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Fermented Botanicals for Cold Resilience in Chickens and Priorities for One Health Research

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Abstract

Cold exposure can disrupt intestinal function, redox balance and immune responses in chickens, creating a rationale for preventive nutritional interventions. Fermented botanicals are of interest because microbial processing can alter plant constituents and generate biologically active metabolites. This narrative review examines whether the poultry evidence supports their use for winter resilience and identifies the outcomes needed to evaluate antimicrobial stewardship within a One Health framework. Targeted reference searches and verification through August 2026 distinguish cold-stress pathophysiology, non-fermented interventions tested during cold exposure, fermented-botanical studies under other conditions, and mechanistic extrapolation. Cold-stress experiments document intestinal and immune disturbances, while studies of rutin and a ginger-containing formulation show that dietary bioactives can modify selected responses. Fermented garlic, Astragalus and Allium products have also affected performance, intestinal morphology, antioxidant status or bacterial outcomes in poultry. These findings are product-specific, and most do not isolate the contribution of fermentation. None of the studies synthesized here directly establishes the efficacy of a fermented botanical during winter cold stress or demonstrates a resulting reduction in therapeutic antimicrobial use or resistant bacterial shedding. Translation therefore requires verified botanical identity, reproducible processing, product-specific safety assessment and controlled winter trials, followed by independent field evaluation. Clinical disease, veterinary treatment requirements, resistance outcomes and farm costs should determine practical value. Fermented local crops may complement established poultry-health measures, but their One Health benefits remain to be demonstrated.

Keywords: Antimicrobial stewardship; Cold stress; Fermented botanicals; Poultry; One health

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Introduction

Winter cold presents a practical health challenge for poultry kept in open, free-range or semi-intensive housing. Experimental studies associate cold exposure with poorer growth, altered intestinal stress responses and changes in gut microbial function. The response depends on bird age, genotype, acclimation and the intensity and duration of exposure [1,2,3]. A winter flock also encounters interacting conditions, including humidity, drafts and wet litter that are poorly represented by a single chamber temperature. Nutritional support is therefore of interest, but its value must be judged within the husbandry conditions in which it will be used.

The relevance to antimicrobial stewardship is indirect. Preventing disease could reduce the need for treatment, while unnecessary antimicrobial exposure can select resistant bacteria in birds and their environment. Poultry-associated antimicrobial resistance (AMR) connects animal health with food safety, occupational exposure and environmental contamination. This makes One Health a useful framework for evaluating preventive interventions. It does not, by itself, establish that a feed supplement will reduce resistance or improve human health [4,5,6,7].

Locally grown botanicals offer a potentially accessible source of phytochemicals and fermentable substrates. Fermentation can change substrate composition, nutrient availability and microbial metabolites, although results vary with the plant material and process. The relevant unit of evaluation is consequently a defined botanical product, rather than a plant name or the broad category of fermented herbs [8,9,10,11]. This review brings cold-stress biology together with poultry studies of fermented botanicals to identify where the evidence converges, where extrapolation remains necessary and how winter applications could be tested.

Materials and Methods

Review Scope and Literature Approach

This is a targeted narrative review, not a systematic review or meta-analysis. The literature assembled for the manuscript was checked and selectively updated through 16 October 2026 using PubMed-indexed records, publisher websites, targeted web searches and reference checking. Search concepts combined poultry or broiler terms with cold stress, low temperature or

winter; a second group combined fermented or fermentation with botanical, herb, Allium, garlic, ginger or Astragalus. Additional searches addressed gut integrity, oxidative stress, immunity, microbiota, AMR and One Health. Primary poultry studies were used for efficacy claims, with reviews, consensus statements and institutional reports providing context. No protocol was registered, no exhaustive screening count is claimed and no pooled effect size was calculated.

Evidence was organized by its relationship to the proposed winter application. Cold-exposure studies describe the biological problem; trials of non-fermented compounds during cold stress show whether those responses can be modified nutritionally; fermented-botanical studies outside cold stress provide indirect product evidence; and process or biochemical observations support mechanistic plausibility. Direct efficacy evidence would require a fermented botanical to be evaluated in cold-exposed chickens against an appropriate comparator. These categories describe applicability, rather than formal risk-of-bias grades. Study selection and narrative interpretation may introduce bias, and absence statements below refer to the evidence synthesized here.

Results and Discussion

Cold Exposure and Intestinal Resilience

Report reduced weight gain and poorer feed conversion after a short period of cold exposure in young broilers, together with higher circulating endotoxin and altered jejunal stress and barrier-related responses. In that experiment, some tight-junction transcripts increase [1]. Such changes may reflect an adaptive response and should not be interpreted automatically as improved barrier function. Lyte et al. link early cold exposure with intestinal neurochemical responses and functional shifts in the microbiome, extending the potential consequences beyond growth alone [2].

Cold responses are also modified by prior exposure. Bi et al. find intestinal inflammation, oxidative injury and immune dysfunction during acute cold stress, with partial protection following intermittent mild cold acclimation. These findings caution against treating all low-temperature exposure as biologically equivalent [3]. Oxidative and inflammatory processes interact with mucosal function, but changes in antioxidant enzymes, cytokine transcripts or microbial composition remain surrogate outcomes. Functional barrier measures and clinical observations are needed before those changes can be interpreted as improved resistance to disease [12,13].

Two nutritional studies help define the opportunity without proving fermented-product efficacy. Rutin supplementation improves selected growth, barrier, antioxidant and cecal microbiota outcomes in cold-stressed broilers. A ginger-oil-enriched Sini Decoction formulation also alleviates several intestinal responses to acute cold stress [14]. Because the latter was a multicomponent intervention, its findings cannot be assigned to ginger alone. Neither study tested a fermented botanical [15]. Temperature-related effects on poultry meat quality provide an additional reason to assess carcass and food-quality outcomes when nutritional strategies are evaluated. Figure 1 separates these experimental observations from the proposed stewardship pathway [16].

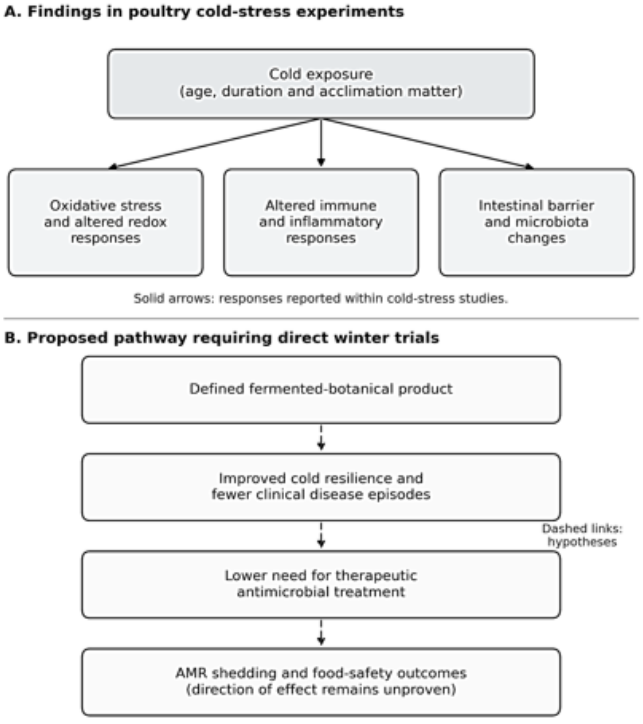


Figure 1: *Cold responses and proposed fermented botanical benefits in chickens.*

Note: Solid arrows summarize response domains reported in poultry cold-stress experiments. Dashed arrows describe an unvalidated winter-intervention hypothesis [1,2,3]. Changes in biomarkers do not establish fewer clinical infections, reduced treatment requirements or lower AMR shedding. Necessary veterinary treatment must remain available under equivalent criteria in all groups. AMR, antimicrobial resistance. Schematic developed for this review.

What Fermentation Changes and What it does Not Establish

Controlled starter fermentation uses a deliberately selected microbial culture. Spontaneous fermentation depends on organisms already present in the substrate or environment, whereas back-slopping transfers material from an earlier batch to a new one. These processes should be identified explicitly because their reproducibility and safety may differ. The term fermented also does not establish that a product is probiotic: fermentation describes microbial processing, while a probiotic claim requires evidence relevant to the microorganisms and host benefit [17].

Several components can contribute to the response to a fermented botanical: the original plant constituents, compounds released or transformed during processing, organic acids, residual microorganisms and changes in the nutritional matrix. General

fermented-feed literature supports these possibilities, but it cannot establish that each occurs in every herbal preparation. A 2024 meta-analysis finds effects of fermented herbal products on selected broiler outcomes, while also bringing together products and experimental settings that differ substantially [8,9,10]. Its relevance is to the wider intervention class; it does not provide a winter-specific effect estimate [18].

Attribution is a recurring weakness in the primary literature. Comparing a fermented preparation only with a basal diet or an antibiotic comparator tests the complete preparation, not the benefit added by fermentation. A matched unfermented substrate and a suitable process or starter control are needed to distinguish those effects. Product dose also requires a defined basis. A percentage of a liquid extract, a mass of dried material and a concentration in drinking water cannot be compared directly without dry-matter content, chemical characterization and actual feed or water intake. These limitations matter when apparently positive studies are used to select a product for cold conditions.

Poultry Evidence for Fermented Botanicals

Independent garlic studies illustrate both the potential and the inconsistency of the evidence. Lee et al. report changes in intestinal morphology and selected physiological indices after fermented garlic supplementation, with limited effects on growth. Ao et al. similarly find effects on blood indices and breast-meat oxidative stability without a consistent growth response. These results support product-specific biological activity in broilers, but neither experiment establishes protection from winter cold stress [19,20].

Astragalus provides a useful comparator beyond Allium. Han et al. evaluate mixed-culture fermented powder and report effects on selected performance, immune, antioxidant and microbiota outcomes. Study fermented Astragalus polysaccharides and report improved performance, antioxidant measures and intestinal morphology, alongside changes in barrier-related gene expression and cecal microbiota [21]. The products differ in substrate and microbial processing, so their results should not be treated as interchangeable [22]. Neither study tested the winter application considered here.

A series of Vietnamese Allium studies addresses related questions. Initial screening identifies lactic acid bacterial candidates for onion fermentation and antibacterial activity. A fermented chive preparation improves several health and performance outcomes in an experimental Escherichia coli challenge [23]. Other reports examine fermented onion or chive extracts against bacterial isolates, including multidrug-resistant isolates whose pathogenicity was assessed in chickens [24]. Those extract assays provide antibacterial evidence; pathogenicity testing of an isolate does not convert an in vitro extract assay into an in vivo treatment-efficacy trial [25,26].

Dietary fermented chive has also been assessed for production, meat-quality, cecal bacterial and noxious-gas outcomes. Separate water-supplementation studies report benefits from fermented shallot in broilers challenged with Salmonella or E. coli [27]. A heat-stress study of fermented red onion reports improved feed efficiency and selected bacterial and ammonia-related outcomes [28,29,30]. Challenge protection, heat-stress responses and laboratory antibacterial activity are useful but distinct signals [31]. They cannot be assumed to predict cold-season efficacy, and the concentration of several Allium reports within one research group increases the importance of independent replication.

Table 1 summarizes the relevance of selected studies to winter use. No fermented botanical in this evidence set was directly evaluated for cold resilience. An antibiotic comparator, activity against a resistant isolate and reduced total bacterial counts each answer different questions from a reduction in therapeutic antimicrobial exposure or resistant bacterial shedding.

Table 1: *Selected poultry evidence relevant to fermented botanicals and cold resilience.*

Study and model	Intervention	Reported findings	Interpretation for winter use
Cold exposure [1]	No botanical	Lower growth; higher endotoxin; altered jejunal responses.	Cold-stress biology only.
Early cold exposure [2]	No botanical	Gut neurochemical and microbiome functional changes.	Cold-stress biology only.
Acute cold stress [3]	Prior mild acclimation	Partial attenuation of intestinal inflammatory and immune disturbances.	Acclimation evidence, not botanical efficacy.
Cold-stressed broilers [14]	Rutin	Improved selected growth, antioxidant and intestinal outcomes.	Non-fermented nutritional evidence.
Acute cold stress [15]	Ginger-oil-enriched formulation	Reduced intestinal injury and altered barrier and microbial outcomes.	Multicomponent and non-fermented.
Broilers without cold challenge [19,20]	Fermented garlic products	Selected intestinal, blood or meat-quality effects; growth responses limited.	Indirect; products and comparators differ.
Broiler feeding trial [21]	Fermented Astragalus powder	Selected performance, immune, antioxidant and microbiota effects.	Indirect; whole fermented substrate.

Broiler feeding trial [22]	Fermented Astragalus polysaccharides	Performance, redox, morphology and barrier-related transcript changes.	Indirect; processed polysaccharide product.
E. coli challenge [24]	Fermented chive	Improved selected clinical, production and intestinal outcomes.	Indirect challenge evidence.
Bacterial challenges [28,29,30]	Fermented shallot in water	Selected survival, growth, immune or intestinal benefits.	Indirect; winter efficacy untested.
Tropical heat stress [31]	Fermented red onion in water	Feed efficiency and selected bacterial and ammonia-related responses.	Heat and cold are different exposures.

Note: Descriptive summaries, not pooled effect estimates. No listed study tests a fermented botanical during cold stress or establishes reduced antimicrobial exposure or AMR shedding. E. coli, Escherichia coli; AMR, antimicrobial resistance.

Botanical Selection and Identity

Local availability is useful only when the raw material can be identified and standardized. Onion and shallot cultivars differ, and the word chive is especially problematic across local and English usage. Studies in this review report Allium schoenoprasum, while the garlic-chive study reports A. tuberosum; these are distinct accepted species. We retain the botanical identities stated by the original authors rather than retrospectively reassigning their materials [24,25,26,32,33]. Future products should document the species, cultivar where relevant, plant part and a botanical voucher or equivalent identity record.

Table 2 distinguishes candidates with poultry product evidence from plants retained primarily for investigation. Garlic and the studied Allium products have fermented-product data outside cold stress. Ginger has a rationale informed by a non-fermented, multicomponent cold-stress intervention. Turmeric and lemongrass remain formulation candidates in this review, without evidence sufficient to support a fermented winter-use claim. Astragalus serves as an external evidence benchmark; its inclusion does not imply that it is a locally economical crop in every poultry-producing region.

Table 2: *Botanical candidates and priorities before winter application.*

Botanical material	Evidence relevant to this review	Priority before winter testing
Onion and shallot Allium cepa bulbs	Fermented extracts tested in antibacterial, challenge and heat-stress settings [23,25,28,30,31].	Verify cultivar, product composition and intake; independently reproduce effects.
Chive A. schoenoprasum as reported	Fermented preparations evaluated in challenge and feeding studies [24,25,27].	Verify botanical identity and plant part; characterize palatability and product dose.
Garlic chive A. tuberosum as reported	Antibacterial extract evidence against resistant isolates [26].	Establish in vivo product efficacy; do not equate isolate testing with AMR reduction.
Garlic A. sativum cloves	Independent fermented-garlic feeding studies [19,20].	Confirm chemical stability and formulation-specific effects under cold conditions.
Ginger Zingiber officinale rhizome	Cold-stress evidence for a non-fermented multicomponent formulation [15].	Separate ginger effects from co-ingredients and test any fermented preparation directly.
Turmeric and lemongrass Curcuma longa; Cymbopogon citratus	Proposed candidates; no direct fermented-product cold trial in this synthesis.	Establish product chemistry, safety and poultry efficacy before winter claims.
Astragalus products	Independent fermented powder and polysaccharide studies outside cold stress [21,22].	Use as external comparators; verify supply, identity and formulation comparability.

Note: Names follow the identities reported in the cited studies. Chive and garlic chive are not interchangeable taxonomic labels. General phytochemical or fermentation plausibility does not establish the efficacy of a specific preparation.

One Health Outcomes and Antimicrobial Stewardship

An appropriate winter-health intervention should complement adequate brooding, ventilation, dry litter, biosecurity, vaccination,

nutrition and prompt veterinary care. One Health assessments of animal agriculture emphasize that resistant organisms and resistance determinants can move through connected animal, food and environmental pathways. A botanical preparation therefore needs to demonstrate a health benefit while avoiding new feed-safety problems [6,34]. It should never create an incentive to delay diagnosis or withhold indicated treatment.

Clinical outcomes should lead the evaluation. A predefined measure such as the incidence of veterinary-diagnosed disease requiring treatment can be supported by mortality, welfare, growth and feed conversion. Treatment exposure should then be recorded prospectively using a transparent denominator, for example treated bird-days per 1,000 bird-days at risk, together with indication, antimicrobial class, dose and duration. The counting rule for combination therapy must be specified. Equivalent diagnostic and rescue-treatment criteria are essential because a lower treatment count is uninterpretable if sick birds in one group receive less care. AMR assessment requires measurements beyond bacterial inhibition. Resistance phenotypes, absolute quantities of relevant organisms and selected resistance determinants should be interpreted alongside antimicrobial exposure. A fall in total E. coli does not necessarily mean that the resistant fraction or absolute resistant burden has fallen. Likewise, a change in relative resistance-gene abundance does not alone establish reduced transmission risk. Food-chain or human-health benefits would require additional evidence; they cannot be inferred from improved broiler performance. The proposed evaluation domains are summarized in Table 3.

Environmental claims also need measurement discipline. Litter ammonia concentration, emission rate and nitrogen loss are different endpoints. An ammonia-related response cannot be presented as proof of reduced greenhouse-gas emissions. Farm feasibility should include rejected batches, labour, quality control, storage, intake and veterinary costs, rather than substrate price alone. These measures would show whether an intervention remains useful when implemented outside a controlled study.

Table 3: *Proposed One Health outcomes for winter validation.*

Domain	Core measurements	Interpretation requirement
Animal health	Diagnosed disease episodes; mortality; welfare; growth; feed conversion.	Predefine a primary clinical outcome and retain consistent treatment thresholds.
Antimicrobial exposure	Treated bird-days per 1,000 bird-days at risk; indication; drug class; dose and duration.	Define denominator and combination-therapy rules; record necessary rescue therapy.
Intestinal mechanisms	Histology; functional permeability where feasible; barrier transcripts or proteins; mucosal immunity; redox measures.	Treat biomarkers as supporting outcomes, not proof of clinical prevention.
AMR and food safety	Relevant bacterial burden; resistance phenotype; selected resistance determinants; pre-slaughter carriage.	Interpret absolute and relative measures with antimicrobial exposure.
Environment	Litter moisture and nitrogen; clearly defined ammonia concentration or emission measurements.	Match each environmental claim to the actual measurement.
Product safety	Microbiological and chemical specifications; stability during intended storage and use.	Reject nonconforming batches; final pH alone does not prove safety.
Farm feasibility	Product and quality-control costs; labor; rejection rate; intake; treatment costs.	Estimate net benefit under realistic farm conditions.

Note: All measures are proposed outcomes, not established benefits of winter botanical supplementation. AMR, antimicrobial resistance. Selection of individual assays should follow the product hypothesis and study design.

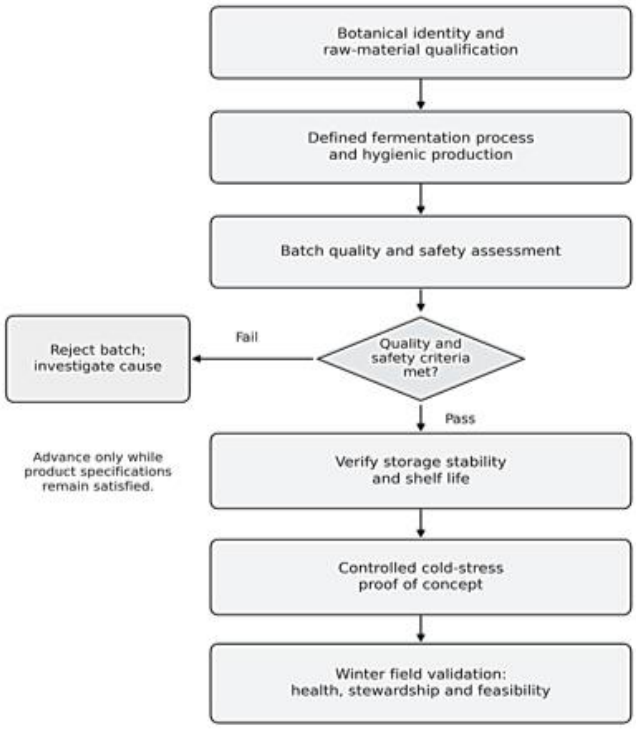
Product Qualification and Safety

Process control should begin with raw-material acceptance criteria and continue through storage and delivery to the bird. Records need to identify the substrate, microbial input, processing conditions and relevant chemical and microbiological attributes. Release criteria should address pathogens and other hazards appropriate to the matrix, including spoilage, mycotoxins or undesirable metabolites where relevant. Final acidity is useful process information, but it cannot substitute for a validated safety assessment. No universal fermentation pH, dose or shelf life can be derived from the studies reviewed here [8,9,17].

Reproducibility is as important as an apparently effective batch. Marker constituents, microbial attributes and stability should remain within predefined limits across independent preparations. Spontaneous or back-slopped products need particular attention to variability and the possibility of carrying contamination into subsequent batches. A failed batch should be rejected and its cause

investigated. Figure 2 summarizes the development sequence. The framework is intended to guide product qualification, rather than supply an on-farm fermentation recipe.

Figure 2: *Product qualification before winter efficacy testing.*



Note: Development begins with verified botanical material and a defined hygienic process. Batches failing quality or safety specifications are rejected. Acceptable products proceed to storage validation and then controlled and field efficacy assessment. Advancement depends on continued conformity with product-specific specifications. The sequence represents a proposed development framework, not a validated production protocol. Schematic developed for this review.

Research Priorities and Study Design

The next decisive experiment is a winter-specific product trial with controls that answer a clear causal question. A fermented preparation should be compared with its matched unfermented substrate and an appropriate process or starter control, while thermo neutral and cold-exposed groups establish the role of temperature where ethically justified. The formulation should be fixed before confirmatory testing. Pilot work can identify intake problems and practical delivery constraints, but it should not be used to select favourable outcomes after results are known.

Field studies should follow product qualification and controlled proof of concept. Randomization, a prespecified primary endpoint, adequate replication and blinded outcome assessment where feasible would improve interpretability. The experimental unit must follow the level at which treatment is allocated and independently delivered. It may be a pen, water-line group, house or flock; individual birds sampled from a shared unit are subsamples. Environmental monitoring should capture the actual winter exposure, including temperature, humidity and litter conditions. Effect estimates with confidence intervals would be more informative than a long list of nominally significant biomarkers.

Stewardship outcomes should be collected alongside health outcomes from the start, even if a larger multisite study is needed to evaluate them reliably. The key question is whether healthier flocks require less treatment under the same veterinary decision rules. Independent replication across production cycles or settings would then establish whether the response is reproducible. Table 4 proposes a staged program in which progression depends on safety, clinical relevance and practical benefit. The stages can overlap; they are not evidence that any existing product has already met those requirements.

Table 4: *Staged research priorities for winter applications.*

Stage	Main question and design	Requirement for progression
Product qualification	Verify identity, reproducibility, microbiological and chemical safety, and storage stability.	Independent batches meet predefined specifications throughout intended use.
Controlled proof of concept	Compare fermented material with matched substrate and process controls under a defined cold-exposure model.	Clinically relevant or coherent mechanistic benefit without toxicity or an intake penalty.
Winter field efficacy	Use independently randomized treatment clusters and record exposure, clinical events and product consistency.	A reproducible health benefit across relevant winter settings or cycles.
Stewardship and One Health	Record treatment decisions and exposure; assess resistant organisms, food safety and environmental outcomes.	Lower treatment need without delayed care, worse welfare or adverse safety signals.
Implementation	Evaluate full costs, rejected batches, labor, adherence and seasonal reliability.	A feasible process with net benefit under routine veterinary oversight.

Note: This roadmap is proposed by the review. Progression criteria require prespecification for each product and production setting; no universal numerical thresholds are implied.

Limitations of the Evidence

This synthesis is selective and may miss relevant studies. Products differ in botanical identity, microbial processing, delivery route and composition, and the studies vary in comparator choice and outcome reporting. These differences prevent a reliable common dose recommendation or quantitative winter-efficacy estimate. Several Allium reports come from overlapping author groups, while some independent studies assess different substrates or purified fractions. Cold challenges also differ from the fluctuating exposure of commercial winter flocks. These limitations narrow the conclusions to biological plausibility and product-specific effects outside the intended winter setting.

Conclusion

Fermented botanicals warrant investigation as an adjunct to winter poultry-health management. Cold-stress studies identify intestinal, redox and immune responses that are potentially modifiable, and fermented garlic, Astragalus and Allium preparations have affected related outcomes under other conditions. The remaining step is direct validation in cold-exposed chickens using reproducible products and appropriate controls. Practical value should be determined by clinical health, treatment requirements, safety and cost. A One Health claim will require measured resistance, food-safety or environmental outcomes in addition to production responses. Until those data are available, winter use should be treated as a product-specific prevention hypothesis under veterinary oversight.

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Ethics Approval

Not applicable. This review did not involve new experiments with animals or human participants.

Competing Interests

The authors declare no competing interests.

Data Availability

No new datasets were generated or analysed. The evidence discussed is available in the cited literature.

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