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Evidence-Based Recommendations for Effective Enrichment to Improve the Welfare of Caged Hens Used for Research and Teaching Purposes

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Abstract: Currently, there are no guidelines on housing or recommendations for practical environmental enrichments for chickens used for research and teaching purposes. This study was conducted to identify optimal enrichment programs to improve the health and welfare of caged hens used for teaching and research purposes. The 24-week-old Hy-line Brown laying hens (n = 168) were allocated at random to six enrichment programs/treatments with 14 replicate cages of two birds per cage during a 5-week experiment. Hens had physical access to the following treatments: no enrichment provided (control); round, wooden perches provided (perch); scratch pads made of wood and covered with sandpaper provided (scratch pad); hanging CDs provided (hanging CD); all three enrichment forms provided (complex environment); and each enrichment form provided on a 2-week rotation (novelty). While the egg quality was consistent, the complex group had a significantly lower feed intake ($p < 0.001$) but similar egg mass; thus, they also had a lower feed conversion ratio ($p < 0.001$). Additionally, hens in the complex treatment group had the leanest average body weight at week 5 ($p < 0.01$). It should be noted that while some measures of welfare did show significant differences, the biological or practical difference may be negligible, as in the case of the body condition score in this study. The results show that providing three different forms of environmental enrichment had positive effects on the welfare, health condition, and laying performance of laying hens relative to no enrichment or only one enrichment item.

Keywords: enrichment program; welfare; health; egg chickens; perch; scratch pad; hanging CD

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1. Introduction

The three R's, Replacement, Reduction, and Refinement, are essential for ensuring the ethical treatment of animals used in teaching and research environments. Refinement includes "methods that alleviate or minimize potential pain and distress, and enhance animal wellbeing" [1]. According to the NSW Department of Primary Industries and the Animal Research Review Panel [2], the provision of environmental enrichment is an optimal method to practice refinement and improve the welfare of animals. However, despite these recommendations, there are no guidelines for housing practices or environmental enrichment provisions for chickens that are used for teaching and research purposes. Additionally, there are limitations to the kinds of environmental enrichment that can be used in nutritional research settings as key results, such as feed consumption, body weight and egg production, may be affected by consumable enrichment types (i.e., wood

shaving litter or hay bales). There is a need for evidence-based solutions to improve the welfare of caged laying hens through effective environmental enrichment that adheres to the scientific methods required for nutritional studies. Following the framework defined by Taylor et al. [3], this study aimed to identify environmental enrichment items that are both practical for use in nutritional research trials and cost-effective for laying hens, including perches, scratch pads, and compact discs (CDs). This study implemented three types of non-consumable and cost-effective enrichment types. Perches have been shown to provide psychological and physical benefits in chickens as they allow for natural and highly motivated roosting behavior [4–6]. Perches larger than 15 mm in diameter are recommended for laying hens [7]. Round perches that are 32 mm in diameter have been shown to improve claw length and feather condition [6]. Hardwood perches (40 mm) have also been shown to improve the social interactions of laying hens. Semi-circle perches (i.e., curved on top and slat on the bottom at a diameter of 30–36 mm) may provide more stable perches in the cages and have been shown to improve the feather, bone strength, and foot health scores of hens in cages [5]. Scratch pads made of wood and sandpaper have been shown to improve foot health, nail sharpness, and length and reduce associated risks of injury due to nail length [8,9]. Hanging CDs from the cage roof has been proposed to provide mental stimulation via visual inspection and pecking through anecdotal evidence [3]. In the current study, the use of these three enrichment types was observed in isolation, in combination, or on a rotation to determine the standalone and combined benefits that could help to develop an optimal enrichment program for use in teaching and research environments that require the cage housing of laying hens. Whilst this project targets laying hens used for nutritional studies, this information can also be applied to other types of research that require cage housing.

2. Materials and Methods

2.1. Animal Husbandry and Experimental Design

This study was conducted at the University of New England (UNE) Animal House facility, Armidale, NSW, Australia. All experimental procedures were approved by the UNE Animal Ethics Committee (approval number: ARA23-059) and met the requirements of the Australian Code of Practice for Care and Use of Animals for Scientific Purposes [1]. A total of 168 Hy-line Brown laying hens were obtained from a laying hen farm in Tamworth, NSW, Australia, at 15 weeks of age. The birds were fed a common commercial feed over the entire study (Barastoc—Premium Top Layer Mash, CP: 16.5%, crude fat: 2.5%, crude fiber: 6%, salt: 0.3%, copper: 8.0 mg/kg, selenium: 0.3 mg/kg, and calcium: 3.6%, Melbourne, VIC, Australia). Birds were reared in the cage facility. The cage size was 30 cm wide × 50 cm deep × 45 cm high (0.15 m^2 floor space) with 2 nipple drinkers and 1 feed trough per cage. The average starting hen weights were similar between the treatments ($p > 0.05$). Birds were housed in a curtain-sided house, and feed and water were provided ad libitum throughout the study. The experimental period lasted for 5 weeks, from 24 to 28 weeks of age. The lighting program of 16 h of light and 8 h of dark was maintained throughout the study. The temperature and relative humidity inside the shed were measured daily at bird height. Baseline measurements were performed on indicators of hen welfare, health, and performance at the start of the trial as per the section entitled 'data collection'. Mortality rate, egg weight, and egg production were recorded daily, and feed consumption was measured weekly over the experimental period. Welfare and health measurements were repeated in week 5.

There were 6 treatments with 14 replicate cages and 2 birds per cage per treatment in this study. Hens had physical access to the following treatments: (1) no enrichment provided (control); (2) round, wooden perches provided (perch); (3) scratch pads provided (scratch pad); (4) hanging CDs provided (hanging CD); (5) all three aforementioned enrichment forms provided (complex environment); and (6) each aforementioned enrichment form was provided on a 2-week rotation (novelty). Specifically, the control group was not provided with any enrichment. Based on previous findings [5–7], the perch group was

provided with round, semi-circle-shaped perches that were 32 mm in diameter, made of wood, and placed approximately 2.5 cm above the floor of the cage. The design of the scratch pad treatment was partly based on our previous observations during two different experiments in the same cage housing system, although there was no empirical data to support this observation. It was observed that birds tended to 'sham' forage near the feed tray, and it was, therefore, assumed that a scratch pad near the feed tray where they liked to sham forage may better satisfy this behavioral motivation. Scratch pads (artificial turf) have been shown to reduce bumble foot [8], and abrasive strips (10 cm wide and 50 cm long; angled 60° from the bottom of the cage) of material and have been shown to reduce toenail sharpness (subsequently, reducing the risk of injury), reduce fearfulness, and improve the feather scores of laying hens [9]. Based on this evidence, we built an angled scratch pad along the length of the feed trough at the front of the cage, providing a total length of 30 cm and a height of 10 cm; the scratch pad was made of wood and covered with super fine grit sandpaper (600–800 grit).

The hanging CD group was provided with one hanging CD in the back of the cage at the height of the hen's head. A recent survey of the meat chicken breeder industry conducted by Taylor et al. [3] revealed that producers have tried CDs as a form of enrichment, with anecdotal reports suggesting that the dynamic movement of the hanging items, the shiny surface, and the changing light were very attractive to the birds. However, producers did not use them because providing them at the right density was difficult in a shed of 20,000–40,000 poultry, and they were difficult to clean. However, caged research facilities do not have these same challenges; therefore, we aimed to determine if this practical method is backed by science.

The complex environment group was provided with all three enrichment forms, including a perch, scratch pad, and hanging CDs. Hen's behavioral needs changed temporally throughout, and, therefore, multiple enrichments were provided simultaneously to determine if this would be more effective, as has been shown in mice [10]. The novelty group was provided with each enrichment treatment for 2 weeks at a time—treatments were randomly allocated to account for order effects. This is to understand if novelty to avoid habituation is an important component of effective enrichment programs. However, there may also be some stress induced if enrichment is removed and the hens are highly motivated to use it.

The resources were provided at a density where both birds within the cages could use and access them at the same time to reduce any increase in competition, aggression, and associated stress. The locations of enrichments (for all enrichments in isolation and the complexity and novelty treatment groups) are shown in Figure 1.

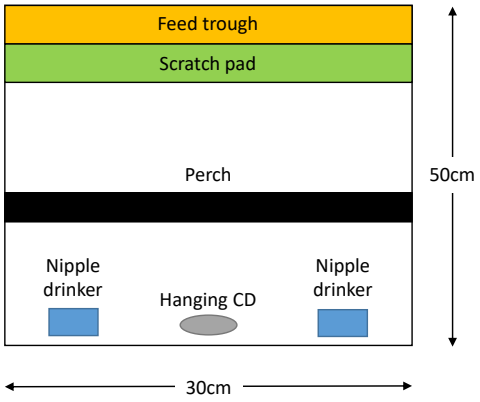

Figure 1. Locations of enrichments (for isolation, complexity, and novelty treatments) within the cage.

2.2. Data Collection

Performance was assessed by feed intake, egg production, egg weight, egg mass, and feed conversion ratio (FCR) over the total trial length. The FCR was calculated as the ratio

of kg feed to kg egg mass. The welfare indicators assessed included feather score on 5 areas on the hen (back of the head, neck, back, rump and tail, wing, and vent), body condition score, keel bone fractures and damage, comb pecking wounds, skin lesions/scratches, and foot pad score following a validated method [11] at the start and end of the study. Briefly, comb pecking wounds were scored by visual assessment as 0 = no wounds, 1 = less than 3 wounds, and 2 = 3 or more than 3 wounds. The body condition score was assessed by feeling the keel bone and scored as follows: 0 = fat (where the muscle and fat coverage protruded greater than approximately a 45-degree angle from the keel bone), 1 = normal (where the muscle and fat coverage protruded at approximately a 45-degree angle from the keel bone), and 2 = skinny (where the muscle and fat coverage protruded at approximately less than a 45-degree angle from the keel bone). The nail sharpness score was assessed as follows: 0 = flat, 1 = rounded, and 2 = pointed. Indicators of performance were assessed, including growth (hen weight change) and reproduction through egg quality analysis (shell thickness, shell breaking strength, albumen height, Haugh unit, yolk color, and yolk index) at week 5, and the incidence of mortality and injury during the experiment duration and foot health (toenail length and sharpness) at week 5 were also investigated. Furthermore, keel bone fractures and damage were assessed by palpating the hens' keel bone and scoring as 0 = no deviations, deformations or thickened sections with the keel bone completely straight; 1 = deviations (flattening, s-shape, and bending), or thickened sections present in a very slight form; and 2 = the deviation or deformation of keel bone (including thickened sections), following a validated method [11].

2.3. Egg Quality Analysis

A digital egg tester (DET6500, Nabel Co., Ltd., Kyoto, Japan) was used to measure the eggshell breaking strength, shell thickness, albumen height, Haugh unit, yolk color, yolk height, yolk diameter, and yolk index. TSS QCE-QCM equipment (Technical Services and Supplies, Dunnington, York, UK) was used to measure eggshell reflectivity. The length and width of eggs were measured using a digital caliper, and the ratio of egg width to egg length determined the egg shape index. The egg yolk was collected on filter paper (CAT No. 1541-090, Whatman, Buckinghamshire HP7 9NA, UK) and weighed. Eggshells were weighed after being rinsed and thoroughly dried. The weight of the albumen was calculated by subtracting the weights of the yolk and shell from the total egg weight. Each egg component was divided by the intact egg weight to determine the egg proportion.

2.4. Data Analysis

R Commander (version 3.3.1, R Foundation for Statistical Computing, Vienna, Austria) was used to perform all data analyses. The individual cage was treated as a replicate, and, as such, the measure of the two hens within the cage was averaged. Data were tested for normal distribution and equal variances between the treatments. The data distribution was checked by a quantile comparison plot, and the homogeneity of variances between the treatments was tested using Levene's test. Either a one-way ANOVA or the non-parametric ANOVA (Kruskal–Wallis test) were used, depending on the results from the above 2 tests, to test statistical differences between the treatments. Finally, pairwise differences between the treatments were identified by the use of Tukey's post hoc test. *p*-values were considered significant at ≤ 0.05.

3. Results

The results on laying performance, welfare indicators, and hen weight of the treatment groups are presented in Tables 1–3, respectively. FCR was slightly higher than the strain standard (a 1.99 FCR was reported by the breeder versus an average of 2.18 FCR for all treatments), which was likely driven by the slightly increased feed intake. However, the laying performance was also slightly greater than the strain standard (59 g of egg weight reported by the breeder versus an average of 63.1 for all treatments; 95% egg production reported by the breeder versus an average of 98% for all treatments), which explains the

greater feed intake. Thus, the hens performed comparably to breed standard. The egg quality results are presented in Tables 4–6. The findings show that hens housed in the cages with all three enrichment forms, including a perch, scratch pad, and hanging CDs (complex environment), had similar egg weight, egg production, and egg mass but a lower feed intake ($p < 0.001$) resulting in a lower FCR, or higher feed efficiency ($p < 0.001$) compared to all other treatments (Table 1). Additionally, hens raised in cages enriched with scratch pads had a lower feed intake ($p < 0.001$) and lower FCR ($p < 0.001$) compared to those raised in cages enriched with a perch or hanging CDs (Table 1).

Table 1. The average laying performance of the treatment groups from weeks 1 to 5.

Treatment	Egg Weight (g/Bird/Day)	Egg Production (%)	Egg Mass (g/Bird/Day)	Feed Intake (g/Bird/Day)	Feed Conversion Ratio (kg Feed/kg Egg)
Control	64.1	98.9	63.4	139 ^{c}	2.195 ^{bc}
Perch	64.4	97.0	62.5	141 ^{c}	2.253 ^{c}
Scratch pad	62.8	98.2	61.7	129 ^{ab}	2.090 ^{ab}
Hanging CD	63.3	97.5	61.8	140 ^{c}	2.267 ^{c}
All three forms	61.3	98.7	60.5	125 ^{a}	2.061 ^{a}
Novelty	62.8	97.4	61.3	135 ^{bc}	2.203 ^{bc}
SEM	0.32	0.32	0.41	1.18	0.015
p-value	0.080	0.466	0.398	<0.001	<0.001

^{a,b,c} Dissimilar superscript letters indicate significant post hoc differences between the treatment groups ($p < 0.05$).

Table 2. Welfare assessment of the treatment groups on week 5.

	Comb Pecking Wounds	Body Condition Score	Nail Sharpness Score	Nail Length (cm)
Control	0.000	0.929 ^{ab}	1.893 ^{c}	1.604 ^{c}
Perch	0.071	0.714 ^{a}	1.852 ^{c}	1.607 ^{c}
Scratch pad	0.071	1.071 ^{b}	0.000 ^{a}	1.157 ^{a}
Hanging CD	0.036	0.714 ^{a}	1.857 ^{c}	1.636 ^{c}
All three forms	0.000	1.071 ^{b}	0.036 ^{a}	1.150 ^{a}
Novelty	0.071	1.000 ^{ab}	0.429 ^{b}	1.271 ^{b}
SEM	0.018	0.034	0.072	0.019
p-value	0.526	0.001	<0.001	<0.001

Notes: Comb-pecking wound: 0 = none, 1 = less than 3 wounds, and 2 = 3 or more than 3 wounds; body condition score: 0 = fat, 1 = normal, and 2 = skinny; nail sharpness score: 0 = flat, 1 = rounded, and 2 = pointing. ^{a,b,c} Dissimilar superscript letters indicate significant post hoc differences between the treatment groups ($p < 0.05$).

Table 3. Hen weight of the treatment groups from weeks 1 to 5.

Treatment	Hen Weight at Week 1 (g)	Hen Weight at Week 5 (g)	Weight Change from Weeks 1 to 5 (g)
Control	2034	2156 ^{ab}	112.7 ^{ab}
Perch	2061	2170 ^{b}	130.5 ^{b}
Scratch pad	2013	2101 ^{ab}	87.7 ^{ab}
Hanging CD	2075	2187 ^{b}	123.2 ^{b}
All three forms	1979	2037 ^{a}	58.0 ^{a}
Novelty	2036	2137 ^{ab}	101.1 ^{ab}
SEM	11.35	13.07	6.21
p-value	0.181	0.008	0.006

^{a,b} Dissimilar superscript letters indicate significant post hoc differences between the treatment groups ($p < 0.05$).

Table 4. Internal egg quality of the treatment groups on week 5.

Treatment	Albumen Height (mm)	Yolk Color	Haugh Unit	Yolk Height (mm)	Yolk Diameter (mm)	Yolk Index
Control	10.8	10.9	101.2	22.3	41.4	0.540
Perch	10.0	11.3	96.0	22.8	41.7	0.548
Scratch pad	11.2	11.9	103.0	22.8	41.6	0.553
Hanging CDs	10.1	11.4	96.8	23.1	42.1	0.543
All three forms	10.6	11.8	100.5	23.0	41.2	0.562
Novelty	11.4	11.1	104.1	23.2	40.7	0.563
SEM	0.24	0.19	1.19	0.12	0.56	0.007
p-value	0.777	0.338	0.753	0.293	0.987	0.925

Table 5. External egg quality of the treatment groups on week 5.

Treatment	Eggshell Breaking Strength (Kgf)	Shell Thickness (mm)	Egg Length (mm)	Egg Width (mm)	Egg Shape Index	Reflectivity (%)
Control	4.98	0.442	57.2	44.8	0.784	25.0
Perch	4.86	0.447	56.7	44.4	0.784	25.1
Scratch pad	4.89	0.443	56.3	44.2	0.785	25.4
Hanging CDs	4.65	0.443	56.9	44.8	0.787	25.7
All three forms	4.70	0.448	56.3	44.3	0.788	24.1
Novelty	4.90	0.443	56.7	44.4	0.784	22.9
SEM	0.08	0.002	0.17	0.11	0.002	0.31
p-value	0.847	0.870	0.687	0.568	0.989	0.105

Table 6. Egg proportion of the treatment groups on week 5.

Treatment	Albumen Weight (g)	Yolk Weight (g)	Shell Weight (g)	Albumen (%)	Yolk (%)	Shell (%)
Control	43.5	15.5	6.45	66.3	23.8	9.81
Perch	43.1	15.0	6.44	66.8	23.3	9.99
Scratch pad	42.3	14.8	6.25	66.7	23.5	9.94
Hanging CDs	43.2	15.2	6.45	66.5	23.5	10.05
All three forms	41.7	15.3	6.27	65.9	24.2	9.94
Novelty	42.7	15.0	6.42	66.6	23.4	9.87
SEM	0.37	0.12	0.05	0.21	0.19	0.05
p-value	0.766	0.583	0.682	0.873	0.796	0.858

Hens were thoroughly checked at the trial's start and were found to have no baseline foot, skin, keel bone, or feather damage (i.e., all score 0). At week 5, no plumage damage was detected on either the back of the head, neck, back, rump, and tail, wing, or vent of the hens in all treatment groups. Similarly, keel bone fractures and damage, skin lesions/scratches, and foot pad lesions were not observed in any hens on week 5. However, hens raised in cages enriched with scratch pads or all three enrichment forms had higher body condition scores ($p = 0.001$), lower nail length ($p < 0.001$), and a lower nail sharpness score ($p < 0.001$) compared to the other treatment groups (Table 2). The novelty treatment showed intermediate effects on the nail length and sharpness score ($p < 0.001$, Table 2).

The hen weight was not different between the treatment groups at the start of the study (week 0, Table 3). However, hens raised in cages with all three enrichment forms had a lower body weight at week 5 ($p = 0.008$) and a lower weight change over 5 weeks of the study ($p = 0.006$) compared to the other treatment groups (Table 3).

Whereas all egg quality parameters were not different between the treatment groups on week 5 (Tables 4–6), no mortality was observed over the 5 weeks of the study.

4. Discussion

This study aimed to determine an effective and practical enrichment program to improve the welfare of caged hens in a teaching and research setting. While the authors acknowledge that cages are banned in the poultry industry in many countries, hens are still housed in cages for some research and/or teaching purposes to collect the required measurements. Thus, we aim to minimize the impact of cages on the welfare of hens in these cages during these circumstances. The presented results demonstrate a clear correlation between increased environmental complexity and hen welfare, where environmental enrichment had positive effects on indicators of welfare, health condition, and the performance of laying hens. Hens in the complex treatment group consistently demonstrated equal to or improved laying performance and welfare over all other treatment groups, including having a lower feed intake and higher feed efficiency without any impact on egg production. This suggests that the combination of mental and physical stimulation given by the three types of enrichment had the greatest benefit on the psychological and biological fitness of the laying hens. However, it is important to consider that too complex an environment can be problematic as chickens may not be able to locate necessary resources [12]. Additionally, the enrichment items in question appear to weigh heavily on the outcome as Barnett et al. [5] did not observe many biologically significant improvements to welfare when undertaking a similar experiment using a combination of wooden perches, dust baths, and nest boxes, except for increased leg strength. This is likely due to the different physical and psychological benefits that the scratch pads and hanging CDs provided in this study as opposed to the dust baths and nest boxes and the difference in welfare indicators assessed in each study. However, it should be noted that due to budget and time restrictions in the present study, the trial could only be run for 5 weeks. So, it is a limitation of our study that enrichments used in the novelty treatment were randomized, such that the time the enrichments were used divided over the 14 replicate cages in the treatment for the 5 weeks. Thus, five replicate cages received the scratch pad for two weeks, followed by a perch for two weeks, followed by the hanging CDs for one week; five replicate cages received the hanging CDs for two weeks, followed by the scratch pad for two weeks, followed by the perch for one week; and finally, four replicate cages received the perch for two weeks, followed by the hanging CDs for two weeks, followed by the scratch pad for one week.

Improvements in welfare indicators observed in the complex environment group compared to the novelty group were observed in a similar study in rats [10]. This suggests that the agency provided to an animal to choose which enrichment it wants to partake in has a positive impact on its psychological state. This is further supported by the fact that the complex environment group demonstrated greater improvements in body condition score and nail length and sharpness score as compared to the novelty group in this study. The body weight and weight gain of hens during complex environment treatment was lower than that of other treatment groups. As the hen weights in all treatment groups were higher than the Hy-Line Brown standards, a leaner hen weight was preferable as overweight hens are a common husbandry issue that can lead to the development of disease [13]. The hen weight data in this study are consistent with the data on body condition scores, where treatments with leaner body weights had a lower average body condition score. The lower nail length and sharpness scores in groups continually enriched with scratch pads, including the complex environment and scratch pad groups in this study, suggest that the hens used this enrichment frequently enough to shorten their nails. Hens partaking of these treatments also had higher body condition scores, suggesting that the hens used this enrichment for exercise and/or were potentially more mentally stimulated than when using the other treatments in this study, leading to them not partaking in overeating due to boredom, as has been shown in rodents [10,14].

Amongst the single enrichment treatments, the scratch pad group by far had the most notable results in this study. Specifically, this group had the most preferable body weight, body condition score, feed intake, FCR, nail sharpness score, and nail length of all three single enrichment treatments in this study. The current findings regarding the effect of

scratch pads on nail sharpness are supported by the findings of Shi [9] and Glatz [15], without an increase in prolapse and cannibalism-related mortality, as found by Glatz [15]. The use of scratch pads has been demonstrated to improve feather scores due to a lower risk of chickens scratching each other [9]. However, Glatz [15] did not find any significant improvements when using scratch pads other than in tail feathers. No plumage damage was recorded in this study. This may be because hens were housed in pairs in this study rather than larger groups, as there was a potential correlation between group size or space per hen and the frequency of aggressive inter-flock pecking that could lead to lower plumage conditions [16].

Interestingly, the presence of perches alone did not impact the claw length of hens in this study, and similar results were reported by Hester et al. [6]. Perches in the present study were made of wood, while previously galvanized steel was used by Hester et al. [17]. Furthermore, Appleby et al. [18] did not find any impacts on nail length amongst perches made of different materials, including metal, softwood, and hardwood, which supports our findings. Alternatively, Barnett et al. [19] found that the increased use of perches led to an increase in nail length. This discrepancy could be due to the difference in cage setups between the current study and the study conducted by Barnett et al. [19]. The use of perches has been demonstrated to increase bone strength and subsequently lead to less frequent bone fractures [5] as well as improved general foot health [8,16,18]. Others have reported that perches increase the incidence of keel deformities due to excessive pressure being placed on the keel during roosting [17]. However, Barnett et al. [5] found that these deformities only appeared when chickens had access to the perches for at least 44 weeks, and 40% of the chickens found with keel damage were in the control group. Of note, we did not assess the use and interaction of enrichment (i.e., via video observations), so the lack of impact of perches may have been from lack of use. No keel deformities or foot injuries were observed in this study, which may reflect the relatively short study duration (five weeks) compared to other studies reported in the literature.

The use of hanging CDs in this study could be considered similar to the use of mirrors as a form of enrichment, providing a reflective surface but allowing researchers to reuse old materials, providing environmental and economic benefits. Mirrors have been shown to have positive psychological and welfare effects in broiler chickens, leading to more active behaviors and better toe health [20]. This is possible as birds may mistake their reflections as flock-mates, which makes their group size appear larger and, in turn, makes them feel more comfortable [21]. Additionally, it has been suggested that the effects of mirrors may be dependent on age, rearing group size, and the time spent in the presence of the mirror [21]. Zahoor et al. [20] indicated that the presence of mirrors did not have a significant impact on feeding behaviors, except for within the first 21 days of life, in broiler chickens. The authors also found that the FCR of the mirror-treated group was equal to or higher than the control group [20]. Although hens undertaking the hanging CD treatment had a similar feed intake, they had a slightly higher FCR and worse body condition score compared to the control group in this study. However, birds in the mirror-treated group of the study conducted by Zahoor et al. [20] had nearly equal body weights, feed intakes, and FCR to that of the control group. There are several differences between the two studies that might cause these differing results, for example, the bird's age or the fact that hanging CDs may not show clear enough reflections to truly mimic mirrors.

One of the limitations of our study was that the hens had visual access to the enrichments of other treatments. Assessing the individual interactions (e.g., via behavioral observations) may have provided greater insight into the level of interactions and individual outcomes for welfare and provided greater insight into the importance of tactile interactions for welfare outcomes. Furthermore, it should be noted that while some measures of welfare did show significant differences, the biological or practical differences are likely negligible. For example, although significantly different, a body condition score of 0.714 for hens offered a perch vs. 1.071 for hens offered a scratch pad may not have a great practical significance.

The current results did not show any correlations between enrichment type or complexity and egg quality and production, plumage condition, keel bone fractures, and other injuries and wounds. This again suggests that less stimulated birds eat more feed than they needed for body maintenance and the production of eggs, possibly due to boredom or to support the extra energy demand attributed to stress responses. This is an important finding for nutritional research that is performed on hens in cages, as feeding behavior is impacted by barren environments that lack complexity. Thus, this potentially impacts the adaptability of nutritional research conducted in cages compared to those without enrichment for implementation in the industry, where hens may be housed in more complex environments. Available evidence from the literature supports the idea that enrichment availability and type do not affect egg quality and production; however, dust bath enrichment types may increase the percentages of dirty eggs, and perches may increase the percentages of cracked eggs as hens may choose to lay whilst perching [5,8,16,18].

5. Conclusions

We found evidence that providing cage hens with physical access to three enrichment forms, including perches, scratch pads, and hanging CDs, is simultaneously better for laying performance, body condition, and foot health while maintaining plumage, keel bone, skin conditions, and egg quality compared to the enrichments being provided in isolation or rotating them every 2 weeks. The higher laying performance in hens raised in cages enriched with all three enrichment forms might be attributed to the better physiological condition resulting from spending more time interacting with the enrichment; however, investigations into bird behavior are required. Although the combination of perches, scratch pads, and hanging CDs has been demonstrated to have a positive impact on welfare in this study, further studies may be required to determine the standalone effects of the pairs of these enrichment items over a longer duration.

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Data Availability Statement: Data may be made available upon request.

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