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Iron Content in Wild Animal Meats: A Systematic Review Comparing Mammals and Birds

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ABSTRACT

From a nutritional perspective, the viscera of animals are typically richer in iron compared to their muscles, and red meats generally contain more iron than white meats. However, the evidence characterizing iron levels in wild animals is limited. This study aimed to systematically review the iron content in the muscles and viscera of wild mammals and birds. Using PRISMA standards and databases such as Web of Science, Medline/PubMed, and Scopus, we analyzed data from eight pertinent studies. Our findings indicate a disparity in iron content between the viscera and muscles of mammals, with the former exhibiting almost six times the iron content (mean of 15.22 mg per 100g, Pooled Standard Deviation (PSD): 2.07) compared to the latter (mean of 2.56 mg, PSD: 0.28). Additionally, the iron content in the muscles of birds (mean of 3.62 mg, PSD: 4.95) is nearly 40% higher than that in mammalian muscles. This result may be attributed to factors such as slaughter methods, which prevent external bleeding, or the migratory habits of birds, leading to more developed wing muscles with higher iron content. Our study challenges the established notion that red meats have higher iron levels than white meats, suggesting that this rationale may not hold true in the context of wild meats. Future research is needed to further explore and validate these preliminary findings, enhancing our understanding of the nutritional value of wild meats.

Keywords: Wild animals, Biodiversity, Food and nutritional security, Nutritional composition, Iron.

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SIGNIFICANCE STATEMENT

This study offers novel insights into the iron content of wild animal meats, revealing that bird muscles may contain more iron than those of mammals, challenging established knowledge in nutrition. Our systematic review provides a comprehensive analysis of the iron content in the muscles and viscera of wild mammals and birds, addressing crucial data gaps in nutritional science. These findings are particularly significant for Indigenous Peoples and Local Communities (IPLC) who rely on wild meat as a relevant food source. This research bridges gaps between ethnobiological and nutritional knowledge, informing future studies and supporting the development of conservation policies and dietary practices within traditional food systems.

INTRODUCTION

Wild animal meat, or wildmeat, plays a crucial role in food security for Indigenous Peoples and Local Communities (IPLC) worldwide (Nielsen et al. 2018; Khambalia et al. 2011). The term "wild meat" refers to the meat of wild animals, especially non-aquatic vertebrates (such as mammals, reptiles, and birds), taken from their natural habitats for human consumption (Nasi et al. 2008). Beyond sustenance, wild meat consumption is intrinsically linked to cultural heritage and serves as an adaptive strategy in contexts of social vulnerability (Ingram 2020). However, our understanding of its nutritional composition, particularly micronutrient content, remains limited (Jacob et al. 2020; 2023).

From a nutritional perspective, animal viscera typically contain higher iron levels compared to muscles, and red meats generally have more iron than white meats (Lawrie 2005; Cardoso 2006; Zhuo et al. 2013). This correlation is well-documented in domesticated meats (Roça 2012). However, evidence characterizing iron levels in wild animals is scarce. This knowledge gap is significant, considering the potential impact of wild meat consumption on health outcomes, particularly in addressing iron deficiency anemia (IDA).

Iron deficiency anemia (IDA) is a type of anemia that occurs when there is insufficient iron in the body, with inadequate iron intake being one of its primary causes (National Institute of Health 2023). It is estimated that the global prevalence of IDA is 16.42% among children under five years old (Geldfie et al. 2022). IDA poses a serious public health problem on a global scale, particularly affecting young children and pregnant women in developing countries (World Health Organization 2017). However, this is not exclusively a problem of developing countries. IPLC in developed countries also suffer from high rates of IDA. In Canada and Australia, for instance, indigenous populations, particularly pregnant women and children, show significantly higher prevalence of anemia compared to non-indigenous populations (Khambalia et al. 2011; Shafiee et al. 2022). Anemia can have a profound negative impact on the social sphere. For instance, its symptoms related to reduced human cognitive performance can affect academic performance and, consequently, a country's economic development, contributing to the perpetuation of poverty and a low level of human capital (Li et al. 2018).

Studies conducted in various locations, such as the Amazon and Madagascar, underscore the significance of wild meat consumption for child health and its direct impact on hemoglobin levels. Research in the Amazon region established a correlation between wild meat consumption and children's health, revealing that this practice is associated with an average increase in hemoglobin concentration of 0.25 g/dL among children in vulnerable rural areas (Torres et al. 2022). Similarly, a study conducted in Madagascar, which also explored the relationship between hemoglobin levels and wild meat consumption, found that families most dependent on this practice are also the most economically disadvantaged. These families exhibited a four-fold higher likelihood of developing anemia following a loss of access to wildlife (Golden et al. 2011).

As demonstrated, studies linking wild animal consumption with IDA typically focus on the outcomes of anemia rather than evaluating the nutritional composition of the meat itself. This highlights a significant gap in the literature regarding the food composition of wild resources and the need to understand its variation within the framework of diverse cultures and peoples (Jacob et al. 2021). Therefore, the goal of this study is to characterize the iron content in the muscles and viscera of wild mammals and birds. Given the ethical and legal challenges in studying wild meat (Hayward et al. 2019) and the scarcity of comprehensive nutritional data, we conducted a systematic review of existing literature to address this gap. Our research aims to answer the question: What is the iron content of wild mammal and bird meat?

MATERIAL AND METHODS

We conducted this review following the guidelines established in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al. 2021) (Additional File 1). The protocol for this review did not require prior registration since the research did not directly investigate any health outcomes.

Selection Criteria and Search

We selected articles based on the following eligibility criteria: (i) original articles published in any language, with no date restrictions, and (ii) presenting data on the iron composition of meat from wild animals consumed by human populations. Among these studies, we excluded those that (i) analyzed secondary data and (ii) did not detail the methodology of food composition analysis.

During June 2022, we conducted the search in the Web of Science, Scopus, and Medline/PubMed databases (via National Library of Medicine). The search involved the application of descriptors in each database. The following strategy guided the search: ("BUSHMEAT" OR "WILD MEAT" OR "GAME MEAT" OR "INDIGENOUS MEAT" OR "WILD ANIMALS" OR "HUNTING ANIMALS MEAT") AND ("FOOD CONSUMPTION" OR "FOOD INTAKE" OR "DIETARY") AND ("MICRONUTRIENT" OR "NUTRIENT" OR "NUTRITION" OR "FOOD COMPOSITION" OR "MINERAL"). We also consulted experts to receive recommendations on potential studies to be included in our review. We adopted a comprehensive approach in searching for information on micronutrients, rather than focusing exclusively on iron. This choice is justified by the fact that the present study is part of a broader investigation, in which a variety of nutrients are being examined.

Study Selection

We utilized the Rayyan tool to organize the records and remove duplicates found in the search. Three authors (ALSM, MFAM, ALBO) independently selected the articles, applying the eligibility criteria. In the initial screening, titles and abstracts that did not meet the inclusion criteria were excluded. To address discrepancies or uncertainties, such as whether certain wild animals were consumed as food by human populations, two authors (MCMJ, JKSM) were consulted. Subsequently, potentially eligible texts were read in full. After the reading, inclusion, and exclusion process, the selected articles were stored in reference management software.

Data Extraction

Three authors (ALSM, MFAM, and ALBO) independently extracted data from the selected articles to ensure the accuracy of information transcription. For the purpose of this project, two spreadsheets were organized. The first one contains the identification information of the articles, for which we assigned codes to facilitate cross-referencing with the other sets. The second one contains the variables of interest in the research, namely: taxonomy, animal class, analyzed body part, and iron concentration. When necessary, nutritional composition data were converted and standardized in wet weight.

Quality Analysis

To date, there are no records in the literature of specific quality questionnaires for assessing studies on the nutritional composition of wild animals. In response to this gap, we created a questionnaire (Additional File 2) to evaluate the methodological quality of the studies, given our need to enhance the transparency and specificity of the results, and ethical and legal issues of the articles comprising the review. Examples of specific criteria to be addressed in our research and not covered in previous single protocols include topics related to conflicts of interest and funding. The choice of these aspects is grounded in the sensitive ethical context involved in the theme of wild animals. Therefore, we decided to create our own protocol, addressing the most relevant points of these documents and adapting them to the reality of studies on the nutritional composition of wild animal meat. The development of this instrument followed an integrative approach, incorporating elements from existing related protocols, such as LatinFoods/FAO (Masson 1999), QUADAS (Whiting et al. 2003), STROBE (von Elm et al. 2008), among others.

The questionnaire used in this study consisted of a checklist with nine items, covering topics such as study design and sample size, taxonomic accuracy of animal description, procedures employed in sample processing, source of funding, conflicts of interest, etc. For each of the questions, we developed structured responses and scoring: "Yes/Not applicable", equivalent to 1.0 point; "Not clear", 0.5; and, finally, "No", 0.

Three trained assessors (ALSM, MFAM, and ALBO) independently used the questionnaire to assess one of the articles in the review to evaluate the clarity of the instrument. Subsequently, individual results were discussed with the research team, and the instrument was refined and thereafter used in the assessment of the remaining articles. Three trained assessors evaluated all of the articles independently using the checklist, and an average score was calculated for each article.

The articles were categorized into three levels of quality: low quality (0 to 2.9 points); medium quality (3.0 to 5.9 points); and high quality ($>$ 6.0 points). The agreement among the assessors was measured using Fleiss' Kappa (Everitt and Fleiss 1981).

Data Analysis

Due to the unavailability of raw data from the reviewed studies, our analysis relied solely on reported mean values. This approach, while necessary, may have limited our ability to fully capture data variability. To maintain data integrity, we treated multiple studies reporting on the same species as independent data points within our data frame (Additional File 3). Similarly, even when presented collectively as "muscle" in the Results, data for breast and thigh were recorded separately to facilitate comparisons between these distinct tissue types.

We performed a descriptive statistical analysis of iron content in different animal species and groups. First, we calculated weighted mean iron content values for each species, accounting for varying sample sizes across studies. To represent the variability within species, we calculated a pooled standard deviation for each species, combining data from multiple samples when available. Additionally, we calculated pooled standard deviations for three distinct groups: mammal muscle, mammal viscera, and bird muscle. This approach allowed us to quantify the overall variation in iron content within each group. Due to the lack of detailed information on potential confounding factors within the source material, we focused on these descriptive statistics to characterize the central tendency and variability of iron content across species and groups. All statistical analyses were conducted using the Python programming language within the Jupyter Notebook environment.

RESULTS AND DISCUSSION

Study Selection

Following the database review, we identified a total of 565 articles (Web of Science: 68, Medline/PubMed: 325, Scopus: 172). After excluding 142 duplicates, we proceeded to analyze the titles and abstracts of 423 articles. Of these, 75 articles were selected for full-text reading. At this stage, 67 articles were excluded, with five presenting secondary data, 56 being incomplete and not adequately meeting methodological, sampling, statistical analysis, and coherent presentation of results criteria, and six lacking information on iron composition.

Consequently, after screening, eight articles remained that met the criteria for iron mineral analysis. Data from 943 samples of wild meat were assessed in these articles. The selection of articles is schematically presented in Figure 1 and Table 1 presents synthesis of the analyzed studies.

Study Quality

We analyzed the quality of the eight articles, and the agreement among assessors was excellent (Fleiss' Kappa = 0.833). The average quality of the articles was high at 6.52 (Additional File 4), and no article was assessed as low quality. Articles scored highest on criteria related to the detailed reporting of sample processing procedures, analytical methods, and results presentation. Conversely, lower scores were assigned to articles that omitted species' scientific names or lacked information regarding potential conflicts of interest and funding sources. The absence of taxonomic information is relatively less problematic for fauna, due to their distinct characteristics and larger size, which generally make them easier to identify compared to plants or other natural resources with more subtle differences (Bowler et al. 2024)

Analysis of Iron Content in the Studies

In our review, we analyzed nine animal species (Figure 2), including six mammals and three birds.

The overall average iron content in the meats analyzed varied from 2.56 to 15.227 mg, with a high standard deviation (2.46 mg), given the significant variation in iron among different species and even among muscles and viscera. The highest iron concentration was found in the viscera of *Odocoileus virginianus* (white-tailed deer), with an average of 16.13 mg of iron per 100g. Conversely, the lowest value was found in the muscle of *Alces alces* (elk), with a mean iron content of 0.33 mg per 100g. Among the bird species, the animal with the highest iron concentration was *Columba palumbus* (woodpigeon), with an average iron content of 3.96 mg per 100g, having a higher iron concentration in its muscles than some mammalian species.

Figure 3 presents the comparison of iron content considering the different types of animals analyzed.

The results offer insights into the iron content of wild animal meats, particularly between mammals and birds. Due to the lack of data on bird offal, a comprehensive comparison was not possible. Mammal viscera (15.22 mg) have on average almost six times the iron content of their muscle (2.56 mg). Additionally, we found interesting patterns of iron in muscles of birds (3.62 mg), which on average contain over 40% more iron than mammal muscles. Based on these observations, we draw the following conclusions, which we elaborate on in the subsequent sections. Based on these results, we draw the following conclusions, which we elaborate on in the following sections.

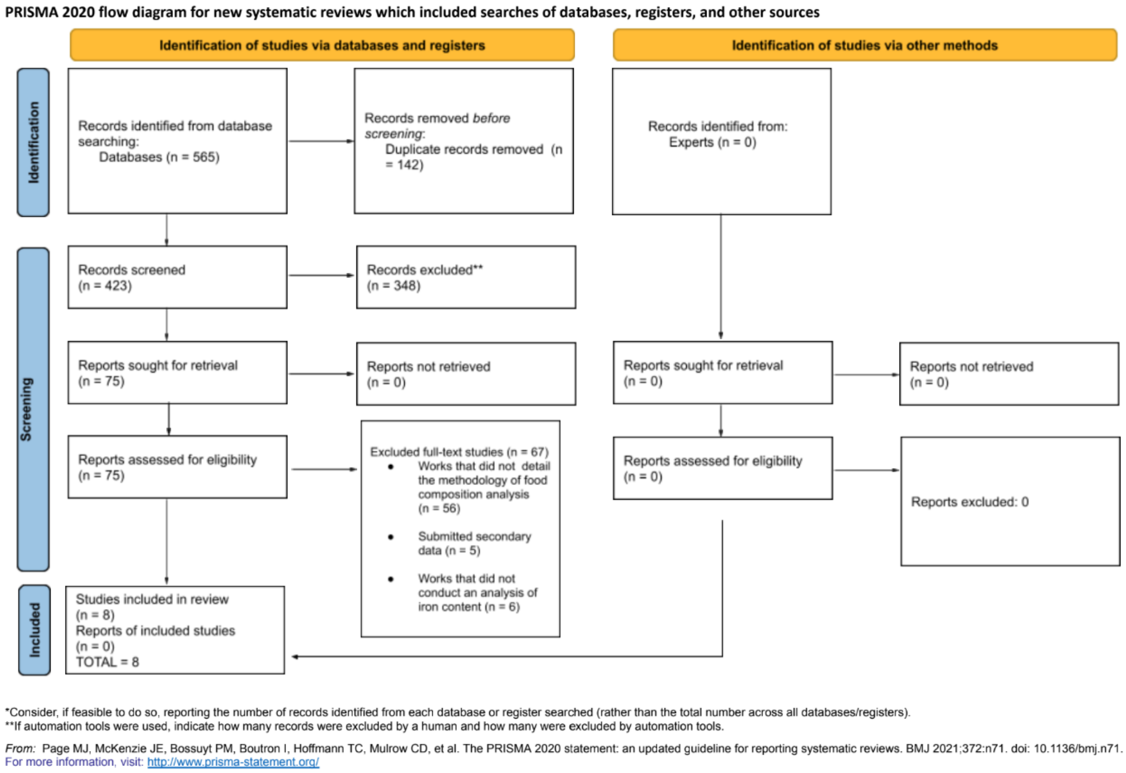

Figure 1. Flowchart of the study selection process.

Figure 2. Wild animals analyzed for their meat's iron content. Species are listed alphabetically from top to bottom and left to right. The species included are: (a) *Alces alces*, (b) *Capreolus capreolus*, (c) *Cervus elaphus*, (d) *Columba palumbus*, (e) *Odocoileus hemionus*, (f) *Odocoileus virginianus*, (g) *Streptopelia turtur*, (h) *Sus scrofa*, (i) *Turdus philomelos.* Species images courtesy of the IUCN Red List of Threatened Species.

Table 1. Characterization of studies on the nutritional composition of wild animals.

#	Publication data (authors, year, and journal)	Study objective	Country of sample collection	Animals collected	Number of samples (part)	Study quality
1	Dannenberger et al. 2012; *Meat Science*	Investigate the effects of gender, age, and region on the macronutrients, micronutrients, and fatty acid profiles of wild boar and deer muscles.	Germany	Wild roe deer (*Capreolus capreolus*), Wild boar (*Sus scrofa*)	203 (*Longissimus muscle*)	High (6.50)
2	Johnson et al. 2007; *Journal of Wildlife Diseases*	They evaluated the mineral content of the horn, liver, and forage to measure deficiencies and toxicities.	United States of America	Tule elk (*Cervus elaphus nannodes*)	240 (Liver)	Medium (5.50)
3	Lorenzo et al. 2018; *Journal of the Science of Food and Agriculture*	Investigate the effects of the age of slaughter on the levels of macro and microminerals in wild deer meat.	Spain	Red deer (*Cervus elaphus*)	150 (Muscle)	Medium (8.50)
4	Milczarek et al. 2021; *Animais*	Compare the proximate composition of nutrients in the meat of roe deer and wild deer.	Poland	Wild roe deer *(Capreolus capreolus),* Red deer *(Cervus elaphus)*	60 (*Semimembranosus muscle*)	High (8.33)
5	Serrano et al. 2020; *Scientific Reports*	Evaluate for the first time the combined impact of country of origin and the type of slaughter/season on the quality and nutritional value of red deer meat.	Spain and New Zealand	Red deer (*Cervus elaphus*)	24 (*Longissimus thoracis et lumborum*)	High (9.0)
6	Sevillano-Caño et al. 2020; *Biological Trace Element Research*	To determine the micronutrient content and the nutritional/toxicological value of game bird meat.	Spain	Wood pigeon (*Columba palumbus),* Wild turtle dove (*Streptopelia turtur*), wild thrush (*Turdus philomelos*)	89 (Breast and thigh)	High (6.50)
7	Strazdiòa et al. 2013; *Proceedings of the Latvian Academy of Sciences*	To compare the nutritional value of elk, wild deer, farmed deer, roe deer, and wild boar.	Latvia	Elk *(Alces alces),* Red deer *(Cervus elaphus),* Wild boar *(Sus scrofa),* Wild roe deer*(Capreolus capreolus).*	54 (Muscle)	Medium(5.00)
8	Zimmerman et al. 2008; *Journal of Wildlife Diseases*	Evaluate the baseline liver mineral concentrations of deer using different habitats.	United States of America	White-tailed deer (*Odocoileus virginianus*), mule deer (*Odocoileus hemionus*)	83 (Liver)	High (5.50)

Wild animal meats are an important source of iron

Based on the data analyzed in this study, we conclude that wild meat presents significant iron content and can be considered a source of this mineral, with more than 5% of the Dietary Reference Intake (DRI) value in a typical portion of each of the nine species considered in this study (Institute of Medicine 2001).

For instance, the reference values for the recommended daily intake of iron are 27 mg/day for pregnant women, 18 for women, 8 for men, 7 for children aged 1 to 3 years, and 10 for children aged 4 to 8 years (National Institute of Health 2023). When comparing these recommendations with the iron content of the viscera of *Cervus elaphus* (14.09 mg), *Odocoileus hemionus* (15.44 mg), and *Odocoileus virginianus* (16.14 mg), we observe that the consumption of 100 g of the meat per day would cover the recommended daily goals for men and children, while being close to the daily recommendation for women. In terms of muscle meat consumption, a 100-gram portion of mammal meat can provide approximately one-third of a child's daily iron needs, while bird meat can supply more than 40%.

Wild meat stands out as rich sources of iron, especially when compared to meats from domesticated animals. For example, considering raw beef liver, known for its high iron content, we find that 100 grams, equivalent to an average steak portion (Pinheiro et al. 2004), contain approximately 5.60 mg of this mineral. Another comparative perspective would be lean sirloin steak, which has 1.7 mg of iron per 100 grams (Núcleo de Estudos e Pesquisas em Alimentação 2011). These comparisons demonstrate that the iron content in wild meat can reach up to three times higher levels than that observed in meats from domestic animals. Nevertheless, it is important to note that elk meat does not exhibit high levels of iron content. This observation should be interpreted with caution due to the limited number of samples and the fact that only one study provides this data. For instance, The United States Department of Agriculture's (2024) FoodData Central database indicates that roasted elk meat (species not specified) can contain up to 3.63 mg of iron per 100 grams. However, it is important to note that roasting food results in water loss, which can concentrate the amount of nutrients.

The composition of meat, including organs, muscles, and fat after *rigor mortis* (Burin et al. 2016), varies considerably due to factors such as age, gender, physical activity, location, diet, ecological interactions, and type of death. These elements influence the nutritional and physical characteristics of meat, explaining the differences in iron content between domesticated and wild meats. Our analyses reinforce the importance of evaluating these factors that influence composition even within the group of wild animals. For example, the analysis of red deer (*Cervus elaphus*) muscle, which was represented in four of the studies analyzed, across different countries, with animals of different ages and engaging in different interactions with their habitat, showed varying iron contents in their composition, ranging from 0.23 mg to 3.80 mg per 100g.

One of the studies explaining this variation was conducted in Spain and New Zealand by Serrano et al. (2020). In this research, the authors compared red deer (*Cervus elaphus*) meat during winter and summer seasons. The results revealed higher iron levels during winter. According to the authors, the higher iron content in red deer meat during winter is due to their seasonal dietary changes and the increased stress associated with winter hunting methods. For instance, in winter, red deer consume woody plants, bark, and evergreen foliage, which are rich in minerals, including iron. This contrasts with their summer diet of grasses, herbs, and deciduous leaves. Additionally, the stress from winter hunting methods, such as using packs of dogs, contributes to alterations in meat quality compared to the less stressful summer stalking methods.

We conclude that the iron content in wild animal meats stands out for its nutritional value, being particularly relevant for populations that rely on hunting as a traditional food source, especially in areas where iron deficiency is prevalent (Golden et al. 2011). Ensuring the physical access of these communities to these food resources is a way to respect and protect the human right to adequate food.

Wild animal viscera contain more iron than muscle tissue

In mammals, the iron content in viscera has been found to be higher than in muscle tissue, as observed in *Cervus elaphus* (red deer), where the average iron content in viscera is 14.09 mg compared to 3.07 mg in muscle tissue. This same trend is also observed in domesticated animals (Roça 2012).

The disparity in micronutrient concentration, such as iron, between the viscera and muscles of animals is intrinsically linked to the specific biological functions of these body areas. Viscera, such as the liver and kidneys, play vital roles in the metabolism and storage of essential nutrients, including minerals like iron (Damodaran and Parkin 2018). They are often rich in a variety of essential nutrients, including fat-soluble vitamins and minerals, which are found in smaller quantities in muscle meats (Burin et al. 2016).

Given this nutritional composition, consuming viscera can be an effective way to incorporate important micronutrients into the diet. However, it is important

Table 2. Weighted mean and standard deviation of iron content (in mg) in different species and tissues of wild animals (n = 943).

Species	Common names	Samples	Weighted mean	Pooled Standard Deviation	Source of data
Mammal muscle (n = 365), mean: 2.56, Pooled Standard Deviation (PSD): 0.28					
Alces alces	Elk	8	0.33	*	7
Capreolus capreolus	Wild roe deer	88	2.77	0.40	7, 1, 4
Cervus elaphus	Red deer	213	3.07	0.07	4, 5, 7, 3
Sus scrofa	Wild boar	56	1.57	0.50	1, 7
Mammal viscera (n = 420), mean: 15.22, PSD: 2.07					
Cervus elaphus	Red deer	340	14.09	2.15	2
Odocoileus hemionus	Mule deer	38	15.44	1.06	8
Odocoileus virginianus	White-tailed deer	42	16.13	2.10	8
Bird muscle (n = 158), mean: 3.62, PSD: 4.95					
Columba palumbus	Wood pigeon	50	3.96	1.72	6
Streptopelia turtur	Wild turtle dove	38	3.56	1.31	6
Turdus philomelos	Wild thrush	70	3.32	7.20	6

* The standard deviations were calculated using the means provided in each original study. For *Alces alces*, only one mean value was reported in study 7. Therefore, it was not possible to calculate the standard deviation for this species.

to highlight that viscera may also have a higher concentration of heavy metals due to their role in metabolizing and eliminating toxic substances from the body (Danieli et al. 2012). Prolonged or high-concentration exposure to heavy metals can lead to damage to the organs and systems of the body (Araújo et al. 2017).

Meats of wild birds contain more iron than those of wild mammals

From a nutritional perspective, red meats generally contain more iron than white meats due to the presence of proteins such as myoglobin and hemoglobin, which influence iron concentration and meat color (Zhuo et al. 2013; Lawrie 2005). However, based on our results, we found that the average iron content in the muscles of wild birds (3.62 mg) is higher than in wild mammals (2.56 mg), contrary to current literature. Even when excluding *Alces alces*, which has a small sample size, and *Turdus philomelos*, which has a large pooled standard deviation, the average iron content of other species supports the pattern of higher iron in birds than in mammals. We believe this observed outcome may be explained not by an inherent characteristic of the animals but rather by factors such as slaughter methods, which prevent external bleeding, or the migratory habits of birds, leading to more developed wing muscles with higher iron content.

The first factor that may explain the variation in iron content in some types of wild animal meats is linked to the pattern of death itself. Many wild animals are hunted and shot with projectiles, namely bullets or shot. In the case of small birds, the part often hit is the breast due to its larger area (Sevillano-Caño et al. 2020), which facilitates successful shooting. Vital biological structures such as the heart, liver, and lungs are located in the chest region. A shot fired in these regions can lead to blood leakage into the muscle fibers in this area, resulting in an increase in the iron content present in the pectoral muscle (Sevillano-Caño et al. 2020). The result is a higher iron content in the breast in bird meat than in the thighs. In our study, for example, breast cuts (4.87 mg) showed average iron values that exceeded those of thigh cuts by almost 87% (2.62 mg) (Additional File 3).

An additional factor related to the animal slaughter is bleeding, defined as the removal of blood from the animal by cutting large vessels (Roça 2012). The literature shows us that wild animals are often not bled immediately after death (Serrano et al. 2020; Lawrie 2005). The elimination of the bleeding phase may, in turn, increase the level of iron available in the wild meat. It is worth noting that the three bird species included in our study are small birds. Therefore, as our birds are small, the impact of both the shot and bleeding might be more pronounced compared to larger an-

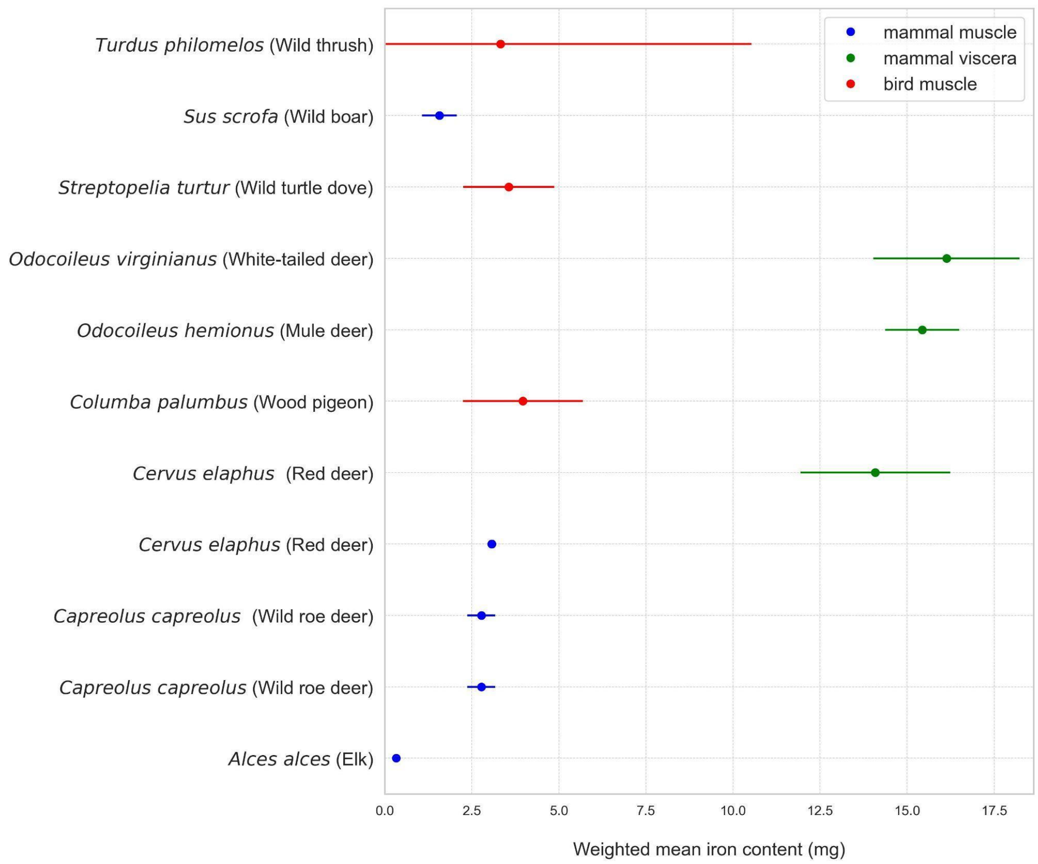

Figure 3. Forest plot of iron content in different species and tissues of wild animals. The plot reveals that mammal viscera have the highest iron content, while bird muscle generally shows higher iron levels compared to mammal muscle.

imals.

The second factor, independent of the cause of death, may be linked to the lifestyle of wild birds. Specifically, the birds examined in this review are migratory and predominantly utilize their pectoral (breast) muscles over their femoral (thigh) muscles (Sevillano-Caño et al. 2020). This pattern is supported by the higher iron content in the breast compared to the thigh, as mentioned. Conversely, this is the reverse pattern of avian species commonly consumed within contemporary food systems, such as chickens, which are typically reared in Concentrated Animal Feeding Operations (CAFOs). In these environments, their behavior leans more towards walking and standing, resulting in more intense color and higher iron content in their thighs.

The relevance of our paper lies in the context in which wild meat can be a resource to enhance food security for IPLC. However, even recognizing the role of wild meat for IPLC in the Global North (Shafiee et al. 2022), the data available for our analysis may have originated in contexts where hunting is not primarily driven by food security needs, but by other socio-cultural or economic factors. While we acknowledge that this approach does not affect our conclusions, which are related to the nutritional content of the meat and not the reasons for hunting, we recommend caution when emphasizing the nutritional potential of wild meat outside the contexts of IPLC, as this could inadvertently encourage its consumption and lead to sustainability issues. Furthermore, we encourage more studies examining the nutritional composition of wild meats from contexts where they truly contribute to food security, as this may provide more comprehensive information to support IPLC in the sustainable use of wild resources.

LIMITATIONS

Several limitations were encountered during the development of this study. One major challenge was the lack of access to original data from the reviewed articles, which may have compromised our ability to capture data variability accurately. Additionally, the lack of control variables that impact composition in the analyzed studies limited our ability to adjust for these elements during tests and conduct subgroup analyses. Furthermore, discrepancies in sample sizes among groups further limited our ability to engage in a traditional hypothesis-driven approach. All these limitations led us to adopt a characterization-based research method instead, making this study a preliminary approach that needs further exploration and validation to enhance our understanding of the nutritional value of wild meats.

During our investigation, we also identified a significant gap in appropriate tools to assess the methodological quality of research related to the nutritional composition of wild animals. Specific ethical and legal considerations in this field exacerbate this need. To address this limitation, we developed our own quality assessment questionnaire (Additional File 2). This tool assisted us in evaluating the quality of the studies included in the review, considering the complexity and variability of the resources in question.

CONCLUSION

This study underscores the nutritional potential of wild meat, particularly as a rich source of iron, especially within its viscera. Our findings challenge the established paradigm that red meats inherently possess higher iron content than white meats, a concept often extrapolated from studies on domesticated species. Our analysis reveals that wild bird muscles can exhibit higher iron concentrations than those of wild mammals, emphasizing the limitations of applying generalized assumptions derived from domesticated animals to wild species. These findings highlight the need to incorporate a more nuanced understanding of factors influencing the nutritional profiles of wild foods. Direct nutritional analyses that consider not only intrinsic compositional differences, but also extrinsic factors related to harvesting and processing techniques are essential for accurate assessments.

This research holds relevance for healthcare professionals working with communities reliant on wild meat and with high prevalence of IDA. It shows that wild resources, which serve as key staples for these populations, are influenced by cultural practices and specific environmental contexts. By understanding these factors, more effective nutritional education strategies can be developed, promoting the well-being and health of these communities.

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DATA AVAILABILITY

The data underlying the results of this study can be obtained from the corresponding author upon reasonable request.

CONFLICT OF INTEREST

We declare that the research has no conflicts of interest.

CONTRIBUTION STATEMENT

Conceptualization:A. L. B. de O., A. L. dos S. M., M. C. M. J., J. K. da S. M. Data curation:A. L. B. de O., A. L. dos S. M., M. F. A. de M. Formal analysis: A. L. B. de O., M. C. M. J. Methodology:A. L. B. de O., A. L. dos S. M., M. C. M. J., J. K. da S. M., D. T. Funding acquisition:M. C. M. J. Project administration:M. C. M. J. Supervision:M. C. M. J. Writing - review & editing:A. L. B. de O., A. L. dos S. M., M. C. M. J., J. K. da S. M., D. T.

REFERENCES

Araújo AD, Freitas MO, Moura LC, Baggio Filho H, Cambraia RP (2017) **Avaliação geoquímica ambiental do garimpo Areinha: estudo da concentração e distribuição de metais pesados nos sedimentos e os danos à saúde humana**. *Hygeia: Revista Brasileira de Geografia Medica e da Saude* 13(26):98. doi: 10.14393/132608.

Bowler DE, Boyd RJ, Callaghan CT, Robinson RA, Isaac NJB, Pocock MJO (2024) **Treating gaps and biases in biodiversity data as a missing data problem.** *Biological Reviews of the Cambridge Philosophical Society.* doi: 10.1111/brv.13127.

Burin PC, Fuzikawa IHS, Souza KA, Fernandes ARM, Tonissi RH, Goes B (2016) **Nutraceutical characteristics of meat and its importance in human nutrition.** *Revista Electrónica de Veterinaria.* 17(12):1-15.

Cardoso (2006) **Ferro.** In: CARDOSO MA, VANNUCHI Helio (eds.) Nutrição e metabolismo: nutrição humana. Guanabara Koogan, Rio de Janeiro.

Damodaran S, Parkin KL (2018) **Fennema's Food Chemistry**. Artmed editora.

Danieli PP, Serrani F, Primi R, Ponzetta MP, Ronchi B, Amici A (2012) **Cadmium, lead, and chromium**

in large game: a local-scale exposure assessment for hunters consuming meat and liver of wild boar. *Archives of environmental contamination and toxicology* 63 612-627.

Dannenberger D, Nuernberg G, Nuernberg K, Hagemann E (2013) **The effects of gender, age and region on macro-and micronutrient contents and fatty acid profiles in the muscles of roe deer and wild boar in Mecklenburg-Western Pomerania (Germany)**. *Meat science* 94(1) 39-46.

Everitt BS, Fleiss JL (1981) **Statistical Methods for Rates and Proportions**. *Biometrics* 37(4) 867. doi: 10.2307/2530193.

Geldfie S, Getaway S, Melku M (2022) **Prevalence and associated factors of iron deficiency and iron deficiency anemia among under-5 children: A systematic review and meta-analysis.** *Global Pediatric Health* 2333794X – 22211108.

Golden C, Fernald L, Brashares J, Rasolofoniaina B, Kremen C (2011) **Benefits of wildlife consumption to child nutrition in a biodiversity hotspot.** *Proceedings of the National Academy of Sciences - PNAS* 108(49), 19653-19656.

Hayward MW, Callen A, Allen BL, Ballard G, Broekhuis F, Bugir C, Clarke RH, Clulow J, Clulow S, Daltry JC, Davies-Mostert HT, Fleming PJS, Griffin AS, Howell LG, Kerley GIH, Klop-Toker K, Legge S, Major T, Meyer N, Montgomery RA, Moseby K, Parker DM, Périquet S, Read J, Scanlon RJ, Seeto R, Shuttleworth C, Somers MJ, Tamessar CT, Tuft K, Upton R, Valenzuela-Molina M, Wayne A, Witt RR, Wüster W (2019) **Deconstructing compassionate conservation: Deconstructing Compassionate Conservation**. *Conservation Biology: The Journal of the Society for Conservation Biology* 33(4) 760–768. doi: 10.1111/cobi.13366.

Ingram DJ (2020) **Wild meat in changing times**. *Journal of Ethnobiology* 40(2) 117-130.

Institute of Medicine (US) Panel on Micronutrients (2001) **Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc.** [https://www.ncbi.nlm.nih.gov/books/NBK222310] Accessed 15 June 2023.

Jacob MCM, Feitosa IS, Albuquerque UP (2020) **Animal-based food systems are unsafe: SARS-CoV-2 fosters the debate on meat consumption.** Public Health Nutrition 23(17):3250-3255. doi: 10.1017/S1368980020002657.

Jacob MCM, Souza AM, Carvalho AM, Neto CFAV, Tregidgo D, Hunter D, Pereira F de O, Brull GR, Kunhlein HV, Silva LJG da, Seabr LMJ, Drewinski M de P, Jr NM, Torres PC, Mayor P, Lopes PFM, Silva RRV, Gomes SM, Silva-Maia JK (2023) **Food Biodiversity as an Opportunity to Address the Challenge of Improving Human Diets and Food Security.** *Ethnobiology and Conservation* 12. doi: 10.15451/ec2023-02-12.05-1-14.

Jacob MCM, Teixeira CD, Bautista DA, Ramos VAN (2021) **Ethnonutrition.** *Ethnobiology and Conservation* 10. doi: 10.15451/ec2021-10-10.35-1-8.

Johnson HE, Bleich VC, Krausman PR (2007) **Mineral deficiencies in tule elk, Owens Valley, California.** *Journal of Wildlife Diseases* 43(1) 61-74. doi: 10.7589/0090-3558-43.1.61.

Khambalia AZ, Aimone AM, Zlotkin SH (2011) **Burden of anemia among indigenous populations.** *Nutrition Reviews* 69(12):693-719. doi: 10.1111/j.1753-4887.2011.00437.x.

Lawrie RA (2005) **Meat Science**. Artmed.

Li L, Huang L, Shi Y, Luo R, Yang M,Rozelle S (2018) **Anemia and educational performance of students in rural China: Prevalence, correlates, and impacts.** *China Economic Review* 51 283-293. doi: .2cm
Lorenzo JM, Maggiolino A, Gallego L, Pateiro M, Serrano MP, Domínguez R, ... De Palo P (2019) **Effect of age on the nutritional properties of Iberian wild red deer meat**. *Journal of Food Science and Agriculture* 99(4) 1561-1567.doi: 10.1002/jsfa.9334.

Masson L(1999) **LATINFOODS and its role in data generation and compilation for Latin America.** *Archivos Latinoamericanos de Nutrición* 49 (3 Supl 1) 89S-91S.

Milczarek A, Janocha A, Niedziałek G, Zowczak-Romanowicz M, Horoszewicz E, Piotrowski S (2021) **Health-promoting properties of the wild-harvested meat of roe deer (Capreolus capreolus L.) and red deer (Cervus elaphus L.)**. *Animals* 11(7) 2108. doi: 10.3390/ani11072108.

Nasi R, Brown D, Wilkie D, Bennett E, Tutin C, Van Tol G, Christophersen T (2008) **Conservation and use of wildlife-based resources: The bushmeat crisis.** Secretariat of the Convention on Biological Diversity, Montreal, and Center for International Forestry Research (CIFOR), Bogor. Technical Series.

National Institute of Health (2023) **Iron: Fact Sheet for Health Professionals.** [https://ods.od.nih.gov/factsheets/Iron-HealthProfessional]. Accessed April 5 2023.

Nielsen MR, Meilby H, Smith-Hall C, Pouliot M, Treue

T (2018) **The importance of wild meat in the global south.** *Ecological Economics* 146:696-705. doi: 10.1016/j.ecolecon.2017.12.018.

Núcleo de Estudos e Pesquisas em Alimentação (2011) **Brazilian Table of Food Composition**. 4 ed. NEPA-UNICAMP, Campinas, SP, Brazil.

Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, ... Moher D (2021) **The PRISMA 2020 statement: an updated guideline for reporting systematic reviews**. *Bmj* 372. doi: 10.1136/bmj.n71.

Pinheiro ABV, Lacerda EMDA, Benzecry EH, Gomes MCDS, Costa VMD (2005) **Tabela para avaliação de consumo alimentar em medidas caseiras.** Brazil, pp. 131-131.

Roça RDO (2008) **Composição química da carne.** Universidade Estadual Paulista Júlio de 27.

Serrano MP, Maggiolino A, Landete-Castillejos T, Pateiro M, Barbería JP, Fierro Y, ... Lorenzo JM (2020) **Quality of the main types of hunted deer meat obtained in Spain compared to farmed deer meat from New Zealand**. Scientific Reports 10(1) 12157.

Sevillano-Caño J, Cámara-Martos F, Aguilar-Luque EM, Cejudo-Gómez M, Moreno-Ortega A, Sevillano-Morales JS (2020) **Trace Element Concentrations in Migratory Game Bird Meat: Contribution to Reference Intakes Through a Probabilistic Assessment**. *Biological trace element research* 197:651-659. doi: 10.1007/s12011-019-02014-9.

Shafiee M, Keshavarz P, Lane G, Pahwa P, Szafron M, Jennings D, Vatanparast H (2022) **Food security status of Indigenous Peoples in Canada according to the 4 pillars of food security: a scoping review.** *Advances in Nutrition* 13(6):2537-2558. doi: 10.1093/advances/nmac081.

Strazdiņa V, Jemeļjanovs A, Šterna V (2013) **Nutrition Value of Wild Animal Meat.** *Proceedings of the Latvian Academy of Sciences. Section B. Natural, Exact, and Applied Sciences* 67:373–377. doi: 10.2478/prolas-2013-0074.

Torres P, Morsello C, Orellana JD, Almeida O, Moraes A, Chacón-Montalván EA, Pinto MAT, Fink MGS, Freire MP, Parry L (2022) **Wildmeat consumption and child health in Amazonia.** *Scientific Reports* 12(1) 5213. doi: 10.1038/s41598-022-09260-3.

United States Department of Agriculture (2024) **FoodDataCentral:** Game meat, elk, cooked, roasted. USDA [`https://fdc.nal.usda.gov/fdc-app.html`] Accessed 23 Sep 2024..

von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, STROBE Initiative (2008) **The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies.** *Journal of Clinical Epidemiology* 61:344–349.

Whiting P, Rutjes AW, Reitsma JB, Bossuyt PM, Kleijnen J (2003) **The development of QUADAS: a tool for the quality assessment of studies of diagnostic accuracy included in systematic reviews.** *BMC Medical Research Methodology.* November 10;3(1):25. doi: 10.1186/1471-2288-3-25.

World Health Organization (2017) **Global Nutrition Monitoring Framework: operational guidance for tracking progress in meeting targets for 2025**..

Zhuo Z, Fang S, Yue M, Wang Y, Feng J (2013) **Iron Glycine Chelate on Meat Color, Iron Status and Myoglobin Gene Regulation of M. Longissimus Dorsi in Weaning Pigs.** *International Journal of Agriculture and Biology* 15(5):983–987.

Zimmerman TJ, Jenks JA, Leslie Jr DM, Neiger RD (2008) **Hepatic minerals of white-tailed and mule deer in the southern Black Hills, South Dakota**. *Journal of Wildlife Diseases* 44(2):341-350. doi: 10.7589/0090-3558-44.2.341

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Additional Files

Add File 1. Checklist of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020).

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	5
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	5
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	5
Information sources	6	Specify all databases, registers, websites, organizations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	6
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	6
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	6
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	6
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	6
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	6

to be continued...

Section and Topic	Item #	Checklist item	Location where item is reported
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	6-7
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	NA
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	NA
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	NA
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	7-8
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	NA
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	NA
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	NA
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	6-7
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	NA
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	9
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	8
Study characteristics	17	Cite each included study and present its characteristics.	9-11
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	12
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	NA

to be continued...

Section and Topic	Item #	Checklist item	Location where item is reported
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	14
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	14, 15, Spp. 3 and 4
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	NA
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	NA
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	NA
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	NA
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	15-17
	23b	Discuss any limitations of the evidence included in the review.	15-17
	23c	Discuss any limitations of the review processes used.	17
	23d	Discuss implications of the results for practice, policy, and future research.	18
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	NA
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	NA
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	NA
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	18
Competing interests	26	Declare any competing interests of review authors.	18
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	18

Add File 2. Checklist for Assessing the Quality of Reports on the Nutritional Composition of Wild Animals. Scoring Explanation to each criterion: A score of 0 points indicates the information is not available; 0.5 points denote ambiguity or unclear information; and 1.0 point signifies the information is either available or not applicable.

Item	Section	Criteria	Question	Source
Study design and sample size	Methods	1	They specify the sampling plan (e.g., random, opportunistic) and, when applicable, the method used for sample size calculation?	LatinFoods/FAO; "QUADAS Tool/ Timmer's Analisis Tool"
Sample	Methods	2	Do they mention the scientific name of the species?	Original authorship
Processing	Methods	3	The procedures used for processing the samples are reported (e.g., if the sample was washed, type of water used, type of knife, time after hunting, storage of the game until reaching the laboratory, type of freezing, type of drying).	LatinFoods/FAO, QUADAS Tool
Analysis	Methods	4	The methods of sample analysis are described?	LatinFoods/FAO, QUADAS Tool, Timmer's, OHAT
Analysis	Methods	5	Were the analyses conducted at least in triplicate or on at least three animals of the sampled species?	LatinFoods/FAO / Original authorship
Quantitative variables	Methods	6	Do they present results with coefficients of variance or standard deviation or standard error?	LatinFoods/FAO
Incomplete data	Methods	7	In the case of losses, incomplete results (losses and exclusions during the experiment) were adequately justified?	Cochrane, QUADAS, Timmers
Funding	Other information	8	Do they specify the study's funding source and the role of the funders?	STROBE
Conflicts of interest	Other information	9	Do they report the existence or absence of potential conflicts of interest?	Original authorship

Add File 3. Iron Content in Wild Animal Meats.

id	species	animal species	animal class	animal part	iron content	sample size	country	sd	reason 2 samples	common names
14	*Alces alces*	aa	mammal	muscle	0.000326	8	Latvia	NA	NA	Elk
14	*Capreolus capreolus*	cc	mammal	muscle	0.000206	16	Latvia	NA	NA	Wild roe deer
2	*Capreolus capreolus*	cc	mammal	muscle	0.00321	42	Germany	0.00057	NA	Wild roe deer
7	*Capreolus capreolus*	cc	mammal	muscle	0.003531	30	Poland	0.0000980	NA	Wild roe deer
7	*Cervus elaphus*	ce	mammal	muscle	0.0038	30	Poland	0.0000981	NA	Red deer
9	*Cervus elaphus*	ce	mammal	muscle	0.003410	10	New Zeland	0.000106	Different locations	Red deer
9	*Cervus elaphus*	ce	mammal	muscle	0.002950	14	Spain	0.000107	Different locations	Red deer
14	*Cervus elaphus*	ce	mammal	muscle	0.000230	9	Latvia	NA	NA	Red deer
16	*Cervus elaphus*	ce	mammal	muscle	0.003370	50	Spain	0.000060	Different age	Red deer
16	*Cervus elaphus*	ce	mammal	muscle	0.003142	50	Spain	0.000059	Different age	Red deer
16	*Cervus elaphus*	ce	mammal	muscle	0.002731	50	Spain	0.000059	Different age	Red deer
5	*Cervus elaphus*	ce	mammal	viscera	0.015131	154	Unites States	0.002147	Different locations	Red deer
5	*Cervus elaphus*	ce	mammal	viscera	0.013225	186	Unites States	0.002147	Different locations	Red deer
10	*Columba palumbus*	cp	bird	muscle	0.005350	25	Spain	0.00207	Breast	Wood pigeon
10	*Columba palumbus*	cp	bird	muscle	0.002580	25	Spain	0.00129	Thigh	Wood pigeon
13	*Odocoileus hemionus*	oh	mammal	viscera	0.015747	19	Unites States	0.001078	Burned habitat	Mule deer
13	*Odocoileus hemionus*	oh	mammal	viscera	0.015128	19	Unites States	0.001044	Unburned habitat	Mule deer
13	*Odocoileus virginianus*	ov	mammal	viscera	0.018227	21	Unites States	0.002707	Unburned habitat	White-tailed deer
13	*Odocoileus virginianus*	ov	mammal	viscera	0.014043	21	Unites States	0.001209	Burned habitat	White-tailed deer
10	*Streptopelia turtur*	st	bird	muscle	0.004190	19	Spain	0.00126	Breast	Wild turtle dove
10	*Streptopelia turtur*	st	bird	muscle	0.002930	19	Spain	0.00135	Thigh	Wild turtle dove
2	*Sus scrofa*	sc	mammal	muscle	0.0019	44	Germany	0.00056	NA	Wild boar
14	*Sus scrofa*	sc	mammal	muscle	0.000344	12	Latvia	NA	NA	Wild boar
10	*Turdus philomelos*	tp	bird	muscle	0.005080	25	Spain	0.00135	Breast	Wild thrush
10	*Turdus philomelos*	tp	bird	muscle	0.002350	45	Spain	0.0089	Thigh	Wild thrush

Add File 4. Quality Assessment of Included Studies, Based on Reviewers' Judgments Using the Quality Assessment Questionnaire. Scoring Explanation - A score of 0 points indicates the information is not available; 0.5 points denote ambiguity or unclear information; and 1.0 point signifies the information is either available or not applicable.

N°	**ARTICLE DATA**	**QUESTIONS**									**FINAL ASSESSMENT**
		1	2	3	4	5	6	7	8	9	
1	D. Dannenberger a; G. Nuremberg b; K. Nuremberg a; E. Hagemann; 2012	1	0	1	1	1	1	0.5	1	0	6.5
2	Heather E. Johnson , Vernon C. Bleich , Paul R. Krausman.; 2007	0.5	0	0	1	1	1	1	1	0	5.5
3	José M Lorenzo, Aristide Maggiolino, Laureano Gallego, Mirian Pateiro, Martina Pérez Serrano, Rubén Domínguez, Andrés García, Tomás Landete-Castillejos, Pasquale De Palo; 2018	1	1	1	1	1	1	0.5	1	1	8.5
4	Anna Milczarek, Alina Janocha, Grażyna Niedziałek, Michalina Zowczak-Romanowicz, Elżbieta Horoszewicz, Sławomir Piotrowski ; 2021	1	1	1	1	0.5	1	1	1	1	8.33
5	Martina Pérez Serrano ,Aristide Maggiolino ,Tomás Landete-Castillejos ,Mirian Pateiro ,Javier Pérez Barbería ,Iolanda Fierro ,Rubén Domínguez ,Laureano Galego ,Andrés García ,Pasquale De Palo &José Manuel Lorenzo; 2020;	1	1	1	1	1	1	1	1	1	9
6	Jesús Sevillano-Caño, Fernando Cámara-Martos, Eva María Aguilar-Luque, Manuel Cejudo-Gómez, Alicia Moreno-Ortega & Jesús Salvador Sevillano-Morales; 2020	1	0.5	1	1	1	1	0	0	1	6.5
7	Vita Strazdiòa, Aleksandrs Jemeïjanovs, and Vita Ðterna; 2013	1	0	0	1	1	0	0.5	1	0.5	5
8	Teresa J Zimmerman, Jonathan A Jenks , David M Leslie Jr, Regg D Neiger; 2008	1	0	0.5	1	1	1	0	1	0	5.5