Supplementary Material 1

Table SM1

Full review protocol in accordance with PRISMA recommendations

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Title (page 1).
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	Abstract (page 2).
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Introduction (pages 3-4); paragraphs on motivation and current limitations of synthetic antioxidants in meat reformulation.
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Introduction (page 4), final paragraph; explicit objective and PICo-based research question.
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Section 2.1 "Research question and review framework" (pages 5-6); inclusion and exclusion criteria detailed in Table 2.
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Section 2.2 "Search strategy" (page 6); Scopus and Web of Science accessed on September 20, 2025, with verification search performed on April 30, 2026.
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Section 2.2 "Search strategy" (page 6) and Table 1 "Search equations used in Scopus and Web of Science"; full Boolean strings reported.
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.	Section 2.3 "Selection process" (pages 6-7); two-phase PRISMA screening (titles/abstracts and full text) by two independent reviewers in Rayyan, with arbitration by a third reviewer.
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.	Section 2.4 "Data collection process" (page 7); duplicate independent extraction by two reviewers using a standardized Excel template.
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.	Section 2.4 "Data collection process" (page 7); outcomes listed in five domains (oxidative stability, sensory quality, nutritional value, technological functionality, microbial stability).
	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.	Section 2.4 "Data collection process" (page 7); additional variables include matrix type, mushroom species and part, ingredient format, dose, processing and storage conditions, country of affiliation, funding sources.
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.	Section 2.5 "Quality assessment" (page 8); six-criterion rubric adapted from PRISMA principles and McClements et al. (2024); detailed scoring per study reported in Material Suplementario S2 (sheet "Quality Assessment").
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.	Section 2.6 "Data synthesis" (page 8); narrative and qualitative synthesis with direction-of-effect reporting; no meta-analysis performed due to heterogeneity of matrices and outcomes.
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)).	Section 2.6 "Data synthesis" (page 8); studies grouped by mushroom species, ingredient format, meat matrix, and outcome category for tabular cross-presentation in Tables 3-9.
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	Section 2.6 "Data synthesis" (page 8); units of measurement standardized across studies (TBARS as mg MDA/kg; CIELab parameters; phenolic content as mg GAE/g).
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Section 2.6 "Data synthesis" (page 8); evidence synthesized in Tables 3-9 and visualized in Figures 1-9 (integrative synthesis, PRISMA flow, annual evolution, keyword network, thematic evolution, country map, word frequency, authors-themes-countries Sankey, future trends).
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If	Section 2.6 "Data synthesis" (page 8); narrative qualitative synthesis chosen due to heterogeneity of matrices,

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		meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	mushroom species, ingredient formats, and outcome metrics; bibliometric analysis performed in VOSviewer (van Eck and Waltman, 2010) and Bibliometrix (Aria and Cuccurullo, 2017).
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	Sections 3.2-3.8; subgroup discussion by mushroom species, ingredient format, and meat matrix to explore heterogeneity.
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	Not applicable; no quantitative meta-analysis was performed and therefore no statistical sensitivity analysis is reported. Robustness was assessed qualitatively across subgroups.
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	Section 2.5 "Quality assessment" (page 8); reporting bias examined qualitatively by checking consistency between declared and reported outcomes per study; documented in Material Suplementario S2.
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	Section 3.9 "Advances and emerging trends" (pages 21-23); certainty assessed qualitatively per outcome (high for lipid oxidation, moderate for color and sensory acceptance, low for protein oxidation and digestion), summarized in Tables 8 and 9.
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.	Section 3.1 "Article selection process" (page 9) and Figure 2 (PRISMA 2020 flow diagram); 836 records identified, 15 duplicates removed, 60 studies retained for synthesis.
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Section 3.1 "Article selection process" (page 9); reasons for full-text exclusion (n=212) reported in the PRISMA flow diagram (Figure 2): wrong matrix, no quantitative outcomes, review article, non-English language.
Study characteristics	17	Cite each included study and present its characteristics.	Table 3 "Summary of the studies included in the systematic review according to the PRISMA selection: research topic, mushroom species and part used, and main findings reported by each primary study"; complete bibliographic data in Material Suplementario S2 (sheet "Bibliographic Data").
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Material Suplementario S2 (sheet "Quality Assessment"); per-study scoring on six criteria with overall categorization (high, medium, low).
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.	Tables 3, 4 ("Comparative antioxidant effectiveness of edible mushroom species"), 5 ("Antioxidant effectiveness by mushroom format"), 6 ("Optimal inclusion levels"), and 7 ("Mechanistic mapping: bioactive compounds based on mechanisms and functional outcomes").
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Sections 3.2-3.8; per-synthesis summary of contributing studies and their quality. Bibliometric synthesis in Figures 3-8.
	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.	Sections 3.2-3.8; direction-of-effect summaries reported across mushroom species, ingredient formats, and meat matrices. No meta-analytic estimates due to heterogeneity.
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	Sections 3.2-3.8; heterogeneity discussed by subgroups (species, format, matrix); bibliometric clustering in Figures 4 and 5.
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	Not applicable; no statistical sensitivity analyses performed (qualitative synthesis).
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	Section 3.9 "Advances and emerging trends" (pages 21-23) and Table 8 "Evidence gaps and limitations in current research"; reporting bias discussed qualitatively, with emphasis on underreporting of protein-oxidation markers and digestion endpoints.
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Section 3.9 (pages 21-23) and Tables 8 and 9; certainty of evidence categorized as high (lipid oxidation in pork patties and emulsified sausages with Pleurotus ostreatus and Agaricus bisporus), moderate (color and sensory acceptance), and low (protein oxidation and in vitro digestion).
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Section 3.9 "Advances and emerging trends" (pages 21-23) and Section 4 "Conclusions" (pages 24-25); integrative interpretation organized around three trends and articulated by Figures 1 and 9.
	23b	Discuss any limitations of the evidence included in the review.	Section 3.9 (pages 22-23) and Table 8; key limitations of the evidence include underreporting of protein oxidation, scarcity of in vitro digestion studies, and absence of pilot-plant validation.
	23c	Discuss any limitations of the review processes used.	Section 4 "Conclusions" (page 25), final paragraph; limitations of the review process include qualitative synthesis (no meta-analysis), restriction to English-language reports, and exclusion of grey literature.
	23d	Discuss implications of the results for practice, policy, and future research.	Section 3.9 (page 23) and Section 4 (pages 24-25); future research directions structured around four axes (mechanisms, technology, formats, consumer) shown in Figure 9.

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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.	The review was not registered in PROSPERO because PROSPERO is restricted to systematic reviews of human-health interventions; the methodological protocol was developed prospectively by the team and is provided as Material Suplementario S1.
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Material Suplementario S1 "Protocolo de la revisión sistemática y bibliométrica según PRISMA 2020" (file Material_Suplementario_S1_Protocolo_Revision.docx).
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	No amendments were made to the protocol after data extraction began; the prospective protocol was followed in full.
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Section "Funding"; no external funding received. Institutional support: Universidad Nacional de Moquegua (Peru), Universidad Nacional de Jaén (Peru), and Universidade de São Paulo (Brazil). Funders had no role in design, conduct, analysis, or reporting.
Competing interests	26	Declare any competing interests of review authors.	Section "Conflict of interest"; the authors declare no competing interests of any kind that could have influenced the design, conduct, analysis, or interpretation of this review.
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.	Section "Data availability"; (a) data extraction template available upon request from the corresponding author; (b) extracted data from the 60 included studies in Material Suplementario S2 (Material_Suplementario_S2_Evaluacion_PRISMA.xlsx); (c) all analyses based on the same dataset; (d) bibliometric analyses run in VOSviewer and Bibliometrix with default parameters; (e) protocol in Material Suplementario S1.