present. The process of obtaining MSCM itself favors the destruction of muscle membranes, facilitating the interaction of oxidizing agents with polyunsaturated fatty acids, resulting in the propagation of oxidative reactions (LAROSA et al., 2012). However, the TBARS values found for MSCM in this study were within acceptable sensory conditions that are described by OSPINA et al. (2015), which the values found were less than < 1.0 mg malonaldehyde/kg sample.

For total volatile bases, there was no difference (P < 0.05) during frozen storage (Table 1). The values obtained (4.78 – 6.88 mg/100g of sample) are lower than those found in MSM from the Nile tilapia (*Oreochromis niloticus*) during storage at -18 ºC (KIRSCHNIK & MACEDO-VIEGAS, 2009). The production of total volatile bases during storage of fish is the result of enzyme action of tissues and microbiological activity, being composed mainly of ammonia, trimethylamine, dimethylamine and, probably, by traces of mono methylamine and propylamine, which would be formed in more advanced stages of decomposition (CONTRERAS-GUZMÁN, 2002). However, the values found for TVB in this study are below the recommended acceptable limit for fresh fish in Brazil, which is 30mg/100g (BRAZIL, 2017). The results of pH, TBARS and TVB found in this study showed good stability of MSCM during frozen storage for 90 days, showing MSCM to be adequate for processing derivative products from caiman meat.

The L^* value was significantly higher (P < 0.05) at 30 days of frozen storage (Table 1). The L^* values varied from 48.34 to 51.85 and were lower than those reported by ZUANAZZI et al. (2016) in

Table 1 - pH, TBARS (mg malonaldehyde/kg of sample), total volatile bases (mg/100g) and instrumental color in mechanically separated caiman meat.

	-------0 day-------	-----30 days-----	-----60 days-----	-----90 days-----	------SEM------	-----P Value-----
pH	6.54	6.64	6.50	6.52	0.03	0.28^{ns}
TBARS	0.261^b	0.331^b	0.323^b	0.505^a	0.03	< 0.01
TVB	6.42	5.37	4.78	6.88	0.31	ns
L	49.51^b	51.85^a	48.34^c	48.92^{bc}	0.17	< 0.01
a^*	7.58^a	6.53^b	7.43^a	6.13^b	0.10	< 0.01
b^*	12.46^b	12.49^b	13.51^a	13.45^a	0.08	< 0.01

^{a,b,c} Different lowercase letters on the same line represent difference (P < 0.05) between times.
Instrumental color: L^* = Lightness, a^* = redness and b^* = yellowness.
SEM = standard error.
ns = not significant.

MSM from pacu (*Piaractus mesopotamicus*) stored frozen for 120 days. The lightness is influenced by the amount of water on the surface of the matrix, a consequence of the water retention capacity (REHBEIN & OEHLENSCHLÄGER, 2009; ANDRADE et al., 2010). BARBUT & YOUSSEF (2016) checked that the L* values of sausages depend on the fat content, being directly linked to the surface in meat and meat products. The a* values varied from 6.13 to 7.58, higher values than those found in research performed with MSM from Nile tilapia stored for 120 days under freezing (LAROSA et al., 2012) and MSM from pacu (*Piaractus mesopotamicus*) stored under freezing for 120 days (ZUANAZZI et al., 2016). The b* values increased over storage time and stayed between 12.46 and 13.51, higher values than those found for MSM from Nile tilapia (LAROSA et al., 2012) and lower values than those found for MSM from pacu (*Piaractus mesopotamicus*) (ZUANAZZI et al., 2016).

CONCLUSION

The mechanically separated meat of the Pantanal caiman (*Caiman yacare*) had low lipid and high protein content when compared to other meat raw materials, besides showing good oxidative and color stability during 90 days of frozen storage. These results demonstrated that mechanically separated caiman meat is a suitable raw material for use in developing new caiman meat products, contributing as a potential ingredient in the meat products market.

ACKNOWLEDGEMENTS

The authors would like to thank the Coocrijapan Ltda. and Caimasul Ltda. companies for their support. Marco Antonio Trindade and Andrea Carla da Silva Barretto are members of the HealthyMeat network, funded by CYTED (ref. 119RT0568).

DECLARATION OF CONFLICT OF INTERESTS

The authors reported having no conflicts of interest.

AUTHORS' CONTRIBUTIONS

The authors contributed equally to the manuscript.

REFERENCES

ALEIXO, V. M. et al. Effects of addition different levels of soybean meal to the diet on the development of puppies caiman from Pantanal (*Caiman yacare*, Daudin, 1802). **Ciência e Agrotecnologia**, v.26, n.2, p.411–417, 2002. Available from: <https://silo.tips/queue/the-effect-of-the-addition-of-different-soybean-meal-on-the-performance-of-caima?&queue_id=1&v=1640483969&u=MTc3LjIwMC4yMzAuNg==>. Accessed: Mar. 18, 2021.

ANDRADE, P. L. et al. Qualidade da carne maturada de bovinos Red Norte e Nelore. **Revista Brasileira de Zootecnia**, v.39, n.8, p.1791-1800, 2010. Available from: <https://www.scielo.br/j/rbz/a/QNXJhV8TfZwFM8qypjPj5Kk/abstract/?lang=pt>. Accessed: Mar. 18, 2021. doi: 10.1590/S1516-35982010000800023.

ALTEMIO, A. D. C. et al. Development and characterization of low fat cooked yacare (*Caiman yacare*) meat sausages. **Meat Tecnhology**, v.62, n.2, p.130-139, 2021. Available from: <https://www.journalmeattechnology.com/index.php/meat_technology/article/view/2021.62.2.6>. Accessed: Mar. 20, 2022. doi:10.18485/meattech.2021.62.2.6.

AOAC. **Official methods of analysis of AOAC** (Association of Official Analytical Chemists), Gaithersburg, 18th ed., 2007. Available from: <https://www.scirp.org/(S(i43dyn45teexjx455qlt3d2q))/reference/ReferencesPapers.aspx?ReferenceID=1753366>. Accessed: Mar. 18, 2021.

BARBUT, S.; YOUSSEF, M. Effect of gradual heating and fat/oil type on emulsion stability, texture, color, and microstructure of meat batters. **Journal of Food Science**. In press, 2016. Available from: <https://ift.onlinelibrary.wiley.com/doi/10.1111/1750-3841.13420>. Accessed: Mar. 18, 2021. doi: 10.1111/1750-3841.13420.

BERNADINO FILHO, R.; XAVIER, L. C. A. Obtenção, rendimento e caracterização de CMS produzida com resíduos da filetagem de tilápia do Nilo. **Revista Brasileira de Agrotecnologia**, v.9, n.2, p.01-04, 2019. Available from: <https://www.gvaa.com.br/revista/index.php/REBAGRO/article/view/7534>. Accessed: Mar. 18, 2021. doi: 10.18378/rebagro.v9i2.7534.

BLIGH, E. G.; DYER, W. J. A. Rapid method for total lipid extraction and purification. **Canadian Journal of Biochemistry and Physiology**, v.37, p.911−917, 1959. Available from: <https://pubmed.ncbi.nlm.nih.gov/13671378>. Accessed: Mar. 18, 2021. doi: 10.1139/o59-099.

BRAZIL. Ministry of Agriculture, Livestock and Supply. **Decreto n. 9.013, de 29 de março de 2017**, Regulation of industrial and sanitary inspect products of animal origin. Available from: <http://www.planalto.gov.br/ccivil_03/_Ato2015-2018/2017/Decreto/D9013.htm#art541>. Accessed: Mar. 18, 2021.

CEGIELKA, A. et al. The use of bioactive properties of sage preparations to improve the storagestability of low-pressure mechanically separated meat from chickens. **Poultry Science**, v.98, n.10, p.5045–5053, 2019. Available from: <https://www.sciencedirect.com/science/article/pii/S0032579119480255>. Accessed: Mar. 18, 2021. doi: 10.3382/ps/pez242.

CONTRERAS-GUZMÁN, E. S. **Bioquímica de pescados e invertebrados**. Santiago: CECTA-USACH, 2002, 309p.

CORDEIRO, M. W. S. et al. Effect of gama irradiation on the quality caracteristics of frozen yacare caiman (*Caiman crocodillus yacare*) meat. **Meat Science**, v.185, p.108728, 2022. Available from: <https://www-sciencedirect.ez111.periodicos.capes.gov.br/science/article/pii/S0309174021003144>. Accessed: May, 16, 2023. doi: 10.1016/j.meatsci.2021.108728.

FERNANDES, V. R. T. et al. Commercial cuts of Pantanal caiman meat according to sex. **Ciência Rural**, v.47, n.02, e20160195, 2017. Available from: <https://www.scielo.br/j/cr/a/gCSgY4Bwsg8B3yDJYWTQJTK/abstract/?lang=en>. Accessed: Mar. 18, 2021. doi: 10.1590/0103-8478cr20160195.

FREITAS, S. J. et al. Nile Tilapia (*Oreochromis niloticus Linnaeus*, 1758) Sausages Developed from Mechanically Separated Meat (MSM) and Enriched with Pineapple (*Ananas comosus* (L.) Merril) Fibers. **Journal of Aquatic Food Product Technology**, v.31, n.8, p.801-813, 2022. Available from: <https://www.tandfonline.com/doi/abs/10.1080/10498850.2022.2106806>. Accessed: Mar. 20, 2022. doi: 10.1080/10498850.2022.2106806.

GOMES, L. S.; PHILIPPI, D. A. Características sustentáveis de inovações da carne e do couro de jacaré: estudo de caso na Caimasul. **Brazilian Applied Science Review**, Curitiba, v.2, n.4, Edição Especial, p.1315-1333, 2018. Available from: <https://brazilianjournals.com/ojs/index.php/BASR/article/view/518>. Accessed: Mar. 18, 2021. doi: 10.34115/basr.v2i4.518.

GONÇALVES, A. A. **Tecnologia do pescado: ciência, tecnologia, inovação e legislação**. São Paulo: Atheneu, 2011, 608p.

HAĆ-SZYMAŃCZUK, E. et al. Evaluation of antioxidant and antimicrobial activity of oregano (*Origanum vulgare* L.) preparations during storage of low-pressure mechanically separated meat (BAADER meat) from chickens. **Food Science Biotechnology**, v.28, n.2, p.449–457. 2019. Available from: <https://link.springer.com/article/10.1007/s10068-018-0491-1>. Accessed: Mar. 18, 2021. doi: 10.1007/s10068-018-0491-1.

HOWGATE, P. **Determination of total volatile bases**. Torry Research Station. Aberdeen, TD 564, Appendix 4, 1976.

KIRSCHNIK, P. G.; MACEDO-VIEGAS, E. M. Efeito da lavagem e da adição de aditivos sobre a estabilidade de carne mecanicamente separada de tilápia do Nilo (Oreochromis niloticus) durante estocagem a –18 °C. **Ciência e Tecnologia de Alimentos**, v.29, n.1, p.200-206, 2009. Available from: <https://www.scielo.br/j/cta/a/PbcrBMkdhBn9D5yygPbTzGx/?lang=pt>. Accessed: Mar. 18, 2021. doi: 10.1590/S0101-20612009000100031.

LAROSA, G. et al. Elaboração de produto cárneo de tilápia com antioxidantes visando sua utilização como recheio ou acompanhamento da refeição. **Alimentos e Nutrição**, v. 23, n. 4, p.609-617, 2012. Available from: <http://serv-bib.fcfar.unesp.br/seer/index.php/alimentos/article/viewArticle/609>. Accessed: Out. 15, 2023.

MEDEIROS, N. B. C. Carcass and commercial cuts yields of caiman (*Caiman crocodilus yacare*) farmed in a ranching system in the Brazilian Pantanal. **Anais Da Academia Brasileira De Ciências**, v.93, n.4, 2021. Available from: <http://www.scielo.br/j/aabc/a/jGT9PS7TTj6rgLHCZZn63wzD/>. Accessed: Mar. 18, 2021. doi: 10.1590/0001-3765202120190949.

OLIVEIRA, M. S. R. et al. Utilização da carne mecanicamente separada de frango para a produção de hidrolisados proteicos a partir de diferentes enzimas proteolíticas. **Semina: Ciências Agrárias**, v.35, n.1, p.291-302, 2014. Available from: <https://www.redalyc.org/articulo.oa?id=445744139024>. Accessed: Mar. 18, 2021. doi: 0.5433/1679-0359.2014v35n1p291.

OSPINA-E, J. C. et al. Development of frankfurter-type sausages with healthy lipid formulation and their nutritional, sensory and stability properties. **European Journal of Lipid Science and Technology**, v.117, n.1, p.122-131, 2015. Available from: <https://onlinelibrary-wiley.ez87.periodicos.capes.gov.br/doi/full/10.1002/ejlt.201400157>. Accessed: Mar. 18, 2021. doi: 10.1002/ejlt.201400157.

PAIVA, G. B. et al. Antioxidant effect of acerola fruit powder, rosemary and licorice extract in caiman meat nuggets containing mechanically separated caiman meat. **Meat Science**, v.173, 108406, 2021. Available from: <https://www.sciencedirect.ez111.periodicos.capes.gov.br/science/article/pii/s030917402030838X>. Accessed: Mar. 20, 2022. doi: 10.1016/j.meatsci.2020.108406.

REHBEIN, H.; OEHLENSCHLAGER, J. **Fishery products: quality, safety and authenticity**. Wiley-Blackwell, 2009, 496p.

ROMANELLI, P. F. et al. Processamento da carne do jacaré do Pantanal (*Caiman crocodilus yacare*). **Ciência e Tecnologia de Alimentos**, v.22, n.1, p.70-75, 2002. Available from: <https://www.scielo.br/j/cta/a/TrhsT4QRyVrSg4gyQnyvFTj/?lang=pt>. Accessed: Mar. 18, 2021. doi: 10.1590/S0101-20612002000100013.

SÁ JÚNIOR, P. L. S. et al. Optimization of mechanically separated meat washing cycles and of corn starch addition in saramunete (*Pseudupeneus maculatus*) sausages. **Journal of Processing and Preservation**, v.45, n.16093, 2021. Available from: <https://ifst.onlinelibrary.wiley.com/doi/10.1111/jfpp.16093>. Accessed: Mar. 20, 2022. doi 10.1111/jfpp.16093.

SANCHES, M. A. R. et al. Mass transfer modeling during wet salting of caiman meat (*Caiman crocodillus yacare*) at different brine temperatures. **Meat Science**, 199, 109128, 2023.Available from: <https://www-sciencedirect.ez111.periodicos.capes.gov.br/science/article/pii/S0309174023000347?ref=cra_js_challenge&fr=RR-1>. Acessed: May, 16, 2023. doi: 10.1026/j.meatsci.2023.109128.

SECCI, G. et al. Effect of mechanical separation process on lipid oxidation in European aquacultured sea bass, gilthead sea bream, and rainbow trout products. **Food Control**, v.67, p.75-81, 2016. Available from: <https://www-ciencedirect.ez87.periodicos.capes.gov.br/science/article/pii/S0956713516300792?via%3Dihub>. Accessed: Mar. 18, 2021. doi: 10.1016/j.foodcont.2016.02.033.

SIMONCINI, M. S. et al. Caiman latirostris meat characterization: Evaluation of the nutritional, physical and chemical properties of meat from sustainable ranching program in Argentina. **Aquaculture**, v.515, 734570, 2019. Available from: <https://www.sciencedirect.com/science/article/abs/pii/s0033848619307033>. Accessed: Mar. 20, 2022. doi: 10.1016/j.aquaculture.2019.734570.

TRINDADE, M. A. et al. Estabilidade oxidativa e microbiológica em carne de galinha mecanicamente separada e adicionada de antioxidantes durante período de armazenamento a –18 °C. **Ciência Tecnologia de Alimentos**, v.28, n.1, p.160-168, 2008. Available from: <https://www.scielo.br/j/cta/a/F7ZTHVkwdJt9RkRgtrCwX6r/?lang=pt>. Accessed: Mar. 18, 2021. doi: 10.1590/S0101-20612008000100023.

VICENTE NETO, J. et al. Composição centesimal e colesterol da carne de jacaré-do-pantanal (*Caiman yacare* Daudin

1802) oriundo de zoocriadouro e habitat natural. **Ciência Agrotecnologia**, v. 30, n. 4, p.701-706, 2006. Available from: <https://www.scielo.br/j/cagro/a/JPRcMbyJ8VSmYBnYspcfwbS/?lang=pt>. Accessed: Mar. 18, 2021. doi: 10.1590/S1413-70542006000400016.

VYNCHE, W. Direct detemination of the thiobarbituric acid value in thricloracetic acid extracts of fish as a meansure of oxidative rancidity. **Fette Sefein Anstrichmittel**, v.72, n.12, p.1084−1087, 1970. Available from: <https://onlinelibrary.wiley.com/doi/abs/10.1002/lipi.19700721218>. Accessed: Mar. 18, 2021. doi: 10.1002/lipi.19700721218.

WILHELM, C. et al. Detection of Mechanically Separated Meat from Chicken in Sausages and Cold Meat by Targeted LC–MS/MS. **Analysis Food Analytical Methods**, v.15, p.1899-1980, 2022. Available from: <https://link.springer.com/article/10.1007/s12161-022-02231-4>. Accessed: Mar. 20, 2022. doi: 10.1007/s12161-022-02231-4.

ZUANAZZI, J. S. G. et al. Additives in conservation of meat mechanically separated from pacu cultivated in net-tanks. **Brazilian Journal of Agroindustrial Products**, v.18, n.3, p.265-273, 2016. Available from: <http://www.deag.ufcg.edu.br/rbpa/rev183.html>. Accessed: Mar. 18, 2021.