COALITION FOR SUSTAINABLE EGG SUPPLY

# Research Results

Based on the Coalition's hen housing research results and researcher insight, the following summaries present the Coalition's overall research findings for each sustainability area, along with infographics showing both positive and negative impacts. In these infographics, the Enriched Colony (**EC**) and Cage-Free Aviary (**AV**) systems are compared to a baseline of the Conventional Cage (**CC**) system. The CC system was chosen as the baseline because it is the system in which approximately 95 percent of the laying hens in the U.S. are housed, and because it is the system for which there was the most existing data prior to the CSES project being initiated. There is also an interactive version of these infographics that contains additional information about the sustainability tradeoffs, and which can be found on the CSES website at **http://www2.sustainableeggcoalition.org/**.

The CSES researchers are aware that many egg producers are transitioning away from conventional cages as they install new systems. These summaries provide an overview of the sustainability tradeoffs that should be considered during this transition, and can assist in supporting informed decision-making. They should be evaluated in the context of the other final research materials, including the final research report and the peer-reviewed publications. They also represent a snapshot in time and particular conditions of management and housing design. As egg production systems continue to evolve, future research should focus on continuing to enhance the sustainability characteristics of those systems via advances in design and management.

*Find more information at*
**www2.sustainableeggcoalition.org**

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# Food Safety & Quality

Housing system type did not influence the rate of egg quality decline through 12 weeks of extended storage, and current U.S. egg quality standards/grades are adequate to describe eggs for all three of the housing systems. It is not uncommon for poultry to shed *Salmonella* spp. or other coliforms thus the prevalence (presence or absence) of *Salmonella* spp. and *Campylobacter* spp. were determined for every swab/egg shell pool collected from each system. Hens in all housing systems were shedding *Salmonella* spp. at a similar rate; the prevalence of *Salmonella* spp. on egg shells was very low and did not differ between housing systems. The AV had higher levels of environmental *Campylobacter* spp. recovery (drag swab). *Salmonella* spp. were detected at similar levels of prevalence in the EC and CC production environments however AV were more positive. The manure scraper had low levels of *Campylobacter* spp. recovery in all systems, but AV drag swabs and EC scratch pad swabs had high levels of *Campylobacter* spp. recovery. AV floor shells had the greatest levels of total aerobes and coliforms. Aerobic organisms were also elevated on AV nest box and system shells. Previous studies indicate total aerobe levels are greater on eggs produced in high dust environments. Eggs laid on litter (in AV only) have greater shell microbial levels than eggs laid on system wires or in nest boxes. Coliforms are indicators of fecal contamination which is linked to many human pathogens. In the EC system wire egg shell coliform levels were detected at levels similar to CC. The coliform level in AV nest box egg shells was similar to the EC. The coliform levels were low for all shell samples, excluding the AV floor shells, which had the highest levels of total coliforms.

**An infographic is not available for Food Safety and Quality.*

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# Animal Health & Well-Being

Cumulative hen mortality in the EC and CC was slightly lower than the 6% Lohmann LSL management reference, but double that percentage in the AV. Major mortality causes in all systems were hypocalcemia and egg yolk peritonitis. More AV hens died from being caught in the structure, vent cannibalized or excessively pecked. EC and AV systems offered hens more behavioral freedom than CC with the nesting area and perches generally well used. In the AV the litter was used for dust bathing, but the EC scratch pad was not well used for dust bathing or foraging and accumulated manure. Nest use by AV hens was variable, with a proportion of eggs laid in the enclosure or on the litter. Bone health/strength measures indicate EC hens had more keel abnormalities than CC hens, particularly during late lay. AV reared pullets had more keel bone damage at placement than those reared in CC, and keel breaks were more prevalent in the AV hens during lay. Pullets in the AV rearing system had better bone quality at placement in their tibiae and femurs than pullets reared in the CC rearing system; this good bone quality was maintained throughout the lay cycle. Bone quality in CC and EC was not as good, although it improved somewhat in EC during the lay cycle. Measures of stress overall did not indicate acute or chronic stress. EC hens had slightly less feather loss than CC hens, while the AV hens had the best feathering. Feather cleanliness of EC and CC was similar, but AV hens had slightly dirtier feathers. EC hens had shorter claws and fewer foot problems (e.g. hyperkeratosis) than in CC, and no severe foot problems (e.g. bumblefoot). Incidence of foot problems in AV was lowest, but those problems were more severe. Air temperatures in AV and EC were similar to CC, and the hens were never observed panting. Indoor air quality (dust and ammonia) for EC was similar to CC but worse in AV. However, there were no signs of hen health problems associated with poor air quality in any housing system. Feed and water consumption by hens and body weights were similar across systems.

# Animal Health & Well-Being

**KEY:** HOUSING TYPES — EC *Enriched Colony* **(EC)** | AV *Cage-Free Aviary* **(AV)** | CC *Conventional Cage*

| | NEGATIVE IMPACT | | | | CC | POSITIVE IMPACT | | | |
|---|---|---|---|---|---|---|---|---|---|
| IMPACT SCALE | -4 *Exceptionally Worse* | -3 *Substantially Worse* | -2 *Worse* | -1 *Slightly Worse* | 0 *Similar* | +1 *Slightly Better* | +2 *Better* | +3 *Substantially Better* | +4 *Exceptionally Better* |
| Mortality | – | – | AV | AV | EC, AV | + | + | + | + |
| Behavior | – | – | – | – | EC, AV | EC, AV | EC, AV | EC, AV | + |
| Cannibalism/Aggression | – | AV | AV | AV, EC | | + | + | + | + |
| Keel Damage | – | AV | AV | AV, EC | | + | + | + | + |
| Tibia/Humerus Strength | – | – | – | – | EC, AV | EC, AV | EC, AV | + | + |
| Stress Physiology | – | – | – | – | EC, AV | + | + | + | + |
| Feather Condition | – | – | – | – | EC, AV | AV | + | + | + |
| Foot Condition | – | – | – | – | EC, AV | EC | + | + | + |
| Environmental Comfort | – | – | – | – | EC, AV | + | + | + | + |
| Feeding and drinking | – | – | – | – | EC, AV | + | + | + | + |

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# Environment

Ammonia and particulate matter (PM) concentrations were significantly higher in the AV house than in the EC or CC house. PM concentrations were roughly 8-10 times higher in the AV than either the CC or EC. PM emissions from the EC and CC house remained low and similar year-round, whereas the AV house had 6-7 times more PM emissions than the other two types of housing. The higher AV PM levels and emissions were caused by hens' behavioral activities on the litter floor. Poor indoor air quality may lead to eye and respiratory tract irritation in workers and hens. Farm-level ammonia emissions were lowest for the EC system, approximately half that of CC or AV, due to its lower stocking density and drier manure. Ammonia emissions from manure storage accounted for two-thirds of farm-level emissions. Greenhouse gas (GHG) emissions were low for all systems due to relatively dry manure. Manure removed from the EC house was drier and had a slightly higher nitrogen content than that removed from the CC or AV house. In the AV house, 77% of manure was deposited on the belts and the rest on the litter floor when hens had free access to the litter floor. Manure on the AV litter floor had to be removed separately, either mechanically or manually onto the manure belt. With respect to natural resource use, the EC house had similar energy use and feed efficiency to the CC house. The AV house may need supplemental heat during cold days, and when coupled with lower AV feed efficiency, creates a larger carbon footprint than EC or CC, as feed supply accounts for approximately 80% of total carbon footprint in the egg-supply chain. In addition, more natural resources are needed per bird space in the construction of AV houses.

# Environment

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| Ammonia Emissions | | | | | EC, AV | EC | EC | EC | EC |
| Carbon Footprint | | | | AV | EC | | | | |
| Indoor Air Quality | | AV | AV | AV | EC | | | | |
| Manure Management | | | | AV | EC | | | | |
| PM Emissions | | AV | AV | AV | EC | | | | |
| Natural Resource Use Efficiency | | | | AV | EC | | | | |

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# Worker Health & Safety

Airborne particulate matter (PM) can make its way into workers' airways, with smaller particles being deposited deep into the lungs. In the EC and CC houses, workers were exposed to significantly lower concentrations of airborne particles than when working in the AV house. Inhalable particle and PM 2.5 concentrations were higher in AV house due to the litter on the floor. The overall daily mean indoor ammonia concentration was well below the recommended limit of 25 ppm for the CC (4.0 ppm), EC (2.8 ppm) and AV (6.7ppm). Ammonia concentrations only exceeded 25 ppm in the winter of Flock 1 in each house but for less than 10% of the work shift. In the AV there was worker exposure to significantly higher concentrations of endotoxin than in CC or EC. High use of mask/respirator by workers, and similar concentrations of exposures in both CC and EC, was associated with similar cross-shift lung health outcomes. Average mask use was higher by workers in the AV protecting them from higher exposures and greater respiratory consequences. Ergonomic stressors assessed included force, repetition, and posture. Loading and unloading of cages in EC and CC systems required extreme body positions and significant twisting. Gathering floor eggs in AV required extreme body positions for extended periods and exposure to respiratory hazards. With respect to access, EC and CC systems posed significant hazards normally and at population/depopulation. EC workers stepped on the cage front instead of ladders to reach hens and worked from unapproved platforms and railings. There were no access issues in the AV. During unloading, the cage modules were placed in the aisles blocking them in the event a rapid evacuation was needed, and AV workers placed themselves inside the wire enclosures and locked the doors behind them, reducing the ability for a rapid evacuation.

# Worker Health & Safety

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| Worker particulate matter exposure | | AV | AV | AV | EC, AV | | | | |
| Worker ammonia exposure | | | | | EC, AV | | | | |
| Worker endotoxin exposure | | AV | AV | AV | EC, AV | | | | |
| Worker lung health | | | | AV | EC, AV | | | | |
| Worker ergonomics | | | AV | AV | EC, AV | | | | |
| Worker access | | | | | EC, AV | | | | |
| Worker egress | | | | | EC, AV | | | | |

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# Food Affordability

Feed for hens comprised the largest share of operating costs for each of the housing systems. Feed consumption per dozen eggs was similar across the systems, increasing somewhat over the life of the flock. Feed cost per dozen eggs produced in the AV was higher because production per hen placed in that system declined more over the life of the flock. The cost per dozen eggs for pullets placed in the AV were substantially higher than the other systems, due to higher rearing costs, higher hen mortality and lower production per hen in that system. The EC had higher weekly labor costs (per dozen eggs) than did the CC, though costs did not rise over the life of the flock as they did with the AV. An EC with more hens per house might be more efficient and reduce labor costs per dozen eggs produced. The labor costs per dozen eggs produced were highest in the AV, primarily due to greater labor costs for egg collection. Higher hen mortality and other hen health issues were also contributing factors. The EC had total capital costs per dozen eggs that were 107% higher than CC, largely the result of higher construction costs and fewer hens housed in comparison to CC. The AV had total capital costs per dozen eggs that were 179% higher than CC, largely the result of higher construction costs and fewer hens housed in comparison to CC. The EC had total operating costs per dozen eggs that were 4% higher than CC. Coupled with higher capital costs, EC had total costs per dozen eggs produced that were 13% higher than CC. The AV had total operating costs per dozen eggs that were 23% higher than the CC. Coupled with higher capital costs, the AV had total costs per dozen eggs produced that were 36% higher than the CC.

# Food Affordability

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| Feed Cost | | | | AV | EC | | | | |
| Pullet Cost | AV | AV | AV | AV | EC | | | | |
| Labor Cost | | AV | EC | EC | EC | | | | |
| Capital Cost | AV | AV | EC | EC | EC | | | | |
| Total Capital + Operating Cost | AV | AV | EC | EC | EC | | | | |