

Dietary Turmeric Powder and Its Effect on Broiler Growth, Carcass Traits and Gut Morphology

Dimitrios Theodorou¹ ●, Nandini Goud² ●, Sarika V Acharya³ ●

¹ Associate Professor, Department of Poultry Science, Thessaly Plain Institute of Agriculture, Larissa, Greece. Email: d.theodorou@tpia.gr | ORCID: 0000-0001-1917-2863

² Senior Research Fellow, Department of Poultry Science, Palnadu Institute of Veterinary Sciences, Narasaraopet, India. Email: n.goud@pivs.ac.in | ORCID: 0000-0001-1830-5732

³ Professor, Department of Poultry Science, Palnadu Institute of Veterinary Sciences, Narasaraopet, India. Email: s.acharya@pivs.ac.in | ORCID: 0000-0001-3781-3249

ABSTRACT

*Ground turmeric, the dried rhizome of *Curcuma longa*, is a popular candidate for replacing antibiotic growth promoters in broiler diets, and it is often said to improve growth, carcass quality and the structure of the small intestine. This mini review asks how firm those claims are. It draws on published work on the chemistry of curcuminoids, on their poor uptake and rapid metabolism, on broiler trials with turmeric or curcumin, and on the design and reporting of feeding experiments, and it presents no new data. The plausible routes of action are an improved digestive environment, antioxidant protection and a gentler load on the gut mucosa, yet each depends on how much active material actually reaches the bird, and that quantity is seldom measured. Turmeric products differ in curcuminoid content, trials describe doses in incompatible ways, and small positive reports are more likely to be published than null ones. Framing turmeric as a substitute for antibiotics adds a further strain, because the comparison is rarely made within one trial. The review concludes that a modest benefit is plausible under some conditions, that its size is not established, and it lists the reporting that a convincing broiler trial would need.*

Keywords: Turmeric; Curcumin; Broiler; Carcass traits; Gut morphology; Phytogetic feed additive; Narrative review

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Article Class: Mini Review

1. Introduction

For decades, small doses of antibiotics in feed were an accepted way of getting a little more growth and a little better feed conversion from broilers [1]. Restrictions on that practice, first in Europe and then in other markets, sent nutritionists looking for substitutes [2], and worries about resistance in bacteria that pass between animals and people have kept the search going [3, 4]. Among the candidates, plant-derived feed additives have attracted a great deal of attention because they are cheap, familiar and easy to describe to farmers as natural [5, 6].

Turmeric is one of the most commonly named. It is the dried and ground rhizome of *Curcuma longa*, a spice used in kitchens across South Asia and a staple of traditional medicine, and its yellow pigments, the curcuminoids, have been studied for their chemistry and biological activity for many years [7, 8]. Poultry scientists have taken the next step and put it in broiler diets, hoping for faster growth, better carcasses and a healthier intestine [9]. The idea is attractive and the spice is inexpensive, so it is easy to see why the claim has spread, especially among small and mid-sized producers.

What is harder to see is how well that claim stands up. A benefit in broilers has to travel a long way: from a powder in a bag, through a feed mill, into a bird whose gut absorbs very little of the main active compound, and back out again as heavier birds, better meat and healthier villi. Each step can fail independently, and the usual summary of a trial, one or two differences between a control and a treated group, does not tell the reader which step carried the effect or whether it would carry again. This mini review sets out what is known about turmeric and curcumin as feed additives, the plausible routes to benefit, and how much weight the existing evidence can bear. The aim is a fair account of what is known and what is merely repeated.

The article is a narrative review. It draws on published work on the chemistry of curcuminoids, on broiler nutrition and gut health, and on the design and reporting of feeding experiments, and it deliberately reports no new data and no performance figures. Where the broiler literature is mixed or thin, we say so instead of quoting numbers we could not check against their sources. Readers who want effect sizes should go to the primary trials, which we point to throughout, and we flag the places where our own reading goes beyond what a source states.

2. Literature Review

2.1 Turmeric, Curcuminoids and What Reaches the Bird

Ground turmeric is a mixture. Curcumin and two close relatives, demethoxycurcumin and bisdemethoxycurcumin, make up the pigments that give the spice its colour, and the powder also holds volatile oils, starch, fibre and minerals [8, 10]. Laboratory methods can separate and measure the three curcuminoids [10], but those methods are rarely applied to the material that goes into a feed. Surveys of commercial turmeric and curry powders have shown that the curcumin content of products sold under the same name can differ widely [11]. A broiler trial that simply says it used turmeric powder has therefore told the reader much less than it appears to. Table 1 sets ground turmeric beside purified curcumin on the points that matter for feeding.

The second difficulty is what happens to curcumin once it is eaten. Reviews of the pharmacology describe a compound that dissolves poorly in water, is absorbed in small amounts, and is rapidly changed and cleared by the body [12]. Some of the best known work in animals and human volunteers found that adding piperine, the pungent

component of black pepper, increased the amount of curcumin that reached the circulation [13]. That finding is useful in two ways. It shows that uptake is a real limit, and it hints that a spice given alone may act mainly inside the gut instead of in the tissues. For a feed additive, local action in the intestine is entirely respectable; it simply means that explanations based on blood and tissue levels need to be treated with care. This is why the same spice can look impressive in one report and unremarkable in the next.

Table 1. Turmeric powder compared with purified curcumin as a dietary source.

Attribute	Ground turmeric rhizome	Purified curcumin or extract
Composition	Mixture of curcuminoids, volatile oils, starch and fibre [8, 10]	Mostly curcuminoids, at stated purity
Curcuminoid content	Differs between products and batches [11]	Stated on the label; still worth verifying
Cost and supply	Low cost, locally available	Higher cost, specialist supplier
Uptake	Curcumin is poorly absorbed and quickly metabolised [12]	Same limits unless formulated [13]
Handling	Bulky; large share of the diet needed	Small inclusion; needs even mixing
Broiler evidence	Many small trials [9, 23]	Fewer trials [25, 26]

Note: Qualitative comparison. Curcuminoid content depends on the product and batch; no figures are given because they cannot be generalised.

Words matter here, because turmeric, curcumin and curcuminoids are used interchangeably in feed trials and they are not the same thing. Turmeric is the whole ground rhizome; curcuminoids are the group of pigments within it; curcumin is the principal member of that group [8, 14]. A trial of one cannot be quoted as a trial of another, and a review that blends them without comment overstates how much evidence exists for any single material. In this article we use turmeric for the spice, curcumin for the single compound and curcuminoids for the group, and we say which is meant whenever a source makes it clear.

Broader reviews have swung between enthusiasm and scepticism. Some describe a wide range of biological activities and a long history of use [7, 14], and others summarise what clinical trials in people have and have not shown [15, 16]. A more recent chemical appraisal argues that curcumin is unstable, reactive and poorly absorbed, which makes it an unreliable lead for drug development [17], and a wider warning about compounds that appear active in many laboratory assays for

reasons unrelated to a specific target applies to it as well [18]. None of this settles whether turmeric helps a chicken. It does mean that statements such as curcumin is a proven antioxidant or anti-inflammatory need to be read as claims about test tubes and cell cultures unless they are supported by feeding data.

2.2 Why PhytoGenics at All

Antibiotic growth promoters are thought to work partly by changing the gut microbial community and partly by thinning the intestinal wall and reducing the metabolic cost of mucosal inflammation, though the exact mechanisms remain debated [1]. Plant-derived additives are often proposed as gentler replacements. The proposed routes are stimulation of appetite and digestive secretions, antimicrobial action against some gut bacteria, and antioxidant protection [5, 19]. A review of herbal products in animal nutrition notes the same hopeful list, along with an equally frank account of how variable the products and the results are [6].

Polyphenols, the broad group to which curcumin belongs, have a literature of their own in poultry. The antioxidant argument is the most developed: birds on modern diets and growth rates face oxidative stress, and plant polyphenols are proposed as one practical means of supporting the defences of the bird and the stability of the meat [20]. Alternatives to antibiotics now form a field of their own, and reviews of that field are blunt that no single product has matched the consistency of the drugs it was meant to replace [21, 22]. This is the setting in which turmeric trials have to be read.

2.3 Broiler Trials with Turmeric and Curcumin

Trials of turmeric in broilers go back at least to the early 2000s. One of the better known early reports examined the effect of turmeric on the overall performance of broiler chickens [23], and others studied blood parameters in birds fed varying levels of turmeric rhizome powder [24]. A review of turmeric in poultry diets brought this scattered work together and described a field in which doses, forms of turmeric, bird types and measured outcomes differ from one study to the next [9].

Later work has looked more closely at the gut and the carcass. A trial of dietary curcumin examined growth performance, intestinal morphology and nutrient utilisation in broiler chicks [25], and another examined meat quality and the antioxidant profile of breast muscle at various curcumin levels [26]. Other trials combined turmeric with pepper

and coriander and recorded growth, carcass traits, blood measures and humoral immune response [27]. The mixture of ingredients, outcomes and designs in these reports is the main point: even a reader who wants to pool them will find that the studies have asked slightly different questions.

A separate line of work uses turmeric with a known curcumin level as a protective agent against aflatoxin in the diet. In one such trial, turmeric was tested alone and with a clay mineral binder [28], and a follow-up examined how turmeric affected the expression of liver genes concerned with the handling of toxins, antioxidant defence and immunity in aflatoxin-fed chicks [29]. Those studies are informative because they were designed around a defined challenge. They also show that the answer to what turmeric does may depend on what stress the bird faces.

2.4 Gut Morphology: What the Measurements Mean

Intestinal health in poultry is the sum of many things: the structure of the mucosa, the microbial community, the immune system and the diet itself [30]. Gut morphology has become a popular outcome in feed additive trials because it can be measured with ordinary histology. Taller villi and a moderate crypt depth are generally read as signs of a healthy absorptive surface, though the interpretation depends on the age of the bird and the diet [31]. Even the antibiotics that plant products are meant to replace have been shown to alter gut structure as well as performance [32].

The practical difficulty is that morphology is sensitive to technique. The segment sampled, the way tissue is fixed, the number of villi measured and the criteria for choosing them can all move the result, and published work on feed additives and histomorphology in broilers shows how many choices lie behind each reported value [33]. A reported difference in villus height is therefore only as good as the sampling description that accompanies it, and a sampling description is often missing. A gut that has had time to settle on a new diet behaves differently from one that has not.

2.5 Carcass and Meat Quality

Carcass traits cover yield, the share of breast and leg, abdominal fat and the properties of the meat. Meat quality in poultry depends on genetics, nutrition, handling before slaughter and processing after it [34], so an additive is competing with many larger influences. The oxidative stability of meat is the area where a dietary antioxidant has the clearest theoretical

role [20, 26], while changes in yield are harder to explain by any plausible route.

Interpretation also depends on the birds themselves. Modern broilers differ greatly from those of earlier decades in growth rate and feed efficiency [35], so a result in an older or slower strain may not repeat in current commercial birds. Since many turmeric trials are carried out in small research houses, with strains and diets that are not always described in full, the transfer to a commercial flock is an open question and not a given.

3. Materials and Methods

3.1 Scope and Question

The review asks one question in three parts: does dietary turmeric or curcumin plausibly improve broiler growth, does it plausibly improve carcass traits, and does it plausibly improve intestinal morphology? The question was divided into the sub-questions that a trial would have to answer: what material was fed and how it was characterised, what the birds and basal diet were, how outcomes were measured, and how the analysis handled pens, multiple outcomes and chance. None of these steps is difficult, but each one is easy to skip.

3.2 Literature Assembly

The review draws on peer-reviewed work in four areas: the chemistry and pharmacology of curcuminoids; the use of phytogenic additives and the move away from antibiotic growth promoters; broiler gut and carcass biology; and the methods literature on trial design, bias and reporting. Sources were chosen for relevance, citation in the field and the clarity of their methods. Studies in laboratory animals and humans are used for what they teach about uptake and chemistry, not as evidence of effects in broilers.

We did not run a formal systematic search and we do not claim one. This is a narrative synthesis, and the choice of sources reflects the authors' judgement. The practical consequence is that the review is a better guide to what a good broiler trial should contain than to the exact size of any reported effect, and it avoids quoting figures from individual trials that could not be checked against the primary papers for this article.

3.3 Appraisal Framework

To judge how far a report can be trusted, we used a short set of questions. Is the product identified well enough to know the dose of curcuminoids [10, 11]? Is the experimental unit the pen or the bird, and does the analysis match [36]? Are all

prespecified outcomes reported, or only the ones that came out well [37, 38]? And are the gut and carcass methods described well enough to be repeated [33]? Table 2 lists the reporting items we looked for.

4. Results

4.1 What Reaches the Bird, and Where It Acts

The chemistry and pharmacology literature describe a feed ingredient whose main active compound is only partly available to the bird. Curcumin is absorbed in small amounts and rapidly metabolised [12], and the proportion of curcuminoid in a turmeric product varies [11]. Taken in the order shown in Figure 1, the route from feed bag to performance passes through the feed, the gut lumen and the mucosa before any effect on growth can appear, and each step has its own check. It follows that the most believable effects are those acting inside the gut, such as on digestive conditions, the microbial community or the integrity of the mucosa, and the least believable are those that require high tissue levels of curcumin.

Table 2. Reporting items for a broiler trial of turmeric or curcumin.

Item	What to report	Why it matters
Product identity	Plant part, form, source, assayed curcuminoid content [10, 11]	Dose cannot be judged without it
Dose	Share of diet and curcuminoid supplied per unit of feed	Allows trials to be compared
Basal diet	Ingredients, energy, protein, feed antibiotic use	Response depends on the starting ration
Experimental unit	Pen or cage, and the analysis used [36]	Overstated precision otherwise
Outcome reporting	All prespecified outcomes, not only positive ones [37, 38]	Guards against selective reporting
Gut sampling	Segment, fixation, number of villi measured [33]	Morphology is sensitive to method
Housing and health	Stocking, temperature, disease pressure	Effects may depend on challenge

Note: Items are those discussed in the cited methodological literature; they are not attributed to any single broiler study.

This does not make a benefit impossible. Some plant additives act through taste, smell or effects on secretions as much as through any absorbed compound [5, 19]. It does mean that any trial that attributes its result to curcumin has implicitly assumed more than it measured, particularly when

the form fed was a bulk spice and not a purified compound, and when composition was not assayed [9, 10]. Small differences of this kind are easy to miss in a single pen and easy to over-read in a headline.

4.2 Growth and Feed Use

The broiler literature on growth is a mixed one. Reports exist in which turmeric or curcumin was associated with better performance, others in which little changed, and the review literature describes a field in which inclusion levels, product form and bird type vary from study to study [9, 23, 27]. We read this as a reason for caution rather than as a contradiction: trials that differ in dose, product, strain and diet should not be expected to agree.

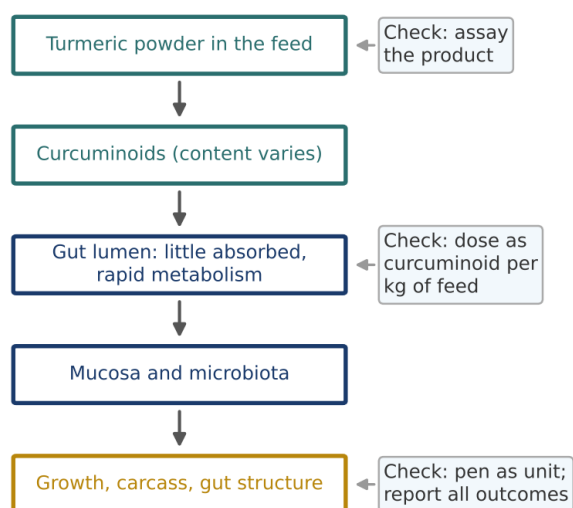


Figure 1. From turmeric powder to bird performance, with the checks that surround each step (schematic, not data).

Several design features make growth outcomes especially hard to interpret (Figure 2). If curcuminoid content was never assayed, the dose is unknown [11]. If the basal diet already supported good performance, there may be little for an additive to improve, and if birds are healthy, an additive meant to support the gut has less to do. And if the strain differs from the commercial bird, results may not transfer [35]. These are not criticisms of any particular study. They are reasons why a positive result in one place tells us little about another.

Antibiotic comparisons deserve a separate comment. Turmeric is regularly introduced as an alternative to antibiotic growth promoters [21, 22], but a claim of equivalence needs a trial that includes an antibiotic group, a plain control and the additive, in the same birds on the same diet. Many trials contain only some of these. Without all

three arms, the language of substitution is a hope, not a finding. That is a modest claim, and it is the one the literature can currently bear.

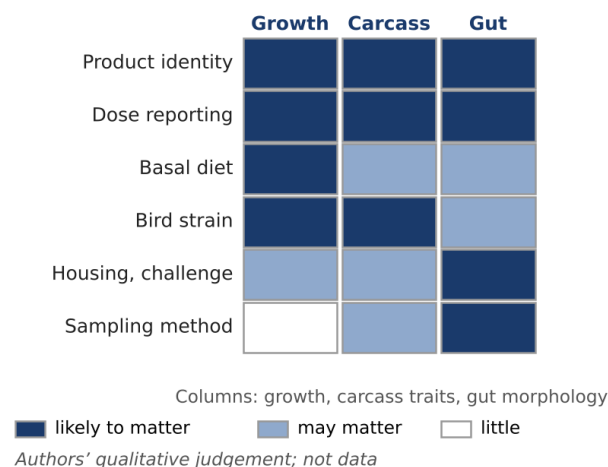


Figure 2. Qualitative grid of sources of variation against outcome domains (authors' judgement, not data).

4.3 Carcass Traits

For the carcass, the plausible route runs through muscle oxidative stability and, less clearly, through changes in fat deposition and yield. Work with dietary curcumin has examined the antioxidant profile and meat quality of breast muscle [26], and the oxidative argument fits the wider case for dietary polyphenols [20]. Meat quality, however, depends on much more than the diet [34], so an additive that nudges oxidative stability may still leave visible quality unchanged.

There is a quieter problem here as well. Carcass outcomes are numerous: weights, yields, parts, fat pads and measures of meat quality. Where many outcomes are examined and only a subset is discussed, the chance of a spurious finding rises, and selective reporting is a recognised bias in the wider literature [37, 39]. A fair reading of a carcass table asks how many outcomes were examined and not only which were significant.

4.4 Gut Morphology and Health

Gut morphology is the most mechanistically sensible outcome for a feed additive that acts in the intestine, and it has been examined directly in broilers given curcumin [25]. The proposed route runs through the mucosal surface: villus height, crypt depth and their relationship are read as markers of absorptive capacity and renewal [31]. Antibiotics, too, change these structures [32], which is why a plain control alone is a weak comparator.

Morphology, however, cannot be separated from method. Because values depend on where along

the intestine the sample was taken, how it was fixed and how many measurements were made [33], differences between laboratories can be as large as differences between diets. Intestinal health also extends beyond structure to the microbial and immune side [30], so a single histology table is a narrow view. Table 3 summarises the outcome domains, the proposed routes and the main caution for each.

Table 3. Outcome domains, proposed routes and the main caution for each.

Domain	Proposed route	Main caution
Growth and feed use	Digestive environment, antioxidant status, microbiota [5, 6]	Modern strains behave differently from those in older trials [35]
Carcass traits	Antioxidant protection of muscle [20, 26]	Yield and quality respond to many factors [34]
Gut morphology	Villus and crypt structure, nutrient uptake [25, 31]	Handling and site of sampling [32, 33]
Toxin challenge	Liver biotransformation and antioxidant genes [28, 29]	Relevant mainly under challenge
Blood and immunity	Changes in serum measures [24, 27]	Blood measures are not performance

Note: Routes are proposed mechanisms from the cited literature, not demonstrated effects in broilers.

A further caution is that structure and performance are not the same thing. A change in villus height can accompany better growth, no change in growth, or even poorer growth, depending on what else is happening in the bird, and the literature on intestinal health stresses that the link between mucosal structure and productivity is real but loose [30, 31]. A gut table that looks favourable should therefore be read together with growth and feed records from the same pens, and a gut change reported without them should be held more lightly than its tidy appearance suggests.

Studies that use a defined challenge are easier to interpret. In aflatoxin-fed chicks, turmeric was examined for its effects on liver biotransformation and antioxidant genes [28, 29]. Whether the same benefit appears in unchallenged, healthy birds is a separate question, and most commercial flocks sit somewhere between the two extremes. Figure 3 sketches the stages of a broiler trial at which each kind of outcome would normally be measured.

4.5 Reading a Claim of Benefit

A reader meeting a claim that turmeric improved broilers can ask a short run of questions. What exactly was fed, and was its curcuminoid content measured [10, 11]? What was the control diet, and

was there an antibiotic group? Was the pen, rather than the individual bird, treated as the unit of replication [36]? Were the methods reported in enough detail to meet accepted standards for animal research [38]? A report that answers all four is rare, and one that answers none should be read as an observation rather than as evidence of effect.

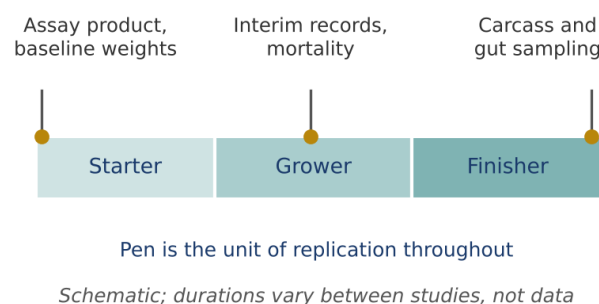


Figure 3. Schematic timeline of measurement points in a broiler trial (not to scale, not data).

Publication bias deserves a mention of its own. Studies with positive findings are more likely to be published than those without, and outcomes that did not work are more likely to be dropped from the report [37, 39]. Where enough trials exist, statistical checks on small-study effects can hint at the problem [40], but in a field where trials are small, varied and few, such checks have little to work with. The sensible assumption is that the published record leans more favourable than the full set of experiments that were run.

Scale matters too. Trials with few pens give unstable estimates, and when such a trial happens to reach significance the apparent effect is likely to be an overestimate of the real one [39]. This is not a special failing of turmeric research; it is a general feature of small experiments in applied animal science. It does mean that the first positive report on a promising additive deserves less trust than the third, independent one, and that the enthusiasm which follows an early positive result tends to run ahead of the replication that ought to justify it [36, 40].

The summary the literature supports is cautious. Turmeric is a cheap, familiar spice that birds will eat. The case for an effect is biologically plausible, mostly through actions in the gut and antioxidant protection, but the size of any benefit in current commercial broilers is not established by evidence we can cite with confidence. The best summary is that a small positive effect is possible under some conditions, uncertain under others, and heavily dependent on the product and the trial. Read this

way, the absence of an effect in a small trial is not evidence that none exists.

5. Discussion

5.1 Interpretation and Practical Reading

The main finding of this review is a conditional one. Turmeric is most likely to help where the diet or the environment leaves something for a gut-acting additive to do, and least likely where the birds are healthy and well fed. This fits what is known about phytogetic additives in general, where consistency has been the stubborn problem [5, 21], and it implies that the question for a producer is not whether turmeric works but what problem it is meant to solve. Nothing in this reading argues against feeding turmeric; it argues for measuring what happens when it is fed.

The second conditional is about the product. Because curcumin content differs between turmeric products [11], and because its uptake is low and variable [12], two farms buying turmeric from different suppliers may be feeding materially different diets while following the same recipe. Standardising the product, or at least assaying it, is the most inexpensive improvement open to a researcher and the one most often skipped. A benefit that disappears once the product is assayed was never a benefit that could be relied on.

A third point concerns the framing. Presenting turmeric as a substitute for antibiotics sets an expectation that few trials are designed to test [21, 22]. Antibiotic growth promoters acted on performance and on the gut in measurable ways [1, 32], and an additive that is simply not antibiotic is not thereby equivalent. The wider public-health reasons for reducing antibiotic use [3, 4] are good reasons to look for alternatives; they are not evidence that any given alternative works. These points apply with equal force to any novel additive, not only to turmeric.

The economics are worth a brief word. Turmeric is inexpensive per kilogram, which is much of its appeal, but a low price does not settle the cost per unit of benefit. If the useful dose of curcuminoid is high relative to what a bulk powder supplies, the amount of powder needed rises, and so do the handling and mixing demands on the mill [6, 9]. Conversely, if the true effect is small, a cheap additive may still not repay its inclusion. Without a measured effect and an assayed dose, neither calculation can be made honestly, and the claim that turmeric is cheap remains true but beside the point.

Three findings would change this reading. A well-designed trial in a current commercial strain, with the product assayed, an antibiotic arm and a plain control, showing a clear and repeatable benefit in growth or gut structure would move the case from plausible to supported. A set of trials using a common product and common outcomes, with enough studies to examine between-study differences, would show whether the mixed picture reflects real heterogeneity or only chance. And evidence that the benefits are confined to challenged birds would redirect the advice towards specific conditions rather than routine inclusion [28, 29].

5.2 Limitations

This is a narrative review and shares the limitations of that form. The selection of sources reflects judgement, no formal search or quality scoring was done, and the review does not quote numerical results from individual broiler trials, because these could not be checked against the primary reports for this article. A reader who needs an effect size should consult the original studies directly, applying the appraisal questions above, or wait for a formal systematic review with meta-analysis, a task that methods for detecting small-study bias are meant to support [40].

The review also draws on evidence from laboratory animals, people and in vitro work for the chemistry and pharmacology of curcumin [15, 41], which are imperfect proxies for the gut of a broiler. We have used them to frame hypotheses, and the conclusions should be read in that light. Reviews of this kind are more useful when they say where the evidence stops than when they smooth it over.

5.3 Implications for Trial Design

A trial that could settle the question would use enough pens to detect a modest effect, with the pen as the unit of analysis where birds share a feeder and drinker [36]. It would assay the turmeric for curcuminoid content, state the dose as the amount of curcuminoid per unit of feed and not only as a share of the diet, and describe the basal ration and the strain fully. It would include a plain control and, if substitution is the claim, an antibiotic arm, and would test more than one inclusion level so that the shape of the response can be seen.

On the outcome side, the trial would prespecify its primary outcomes and report all of them [37, 38], describe the gut sampling in enough detail to be repeated [33], and record carcass traits against a clear protocol. These requirements are

demanding, but they are the ones that distinguish a result a producer can use from one that only supports a hunch.

5.4 Directions for Future Work

Three needs stand out. First, a formal systematic review of broiler trials with a transparent search and quality appraisal, ideally with a meta-analysis that accounts for between-study differences [40]. Second, well-designed trials in current commercial strains with defined and assayed products, including formulations intended to raise uptake [13]. Third, work that separates healthy and challenged birds, since the answer may differ between them [29].

5.5 Practical Reading for Producers and Advisers

For an adviser, the sensible position is neither to dismiss turmeric nor to promise results. A producer who wishes to try it can do so as a small, recorded comparison: a group of pens receiving it alongside comparable pens that do not, in the same house and on the same basal ration, with growth, feed use and mortality recorded in the same way for both. Records of the product source, the amount used and its cost are as important as the weights, because the economic question cannot be answered without them [16, 34].

Such a comparison is not a substitute for a trial, and it should not be reported as one. It can nonetheless tell a producer whether the practice is workable in one house, whether the supply of a consistent product is reliable, and whether any difference is large enough to notice against ordinary variation between flocks. Its value lies in local decision-making, and the broader question of effect size will be settled by designed trials and by systematic synthesis of their results [35, 40].

6. Conclusion

Turmeric is a plausible feed additive for broilers, cheap, familiar and attractive as a response to the loss of antibiotic growth promoters. The evidence, as we can responsibly summarise it, does not yet establish how large its effect on growth, carcass traits or gut morphology is in current commercial birds. What the literature does show is where an effect is most believable, how uncertain the dose usually is, and what a fair trial would contain. Readers should treat claims of large gains with caution until they meet those standards.

A last point concerns how the topic is talked about. Turmeric sits in the comfortable category of natural products, and that label tends to lower the standard of proof people ask for. A spice with a

long culinary history is assumed to be harmless and, by extension, useful. Neither assumption has to be wrong in any given case, but both need the same checks as any other additive: a defined product, a defined dose, adequate replication and complete reporting [6, 38].

For the practitioner the message is practical rather than discouraging. Turmeric can be tried, provided the product is known, the ration is described and the results are written down. For the researcher, the opportunity is a set of trials that identify the product, assay its curcuminoids, include the right comparators and report every outcome, turning a plausible idea into a measured result that producers can rely on, whatever the answer turns out to be.

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9. Conflict of Interest

The authors declare no conflict of interest.

10. Author Contributions

D.T. conceived the review and wrote the sections on broiler production and carcass traits. N.G. wrote the sections on curcumin chemistry and gut morphology. S.V.A. wrote the sections on trial design and reporting. All authors revised the manuscript and approved the final version.

11. Ethics Statement

This is a review of published literature. No animals were used and no ethical approval was required.

12. Data Availability

No new data were generated. All sources are cited in the reference list.

13. References

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