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Impact of direct and indirect heating systems in broiler units on environmental conditions and flock performance

Shaun Smith[1], Joseph Meade[1], James Gibbons[1], Kevina McGill[1], Declan Bolton[2], Paul Whyte[1]

[1] *UCD School of Veterinary Medicine, University College Dublin, Belfield, Dublin 4, Ireland*
[2] *Teagasc Ashtown Food Research Centre, Ashtown, Dublin 15, Ireland*

Abstract

This study compared the impact of three indirect heating systems to direct gas flame heaters on a selection of flock performance and environmental indicators in commercial broiler units. No statistically significant differences ($P \geq 0.05$) were found in flock mortality rates, bird weight, water consumption, stress response, carbon dioxide, ammonia, temperature, relative humidity, litter quality, within-flock *Campylobacter* levels or mean *Campylobacter* counts when flock data from any of the three indirect heating systems were compared to flocks reared in houses with direct heating systems. Differences in litter quality were observed between upper and lower litter layers in all houses, regardless of heating type, which may have implications for bird health and welfare. Carbon dioxide concentrations in houses with direct heating systems were significantly higher than those in houses with indirect heating systems during the first 10 days of bird life ($P \leq 0.05$). This was due to the increased use of heating systems during this period of the flock cycle. Differences in CO_2 concentrations had no effect on flock performance, possibly due to the fact that concentrations did not exceed known safe levels. A statistically significant increase in stress response was observed in birds as a result of partial depopulation (thinning) within houses, irrespective of heating system type used ($P \leq 0.05$). Stress associated with thinning may have consequences for bird welfare and food safety. In conclusion, the results of our study suggest that indirect heating systems do not appear to negatively impact on flock performance, stress response, within-flock *Campylobacter* levels or mean *Campylobacter* counts and do not appear to significantly alter environmental conditions within broiler houses when compared to houses equipped with direct heating systems. Indirect systems are a viable alternative for heating broiler houses in terms of flock performance, bird welfare and food safety.

Keywords: litter quality, welfare, stress, poultry production, campylobacter, environmental conditions

1. Introduction

In recent years with increasing energy costs, the broiler industry has sought to assess the potential efficiency of indirect heating systems for broiler houses. Several indirect heating systems have been developed and available as alternatives to conventional gas heating systems. However, there is little knowledge of the impact that any indirect heating system could have on flock performance, bird welfare and food safety.

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Shaun Smith, Tel: +353-1-7166268, E-mail: Shaunandrewsmith@gmail.com

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At present, broiler houses in Ireland are equipped with direct gas heating systems which consist of open gas burners and a fan that blows heat from the flame directly into the broiler house. These direct heaters produce high concentrations of carbon dioxide (CO_2) and moisture. Prolonged exposure to high concentrations of CO_2 may affect weight gain in birds (Reece and Lott 1980). Increased air moisture content can react with faeces resulting in increased ammonia production which may impact negatively on bird welfare (Estevez 2002). Environmental conditions within broilers houses can significantly impact on stress levels within flocks (Humphrey 2006) and may adversely affect flock performance. Stress may also be an important consideration for *Campylobacter* transmission given that a previous study demonstrated increased stress in chickens induced by transportation resulted in higher levels of *Campylobacter* shedding in faeces (Whyte *et al.* 2001).

Indirect systems heat and transfer air into houses without additional CO_2 and water vapour. As a result, manufacturers claim indirect heating systems could improve environmental conditions by reducing CO_2 concentrations, moisture and ammonia within broiler houses when compared with direct heating systems. The objectives of the current study were to evaluate the impact of broiler house heating systems on (i) flock performance (mortality and weight gain), (ii) environmental conditions within the house (carbon dioxide (CO_2), ammonia (NH_3), and relative humidity (RH), litter quality), (iii) bird stress responses, and (iv) *Campylobacter* flock levels.

2. Materials and methods

2.1. Farm selection

Three multi-house broiler farms (farms A, B and C) located in Counties Cavan and Monaghan in Ireland were selected for the study. Each farm was a contracted grower for a large integrated broiler processing company stocked with Ross 308 birds (Aviagen, Midlothian, Scotland). Farm A consisted of four broiler houses each with a capacity of approximately 35 000 birds. Three houses were equipped with direct gas heating systems. The fourth house on farm A was equipped with a "Cubo" heating system (Choretime, United States). In the "Cubo" system, air was heated indirectly by a gas-fired water heat exchanger located within the house. The heated air was distributed *via* a centrifugal fan. Combustion fumes were exhausted to the exterior of the house. This system recycled air within the broiler house by drawing warm air from the upper air space, reheating it and then distributing it back out at floor level within the house (Fig. 1-A).

Farm B consisted of five broiler houses each with capacity of approximately 28 000 birds. Four houses were heated using the direct fan-assisted gas heating type system. The fifth house on Farm B had a "Blackheat" system installed (Robert's Gordon, United States). Combustion of gas took place within a single steel duct running along the top of the house. The house was then heated by radiant heat from the steel duct and the fumes were exhausted to the outside (Fig. 1-B).

Farm C consisted of three broiler houses each with a capacity of 27 000 birds. Two houses had direct gas heating systems, while the third house was heated *via* a "Wood Pellet" burner (Lee Energy Solutions, United States). The pellet burner was located in a purpose built annex room on the side of the house. Air was passed over the heat exchanger then transferred and distributed within the house *via* an inflatable tube (Fig. 1-C). Farms were sampled from June 2013 until June 2014.

2.2. Flock performance analysis

Production recording sheets were kept for all flocks raised in all six houses during the sampling period. Weight gain, bird mortality rates and water consumption were recorded daily on these sheets.

2.3. Environmental sampling

Carbon dioxide (CO_2) and ammonia (NH_3) concentrations in air within the houses were monitored using a Dräger pump and disposable Dräger tubes as per manufacturer's instructions (Dräger, United Kingdom). Readings were taken at the head height of chickens in order to accurately ascertain the concentrations which birds were exposed to. Readings were taken from two locations along the length of the house to give an average concentration for each house. Two readings were taken for both CO_2 and NH_3 every 3 days for the first 10 days of flock life, then once per week thereafter (Fig. 2). Temperature and relative humidity (%) for each house were recorded on a daily basis using the computerised monitoring systems in the houses.

2.4. Assessment of pH and moisture in the litter

Litter samples were collected at least once every 7 days from four broiler flocks from each of farms A and B and three broiler flocks for farm C over a period of 12 months. Six litter samples were collected from the surface layer at different locations within the house. A further six samples were collected from the bottom layer of the litter 25–75 mm deep once the flock reached 25 days of age (Fig. 2). Litter pH was evaluated *via* pH meter (pH 211 microprocessor pH meter, Hanna Instruments, United Kingdom). Litter moisture (%) was evaluated by weighing 20 g of litter samples then drying the samples in an oven at 100°C for 48 h. Litter samples were then reweighed and litter moisture (%) was calculated.