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Feed restriction in Broiler Breeders: A systematic review of impact on productive performance, reproductive outcomes, and welfare indicators

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Abstract

Feed restriction is indispensable to the management of broiler breeder flocks (*Gallus gallus domesticus*). In the absence of rationing, these birds exhibit abnormal obesity, reproductive dysfunctions, and elevated mortality. Despite five decades of experimental production, no systematic synthesis had simultaneously evaluated the effects of different restriction strategies on productive and reproductive performances and on breeder welfare. This systematic review was conducted to address this gap and drew upon articles published in the Scopus and Web of Science databases between 1989 and 2025. Study selection, carried out via Rayyan, and risk-of-bias assessment using the SYRCLE tool yielded a final corpus of 90 studies. According to the authors, ad libitum feeding is deleterious, as it disrupts the ovarian follicular hierarchy and reduces fertile egg production by approximately 40 units per hen. Every-day feeding (ED) surpasses skip-a-day feeding (SAD) in terms of body weight uniformity, feed efficiency, eggshell quality, and hatchability, with systematically lower corticosterone levels. Furthermore, maintaining SAD after photostimulation induces lasting reproductive dysfunctions and a net loss of at least 17 eggs per hen. Dilution with insoluble fiber reduces stereotypies and improves clinical welfare indicators (plumage quality, foot lesions, fault bars, etc.) without altering the hypothalamic expression of appetite-regulating peptides (AGRP, POMC). Precision feeding improves body weight uniformity but significantly reduces egg production. As a synthesis, this study reveals that daily feed restriction remains the best-supported program for jointly optimizing productive and reproductive performances. Qualitative restriction improves clinical welfare indicators without resolving metabolic hunger. However, no currently available strategy demonstrates a simultaneous and robust benefit across all three domains investigated.

Keywords: *Broiler breeders; feed restriction; productive performances; reproductive performances; animal welfare; systematic review*

Introduction

The poultry sector occupies a central place in animal protein production. Global poultry meat production reached 146 million tons in 2023. According to projections from the OECD and FAO, poultry will account for 62% of total global meat consumption growth by 2034 and will provide 45% of protein intake from all meats combined (OECD & FAO, 2025). Over the long term, total global food demand is projected to increase by 50 to 60% between 2019 and 2050, with a marked trend towards poultry as the dominant form of meat consumption (Falcon et al., 2022). Poultry thus constitutes the preferred vector for this expansion, owing to its low production cost, short cycle duration, and favorable nutritional profile. This expansion is largely underpinned by decades of intensive genetic selection of the broiler (*Gallus gallus domesticus*), which has led to an increase of over 400% in growth rate between 1957 and 2005, of which 85 to 90% is directly attributable to genetic progress, with the remainder attributed to nutritional improvements (Havenstein et al., 2003; Zuidhof et al., 2014).

Genetic selection in favor of rapid growth and high feed efficiency has, through negative correlation, impaired the capacity of broiler breeders to regulate their own feed intake (Richards et al., 2010). Left on ad libitum feeding, these birds develop progressive obesity, metabolic disorders (ascites, cardiac insufficiency, etc.), reproductive dysfunctions characterized by multiple ovulations and a reduced hatchability rate, as well as mortality that can exceed 30% under certain uncontrolled conditions (De Jong & Guémené, 2011; Heck et al., 2004; Mench, 2002). This phenomenon, documented in the literature under the name of the "broiler breeder paradox", highlights a major biological incompatibility. The genetic criteria selected to maximize the rapid growth of offspring directly harm the fertility and health of the parents, unless strict rationing measures are applied (Decuypere et al., 2010).

Thus, to circumvent this paradox, the global poultry industry has for several decades resorted to feed restriction as the primary tool for controlling broiler breeder live weight. This practice, which begins in the first weeks of life and often continues throughout the production cycle, consists of limiting daily energy intake by 25 to 55% of voluntary consumption depending on the production phase and sex. Males are subject to a separate restriction programme owing to their different nutritional requirements and growth profile compared to females (De Jong et al., 2002; De Jong & Guémené, 2011). This practice now constitutes the global industrial standard for this animal category.

While feed restriction is recognized as indispensable to the optimization of reproductive performance and the prevention of metabolic disorders in broiler breeders, its consequences for animal welfare are documented and concerning. Birds subjected to severe restrictions consume their daily ration in less than 15 minutes, after which they exhibit behavioral and physiological signs characteristic of a state of chronic hunger. These include an increase in stereotypic foraging behaviors, redirection of feeding behaviors towards inanimate objects (drinkers, partition walls), an elevation of the heterophil-to-lymphocyte ratio and of basal corticosterone levels, and signs of persistent activation of the hypothalamic-pituitary-adrenal axis (De Jong et al., 2002; De Jong & Guémené, 2011; Mench, 2002). These manifestations are interpreted as the expression of a state of chronic hunger and feeding frustration, constituting a direct threat to animal welfare and resulting in persistent physiological stress.

Added to this welfare issue is a lack of clear, universal scientific consensus regarding the most effective restriction strategies. Rationing programs applied to broiler breeders exhibit marked heterogeneity at the international level. This variability manifests first in the very nature of the methods employed, ranging from quantitative approaches (daily distribution, alternating skip-a-day, 4/3 or 5/2 schedules), qualitative strategies through fiber dilution of the ration, and emerging concepts of individual precision feeding. To this methodological diversity are added major disparities concerning the intensity of restriction defined by the degree of severity of the rationing as well as its duration of application across the bird's life cycle. Nonetheless, despite a substantial body of experimental data accumulated over more than five decades, scientific literature suffers from a lack of comprehensive overview. To date, no global meta-analysis or systematic synthesis exists that would allow a rigorous evaluation and comparison of these different restriction strategies across all key dimensions of productive performance, reproduction, and animal welfare of the breeders themselves.

The present systematic review therefore aims to address this gap by pursuing two complementary objectives. The first is to systematically and reproducibly invent all published experimental studies on feed restriction in broiler breeders, across all methods. The second is to evaluate and synthesize the effects of different quantitative, qualitative, non-daily, and precision restriction strategies on productive and reproductive performances and welfare indicators.

Materials and Methods

Bibliographic search strategy

For this systematic review, the literature search was conducted on Scopus and Web of Science. On Scopus, the search was restricted to the fields of Agricultural and Biological Sciences and Veterinary, while on Web of Science, the disciplinary categories selected were Agriculture Dairy Animal Science and Veterinary Sciences. This choice made it possible to target exclusively the literature in animal production and veterinary medicine, while excluding publications from disciplines without a direct link to the subject of the review. Both platforms were selected for their complementarity in terms of disciplinary coverage of animal and veterinary sciences. The search covered the period from 1989 to 2025. This time boundary was set to reflect the evolution of rearing practices over more than three decades, from conventional skip-a-day programs to the most recent precision feeding and qualitative restriction approaches. Only publications in English and French were retained. The search was constructed around three conceptual blocks linked by the Boolean operator **AND**. The first targets the population (broiler breeders), the second covers the modalities of intervention (feed restriction), and the third groups the outcomes of interest. Within each block, terms are combined with the **OR** operator so as not to exclude synonyms or spelling variants. Truncations (*) were also used to broaden the detection of derived forms of the keywords. The complete Boolean equation is as follows: (“broiler breeder*” OR “broiler parent stock” OR “meat-type chicken breeder*” OR “broiler dam*”) AND (“feed restriction” OR “restricted feed*” OR “feed*restrict*” OR “skip-a-day” OR “skip a day” OR “qualitative restriction” OR “quantitative restriction” OR “restricted feeding” OR “feed dilut*”) AND (“egg production” OR “laying rate” OR “egg number” OR “body weight” OR “body weight gain” OR “uniformity” OR “feed conversion” OR “productive performance” OR “production performance” OR “mortality” OR “livability” OR “fertility” OR “hatchability” OR “embryo*” OR “reproductive performance” OR “semen quality” OR “sperm*” OR “chick quality” OR “chick weight” OR “welfare” OR “behavior” OR “behaviour” OR “aggression” OR “feather pecking” OR “stereotyp*” OR “stress” OR “hunger” OR “corticosterone”). All references were subsequently exported in BibTeX format from each database and then imported into the study management and selection software.

Research question and inclusion and exclusion criteria

Broiler breeder management has for decades relied on feed restriction as a tool for controlling body weight. Although this practice is recognized as indispensable to flock health and reproduction, its consequences for productive performance and animal welfare remain a subject of debate in scientific literature. This systematic review therefore seeks to answer the following question: *To what extent does feed restriction, regardless of its form, influence the productive performance, reproductive performance, and welfare indicators of broiler breeders?*

To structure this research question, the PICOS framework was used, as defined in Table 1 below. Furthermore, before proceeding with the examination of articles, inclusion and exclusion criteria were established a priori to ensure the consistency and reproducibility of the selection process. These criteria are presented in the following table.

Table 1: Inclusion and Exclusion Criteria According to the PICOS Framework

Domain	*Inclusion Criteria*	*Exclusion Criteria*
P Population	Broiler breeders (females and/or males), all ages	Commercial layers, broilers, turkeys, quail, partridges, or any other species
I Intervention	Any form of feed restriction: quantitative, qualitative, skip-a-day, ration dilution, precision feeding, comparison between methods	Absence of feed restriction; isolated additive supplementation without a restrictive dimension; manipulation of a specific nutrient without concomitant restriction
C Comparator	Ad libitum feeding or comparison between restriction programmes	No reference or comparison group
O Outcomes	At least one of: productive performance, reproductive performance, animal welfare measured on the breeders themselves	Outcomes measured exclusively on offspring (embryos, chicks, broilers); exclusively molecular outcomes without link to productivity, reproduction, or welfare
S Study design	Controlled in vivo experimental trial, observational study with comparison group	In vitro studies, conference proceedings without extractable data, abstracts only
Language	English	Any other language

Study selection process

Bibliographic management and the entire selection process were conducted using two complementary software tools. Zotero version 9.0.3 was used for the import, organization, and management of references. Rayyan (Ouzzani et al., 2016), a collaborative platform specialized in systematic reviews, subsequently handled assisted deduplication, title and abstract screening, and the documentation of all inclusion and exclusion decisions. The selection process was carried out in four successive stages, the results of which are summarized in the PRISMA diagram presented in Figure 1.

The search across both databases identified a total of 339 articles, of which 183 were from Scopus and 156 from Web of Science. Following import into Rayyan, a first phase of assisted automated deduplication led to the removal of 119 duplicates, reducing the corpus to 220 unique articles. These were then subjected to a systematic screening of titles and abstracts against the PICOS criteria. This stage resulted in the exclusion of 87 references deemed ineligible, primarily due to a non-conforming population, an intervention without a restrictive dimension, or an outcome measured exclusively on offspring. The remaining 133 articles were retained for in-depth reading. During this examination, 3 additional duplicates were identified, bringing the number of unique studies to 130 for methodological quality assessment. Subsequently, the methodological quality of each study was evaluated using the SYRCLE tool (Systematic Review Centre for Laboratory animal Experimentation), developed specifically for experimental animal studies (Hooijmans et al., 2014). At the end of the assessment of the 130 studies, a single study was excluded due to a high cumulative risk combined with a total impossibility of data extraction (abstract only, data not accessible). The 22 studies presenting a moderate-high to high risk or included with major reservations were not integrated into the synthesis and were not drawn upon in the results section. Only the 107 studies at low or moderate risk constituted the intermediate corpus at the end of this assessment. A fifth and final stage consisted of verifying the thematic conformity of each study with the central objective of the review, defined as the evaluation of the effect of feed restriction, whether quantitative or qualitative, on the productive and reproductive performances and welfare of the broiler breeders themselves. This examination led to the exclusion of 17 additional studies whose primary intervention or primary outcomes fell outside the defined scope. The definitive corpus on which the entire synthesis presented in this review is based comprises 90 studies published between 1989 and 2025.

Results

Overview of studies included in the review

The 90 studies included were published between 1989 and 2025, with a relatively homogeneous temporal distribution. 23% of the studies predate the year 2000, 28% cover the decade 2000-2009, 22% the decade 2010-2019, and 27% were published between 2020 and 2025. This increasing proportion of recent publications reflects the sustained research interest in strategies alternative to quantitative restriction, particularly in the field of insoluble fiber dilution. The studies are distributed across 13 scientific journals, with Poultry Science concentrating most publications (51 articles, 57%), followed by Applied Animal Behavior Science (17 articles, 18%) and British Poultry Science (7 articles, 8%).

In terms of the populations studied, 79% of the studies focus exclusively on female breeders, 9% include both females and males, and 12% focus solely on males in particular cockerels, in the context of recent studies on feed dilution and coarse roughage. The Ross 308 strain is by far the most frequently used (25 studies), followed by Cobb strains in their various forms (9 studies), dwarf or experimental strains (5 studies), and Hubbard strains (3 studies). Nearly half of the studies (44%, i.e. 40 studies) do not specify the strain used, which constitutes a notable limitation for inter-study comparability. The eight categories of feeding strategies identified, the periods covered, the strains used, and the outcomes measured are detailed in Table 2. Qualitative dilution of feed with insoluble fibers and/or coarse roughage constitutes the most represented axis of the corpus (24 studies), followed by comparisons of feeding frequencies (19 studies) and studies on quantitative restriction levels and energy intake (16 studies). Furthermore, multifactorial approaches are largely predominant, with the majority of studies simultaneously combining several variables, which complicates the causal attribution of observed effects.

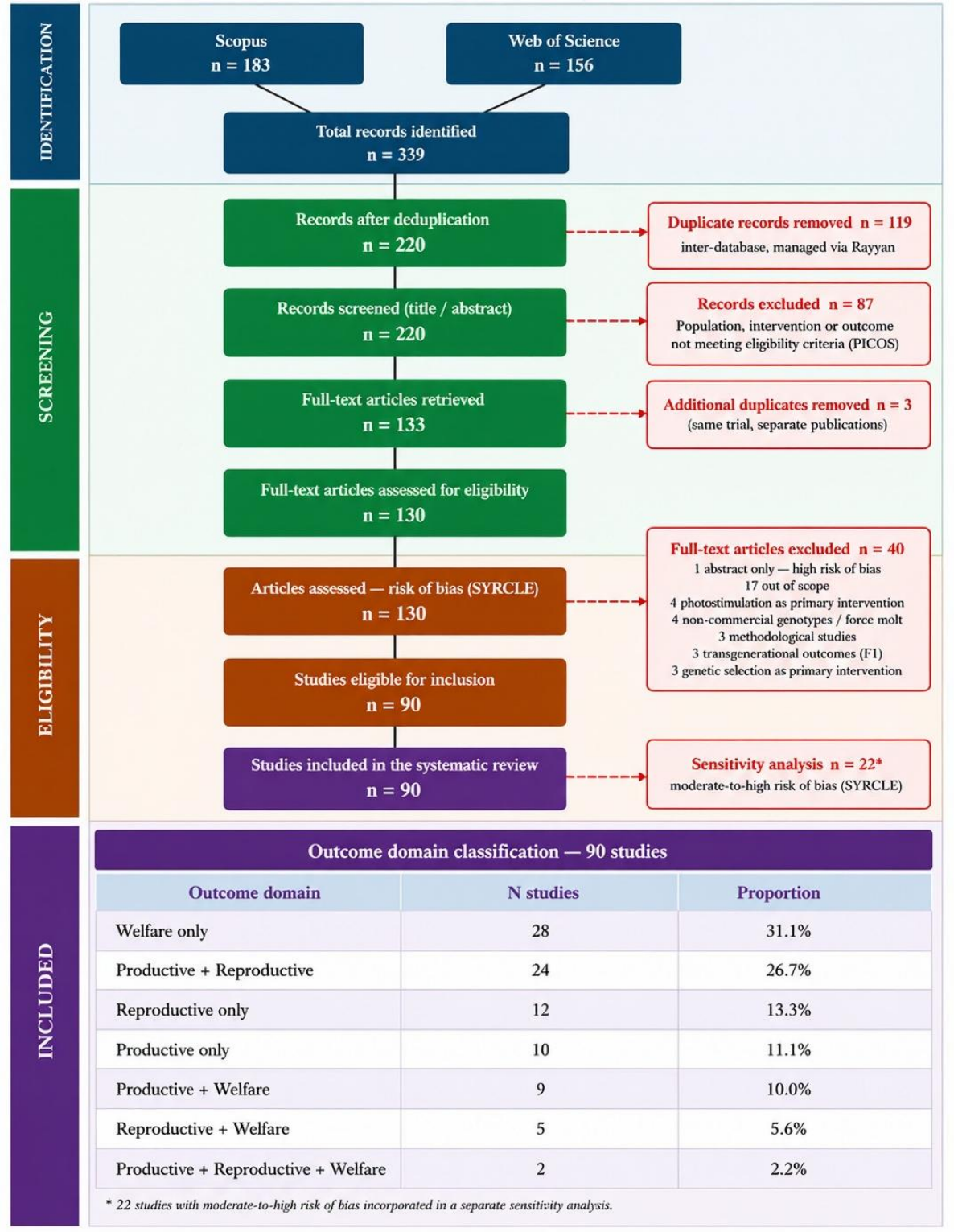

Figure 1: PRISMA Flow Diagram

Table 2: Overview of characteristics of studies included in the review, grouped by feeding strategy

Feeding strategy	*N*	*Period*	*Main breeds / strains*	*Sex*	*Total n (birds)*	*Age studied (wk)*	*Main outcomes measured*	*Domain(s)*
Quantitative restriction - Feeding frequency and schedule (SAD, ED, SOD, STD, 4/3, 5/2, ATD, once- vs. twice-a-day)	19	1989 - 2025	+++Ross 308; ++Ross 708; +Cobb 500; NR	Females and/or Males	35 - 1778	0-65 Rearing; Laying; Rearing + Laying	BW, FCR, body and carcass composition, skeletal growth; egg production, eggshell quality, fertility, hatchability; plasma hormones, CORT; feeding and drinking behaviour, stereotypies, aggression; feather condition; H/L ratio; water intake, litter moisture	P; R; W; P+R; P+W; P+R+W
Quantitative restriction - Level of feed allowance (ad libitum vs. standard or graduated levels; ME levels; release rate at entry into lay)	16	1989 - 2021	+++NR; +Indian River; +Arbor Acres; +Cobb 500;	Females and/or Males	30 - 1092	0-72 Rearing; Laying; Rearing + Laying;	BW, body composition, carcass fat; age at sexual maturity, ovarian follicle structures, reproductive hormones (LH, FSH, E2, P4); egg production, fertility, hatchability, mortality; semen quality; H/L ratio, CORT, ghrelin, dopamine, serotonin; behavioural time budgets, stereotypies	P; R; W; P+R; R+W
Quantitative restriction - Growth curve and body weight target (standard vs. elevated BW curve; timing of full-feed access; early vs. standard photostimulation)	4	2008 - 2022	+++Ross 308; +NR	Females	720 - 3000	0-65 Rearing; Rearing + Laying	BW, body composition, FCR, skeletal development; egg weight and composition; egg production, fertility, CORT; feeding motivation, behaviour	P; P+R; P+W; R+W
Qualitative restriction - Feed dilution with insoluble fibres and/or roughage (oat hulls, soybean hulls, cellulose, wheat bran, sugar beet pulp, maize silage, sawdust, rice husk, alfalfa/lucerne)	24	1995 - 2025	+++Ross 308; ++NR; +Cobb 500; +Hubbard M77; +Ross 1	Females and/or Males	64 - 3000	0-60 Rearing; Laying; Rearing + Laying	BW, FCR, gut fill capacity, GIT development, nutrient digestibility; egg production, fertility, hatchability, embryonic development; CORT, AgRP/POMC expression, plasma lipids; feeding motivation, foraging; behavioural indicators (stereotypies, fear, frustration, novel object); plumage condition, FPD, fault bars; H/L ratio, litter quality	P; P+R; P+W; R+W; P+R+W; W
Qualitative restriction - Dietary protein level (CP concentration, alone or combined with growth pattern or feeding schedule)	5	1998 - 2015	+++Ross 308; +Hubbard Standard; +Hubbard Hi-Y; +2 commercial strains (A and B)	Females and/or Males	640 - 768	0-40 Rearing; Rearing + Laying; Rearing + offspring follow-up	BW, skeletal growth, body composition, breast muscle weight; egg production, egg weight; fertility, hatchability, embryonic mortality; offspring performance; semen quality; CORT, feeding behaviour, feather cover	P; P+R; R; P+W
Qualitative restriction - Appetite suppression (calcium propionate or analogues, alone or combined with dietary diluents, compared to standard quantitative restriction)	7	1993 - 2020	+++NR; +Ross 308; +Cobb 500	Females	60 - 1680	3-46 Rearing; Rearing + Laying	BW, feed intake; egg production, egg quality; feeding motivation; stereotypies, feather condition, fault bars; H/L ratio, CORT; basophil-to-lymphocyte ratio	P+R; P+W; R+W; W
Precision feeding system (individual BW-triggered automated feeding vs. conventional SAD or daily group feeding)	5	2017 - 2018	+++Ross 308; +Cobb 500; +Cobb MX	Females and/or Males	480 - 630	0-52 Rearing; Laying; Rearing + Laying	BW, FCR, ME intake, energetic efficiency; egg production, fertility; aggression, social rank; foraging and oral stereotypies, restlessness	P; P+R; W
Genotype and strain comparison (standard vs. dwarf vs. slow-growing; selected vs. relaxed lines; multi-strain comparisons under varying feed restriction)	10	1993 - 2021	+Standard (S); +Experimental dwarf (E); +Slow-growing (L); +Laying strain; NR	Females and/or Males	48 - 672	0-49 Rearing; Laying; Rearing + Laying	BW, body composition, carcass fat; ovarian follicle structures, reproductive hormones (LH, FSH, E2, P4); egg production, defective eggs, semen quality; livability; feeding time budgets, stereotypies, aggression; CORT, H/L ratio, creatine kinase	R; P+R; W; R+W

SAD = skip-a-day; ED = every day; SOD = skip-one-day; STD = skip-two-days; ATD = alternate-day (fibre-supplemented off-day); 4/3 = 4 feeding days + 3 non-consecutive fasting days/week; 5/2 = 5 feeding days + 2 non-consecutive fasting days/week; AL = ad libitum; QR = quantitative restriction; QL = qualitative restriction; PF = precision feeding; BW = body weight; FCR = feed conversion ratio; CP = crude protein; ME = metabolizable energy; FPD = footpad dermatitis; H/L = heterophil-to-lymphocyte ratio; CORT = corticosterone; AgRP = agouti-related peptide; POMC = pro-opiomelanocortin; GIT = gastrointestinal tract; NR = not reported. Breeds/strains: +++ = most frequently used; ++ = moderately used; + = occasionally used. P = Production; R = Reproduction; W = Welfare.

Effects of feeding frequency programs

Effects on productive and reproductives performances

The trade-off between skip-a-day (SAD) and everyday (ED) feeding clearly favors ED for optimizing reproduction. Wilson et al. (1989) established that early initiation of the program from two weeks of age guarantees faster sexual maturity and higher lay compared to late implementation at eight weeks. Beer & Coon (2009) and Sweeney et al. (2022) confirm that ED advances sexual maturity (by 3 to 6 days) and significantly increases egg yield, while Avila et al. (2023) highlights structural gains such as better bone density, superior intestinal development, and a tendency towards improved hatchability. To further improve these performances during the laying period, Spradley et al. (2008) showed that distributing feed twice daily significantly increases egg production and flock uniformity. However, this practice is accompanied by higher cumulative mortality, which limits its systematic application. Between these two methods, the 4/3 program represents, according to Carneiro et al. (2019), the optimal technical compromise, as it displays the best feed conversion ratio per egg mass and surpasses SAD in fertility and hatchability domains where prolonged fasting is critical. Conversely, maintaining SAD after photostimulation is risky. Gibson et al. (2008) noted lasting reproductive dysfunctions and significantly fewer eggs produced over the entire production period (155 vs. 172 eggs/hen up to 65 weeks of age), with no benefit to live weight uniformity. In summary, if according to Katanbaf et al. (1989), differences between restricted regimes (ALR, SOD, STD) are minor compared to ad libitum feeding, ED or the 4/3 cycle secure productive performance.

Hormonal and metabolic effects

Feeding frequency directly modulates endocrine balances, independently of the total amount of feed consumed. De Beer et al. (2008) demonstrated that the SKIP program doubles corticosterone levels compared to the ED regime, which ensures superior metabolic stability (higher IGF-I and leptin levels). In males subjected to the SAD restriction program, Mench (1991) confirms this persistent increase in stress while suggesting a regulatory avenue, namely tryptophan supplementation for attenuating this physiological response via the serotonergic system. These data confirm that meal rhythm governs the bird's deep biological response well beyond the simple nutritional aspect.

Effects on behavioral welfare

From a behavioral standpoint, studies emphasize that rationing methods differently influence the expression of feeding frustration. Indeed, the welfare assessment of broiler breeders is based on precise physiological characterization in which, as shown by Najafi et al. (2015), corticosterone levels and the H/L ratio increase linearly with the severity of restriction. This profound nutritional stress, highlighted by the foundational work of Hocking et al. (1993) and Kubíková et al. (2001), directly translates into alterations of metabolic circadian rhythms according to De Jong et al. (2002). As a mirror of this internal state, behavioral observations reveal crucial nuances. Indeed, if precision feeding can paradoxically increase aggression and activity compared to the SAD program (Girard et al., 2017a), 5/2 type programs illustrate a phase shift between apparent calm on feeding days and real physiological stress marked by muscle wasting (Lindholm et al., 2018). Similarly, Aranibar et al. (2020) showed that introducing soybean hulls on the fasting days of SAD (Alternate Day feeding program) significantly improves live weight uniformity and egg production and is accompanied by measurable behavioral differences in feeding and comfort activities.

Effects of qualitative feed dilution with insoluble fibers and/or coarse roughage

Live weight control and flock uniformity

Ration dilution with insoluble fibers stands out as the most documented qualitative restriction lever in our documentary corpus for reconciling growth control with animal welfare. In a seminal study, Tolkamp et al. (2005) demonstrated that the massive incorporation of oat hulls (400 g/kg) combined with calcium propionate allowed, under ad libitum distribution, the maintenance of growth curves and production performances up to 46 weeks identical to those of a quantitative restriction control. This productive efficacy is corroborated by the work of Zuidhof et al. (1995), showing that a dilution of 15% oat hulls optimizes egg and chick yield while stabilizing flock uniformity during the laying phase.

In terms of satiety and behavior, De Los Mozos et al. (2017) emphasize that this same 15% dilution extends ingestion time by four to eight minutes and reduces compensatory consumption by 30% during motivation tests. These results suggest a significant attenuation of hunger without degrading general behavior or uniformity. Finally, the contribution of Nascimento et al. (2021) clarifies the divergences observed between studies by demonstrating that the efficacy of dilution depends closely on the physicochemical properties of the substrate. They identify water-holding capacity as the best indicator for defining the maximum intestinal capacity of breeders, underlining that the choice of diluent is decisive for the success of the program.

Effects on feeding motivation and behavioral indicators of hunger

The corpus of Riber, Tahamtani, and collaborators constitutes the most systematic analysis of the subject via a four-treatment protocol (Control, Insoluble, Mixed, Roughage). Riber & Tahamtani (2020) demonstrate that the Insoluble and Mixed (oat hulls + beet pulp) regimes attenuate frustration and that the provision of insoluble reduces

compensatory consumption, a sign of lesser hunger. While fear and exploration motivation tests reveal no notable impact according to Tahamtani & Riber (2020), the study by Riber et al. (2021) calls for vigilance regarding the "Mixed" regime. Indeed, the fact that these birds present the lowest growth suggests that this regime may have an unintentional negative effect on their welfare, beyond simple weight control.

Furthermore, Wurtz et al. (2025) confirm a reduction in feeding motivation and marked clinical benefits (improvement in plumage quality and reduction of fault bars), aligning with Tahamtani et al. (2020), although the effects on keratosis and hock burns remain nuanced. The importance of insoluble fibers is reinforced by Nielsen et al. (2011), whose regime at 89% ISF (insoluble fiber) almost entirely eradicates tail-pecking behaviors and stereotypies. Finally, Dixon et al. (2024) provides a crucial molecular perspective. Indeed, while fibers calm hunger behaviors, the expression of AGRP (Agouti-Related Peptide) remains identical to standard restriction, proving that deep physiological hunger persists.

Effects on reproductives performances

The impact of fibers and nutritional density on laying performances is both metabolic and physiological. Moradi et al. (2013) demonstrate that the integration of insoluble fibers (cellulose, wheat bran) boosts egg production while significantly reducing corticosterone levels, a sign of attenuated stress and hunger. However, the choice of source is crucial. Indeed, cottonseed meal may prove counterproductive by causing dyslipidemia and abdominal fat accumulation.

In addition, the work of Enting, Kruip, et al. (2007) and Enting, Veldman, et al. (2007) reveals that low-density diets stimulate the development of the reproductive tract (ovaries and oviduct) from the rearing phase. During the laying period, an 11% reduction in nutritional density not only improves laying rate and egg weight but also promotes better embryonic development at 29 weeks. These data confirm that fiber quality and caloric dilution are major levers for optimizing the productive longevity of breeders.

Effects on cockerels

A recent and coherent set of studies from researchers (Kittelsen, Vasdal, Tahamtani, and collaborators) has extended the evaluation of the D+R strategy (20% oat hull dilution + alfalfa roughage) to male breeder cockerels, a population that had until then been largely absent from the literature. In the Ross 308 strain, Kittelsen et al. (2023) and Tahamtani et al. (2025) report some behavioral benefits (less frustration in the thwarted feeding test, reduced tonic immobility duration), but contradictory results on fault bars and an absence of effect on the main postmortem health indicators. In the M77 strain (Hubbard), Kittelsen et al. (2025) and Tahamtani et al. (2025) conclude that effects are globally absent or inconsistent, and Vasdal et al. (2025) on the Ross 308 strain find no behavioral differences in the home pen. These results converge to indicate that the D+R strategy in cockerels does not offer a significant improvement in welfare according to the indicators commonly used and raise the question of the extrapolability of results obtained in females to the male population.

Effects of quantitative restriction levels and energy intake levels on reproductives performances

Ad libitum feeding severely degrades reproduction by inducing an obesity that disrupts the physiological regulation of the birds. Katanbaf et al. (1989) established that ad libitum feeding advances sexual maturity by 60 days, with a live weight at onset of lay higher by 1,200 g but drastically reduces normal egg production and fertility. Robinson & Wilson (1996) confirm a loss of 40 eggs per hen, an increase in double-yolk eggs, erratic laying, and shell quality problems, attributable to a disruption of the ovarian follicular hierarchy. In males, Sexton et al. (1989) state that while ad libitum feeding boosts sperm production, spermatozoa concentration, and testosterone levels in the short term, Robinson & Wilson (1996) demonstrate that this advantage reverses with age, making weight control vital for the persistence of fertility. The work of Fattori et al. (1991, 1993) demonstrates that feed restriction leads to reductions in live weight and the frequency of double-yolk eggs, without significantly affecting egg weight, fertility, or hatchability. Finally, Hocking (2004) specifies that the number of follicles is linearly correlated with live weight and that dietary energy is the limiting factor for triggering lay in severely restricted birds.

Effects of appetite suppressants

Calcium propionate has been the most studied additive as a qualitative restriction agent. Sandilands et al. (2006) and Savory et al. (1996) emphasize that this type of restriction, combining fibrous diluents such as oat or soybean hulls with calcium propionate, makes it possible to stabilize the growth of breeders while almost entirely suppressing object-pecking and abnormal repetitive behaviors. The studies of Arrazola et al. (2019, 2020, 2020) indicate that at the start of the rearing period, these regimes as well as non-daily distribution programs reduce feeding motivation and improve plumage condition. However, the research of Savory & Lariviere (2000) underlines that feeding motivation remains intrinsically linked to the degree of growth retardation, irrespective of the restriction method employed. Although the visible signs of frustration diminish, physiological stress indicators such as the heterophil-to-lymphocyte ratio or corticosterone levels do not show systematic improvement. Ultimately, the disappearance of oral stereotypies is insufficient to confirm improved welfare, as the sensation of hunger persists and the effect of the additives may sometimes stem from digestive discomfort rather than genuine satiety.

Effects of precision feeding

The precision feeding (PF) system, developed by Zuidhof's group at the University of Alberta, has been the subject of consistent evaluation through five studies in our documentary corpus. In terms of productive performance, Hadinia et al. (2018) show that in pullets, PF reduces the feed conversion ratio and thermal losses without affecting growth, suggesting better nutrient utilization. In laying hens, however, PF significantly reduces egg production. Zuidhof (2018) confirms a reduction in live weight variability (2% vs. 14%) and a 3.8% increase in fertility, but a 27% lower egg production, possibly due to the absence of a metabolic signal for sexual maturation. From a behavioral standpoint, Girard et al. (2017b) observe a decrease in locomotor activities and pecking, but a paradoxical increase in aggression without destabilization of the hierarchy. In conclusion, PF partially improves welfare but generates new tensions related to competition for access to feeding stations.

Effects of dietary protein level

Protein intake acts as a precision lever on the body composition and skeletal development of breeders. Van Emous et al. (2013) show that a low-protein diet promotes abdominal fat deposition at the expense of pectoral muscle during rearing, although these differences are fully resolved by 40 weeks of age. Consistent with these findings, Yaissle & Lilburn (1998) confirm that nutrition prevails over genetics below 380 g, temporarily directing development towards adipose rather than muscular tissue, while the strain-specific potential only asserts itself beyond 480 g. In terms of reproduction, a sustained growth profile improves initial fertility and hatchability (Van Emous et al., 2015), while Hocking et al. (2002) reminds that a relaxation of conventional quantitative restriction remains counterproductive for viability and lay. From a behavioral and physiological standpoint, protein dilution increases feeding time by up to 63%, thereby reducing pecking stereotypies without, however, lowering corticosterone levels (Van Emous et al., 2014). Finally, for males, Zhang et al. (1999) recommend a diet at 12% protein to optimize semen volume, highlighting that spermatozoa production depends critically on weight gain maintained after sexual maturity.

Discussion

The present systematic review confirms and extends the conclusions of several reference narrative and scientific syntheses on the consequences of feed restriction in broiler breeders. The entire corpus analyzed converges towards three cross-cutting conclusions that prior work had posed in a fragmentary manner, without ever articulating them within a unified methodological framework simultaneously covering the three domains investigated.

In terms of productive performances, the available evidence designates everyday feeding (ED) as the program offering the best feed efficiency and weight uniformity compared to the skip-a-day program (SAD). This result partially aligns with the observations of Van Krimpen & De Jong (2014), who attribute these gains primarily to fiber dilution rather than to distribution rhythm. Conversely, unlike most studies in our review, these authors report that SAD does not induce greater physiological or behavioral stress than everyday feeding and place the reduction of energy density (insoluble fibers) at the heart of strategies reconciling welfare and productivity. In terms of reproductive performance, the results of this review are in direct continuity with the findings formulated by De Jong & Guémené (2011) in their reference review on major welfare problems in breeders. For these researchers, feed restriction is indispensable to reproductive performance, but its form, timing, and intensity largely condition the expression of this performance. Our analysis confirms that maintaining SAD after photostimulation constitutes the main reproductive management error documented in the literature, responsible on its own for a loss of several eggs per hen. It also shows that non-daily alternative programs, particularly the 4/3 program, present a superior reproductive profile compared to SAD, but that the available evidence, resting on a limited number of studies, is insufficient to formulate a firm recommendation. In terms of animal welfare, the most important and original result of this review is the systematic and robust dissociation between behavioral indicators and physiological markers of hunger in response to qualitative restriction strategies. This result, consistent across three independent studies having measured the hypothalamic expression of AGRP and POMC, calls into question the founding hypothesis of qualitative restriction as it was formulated at the beginning of the 2000s, notably in the pioneering work of Sandilands et al. (2006) and Savory et al. (1996), according to which increasing the volume ingested at iso-caloric intake improves perceived satiety. Our review shows that this improvement is behavioral and not metabolic. Indeed, fiber-rich feeds reduce stereotypies by keeping birds occupied, without modifying the central hypothalamic hunger signal. This result enters direct resonance with the narrative review of De Jong & Guémené (2011), who had anticipated this limitation by underlining that the behavioral modifications induced by diluents might reflect a displacement of behavioral expression rather than an improvement in affective state. In this sense, our review provides the first molecular demonstration of this hypothesis in this corpus. It nuances this conclusion with a convergent result on clinical welfare indicators. Indeed, plumage quality, fault bars, and foot lesions improve consistently with fibre-enriched feeds, suggesting a reduction in cumulative chronic stress measurable on integrative indicators, independently of acute hunger markers. This dual result namely clinical improvement without physiological improvement of satiety is consistent with the conclusion of Hartcher & Lum (2020), who

had established in their review on the consequences of genetic selection on poultry welfare that no available management strategy makes it possible to resolve the fundamental paradox between performance and welfare in modern commercial broiler breeders. However, this review presents several limitations that must be considered in the interpretation of its conclusions. For example, the over-representation of the Ross 308 strain and the under-representation of current commercial strains limit the generalization of the conclusions to flocks in production today, and the under-representation of male breeders in the corpus constitutes a major methodological gap.

Conclusion

In synthesis, the analysis of the 90 included studies highlights several robust points of convergence. First, ad libitum feeding is unanimously and systematically deleterious for reproduction in females, irrespective of the program, strain, or period considered. Second, everyday feeding consistently and reproducibly improves production and hatchability performances compared to skip-a-day when total intake is equivalent, with systematically lower corticosterone levels. Third, extending ingestion time whether achieved through fiber dilution, reduction of the protein level, or precision feeding reduces stereotypic behaviors, although this behavioral effect is not systematically accompanied by a reduction in physiological stress indicators. This review therefore establishes that daily feed restriction is the best-supported program for jointly optimizing the productive and reproductive performances of broiler breeders, that qualitative restriction improves clinical welfare indicators without modifying metabolic hunger, and that no currently available strategy demonstrates a simultaneous and robust benefit across all three domains investigated. A conclusion that confirms and refines, within a rigorous methodological framework, the paradox that has been formulated for more than two decades in this literature.

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