G.T. Tabler[2], I.L. Berry[3], Y.Liang[3], T.A. Costello[3], and H. Xin[4]
[2]Department of Poultry Science, [3]Department of Biological and Agricultural Engineering, University of Arkansas Division of Agriculture; and [4]Department of Agricultural and Biosystems Engineering, Iowa State University.

Cooling Broiler Chickens by Direct Sprinkling[1]

Introduction

Modern broilers grow at an extremely rapid rate and convert feed to meat with exceptional efficiency. However, this rapid growth rate and conversion efficiency have been associated with an increased susceptibility to heat stress. While a variety of genetic, nutritional, feeding and environmental strategies have been examined, much of the burden for dealing with the effects of heat falls to the producer and, in turn, the housing environment (Linn et al., 2006). Evaporative pads, fogger pads and fogger nozzles are commonly used to control heat and its effects in broiler houses (Weaver, 2002). Except in extreme conditions poultry production personnel have tended to avoid systems that deposit moisture directly on the birds. Yet, cattle and hogs are often cooled in hot weather by sprinkling with water and many poultry producers have occasionally cooled chickens by sprinkling with water hoses during extremely hot periods to avoid catastrophic mortality. In practice, the effectiveness of conventional, low-pressure misting systems in broiler houses partially depends on the deposition of much of the released water onto the chickens and their immediate surroundings. Pad systems require large volumes of water to cool birds and many producers are concerned about the availability and cost of water to operate cool cell systems. An alternative sprinkling system for cooling broiler chickens was investigated at the Applied Broiler Research Farm (ABRF).

History

Sprinkling with controlled amounts of water on a regular basis directly on the birds was tested in 1989 in a laboratory study with promising results (Berry et al., 1990). In that study, sprinkling water was applied at the rate determined by:

$$HL = 5.0 \frac{(TA - 80)}{(TS - 80)} \qquad (1)$$

where

HL = rate of water application, in latent heat units of Btu/hr/lb bird,
TA = room air temperature, F,

and

TS = chicken wetted-surface temperature, assumed to 92°F during study.

The control algorithm was based on data from Reece and Lott (1982), who found that the sensible heat production of broiler chickens at 80° F was nearly constant at 5.0 Btu/hr/lb bird after four weeks of age. The equation assumes that the heat transfer from the chicken body core remains at a constant 5.0 Btu/hr/lb bird as long as the wetted surface is cooled to 92°F by the addition of water with increasing air temperature. The use of 92°F for TS was based on radiometer measurements of chicken surface temperatures, recognizing that these surfaces were not necessarily the same as the wetted surfaces.

Field Tests Procedures

Field tests were conducted from 1995 through 2005 in commercial 40 by 400-ft curtain sided broiler houses at the ABRF. A variety of more conventional misting systems were normally used with cross-ventilation in Houses 1 and 3 during this period.

Houses 2 and 4 were arranged as tunnel ventilated houses and contained identical fan

[1]Mention of trade names does not constitute endorsement by the University of Arkansas Division of Agriculture and does not imply their approval to the exclusion of other products or vendors that may be suitable.

configuration patterns. Chickens in House 4 were cooled by the modified tunnel ventilation system with 200 ft of 4-in pads 4-ft in height. The pad cooling system seemed to work adequately, but air velocity in about half the house was not desirably high for tunnel ventilation. Additional heat stress may have resulted from some blockage of natural ventilation by the wall sections with cooling pads during evening hours. Water was applied in House 2 directly to the birds in a coarse mist sprinkled from 63 plastic spinner nozzles (Meter-Man UCS23) placed at 19-ft intervals along three longitudinal 3/4-in PVC pipes in House 2. The nozzles on the center pipe were staggered from those on the outside pipes, which were placed 10 ft from the side walls. Nozzles were placed about 2 in. above the pipes on risers that contained check valves. The pipes were suspended from the roof framing by a winched system so that nozzle height could be adjusted. Water was supplied to the nozzles through a pressure regulator set to 20 psi, so that each nozzle emitted about 0.25 gallons/min over a circle of about 22-ft diameter. The amount of water was metered by controlling the on-time of the nozzles in every 10-min cycle. Separate solenoid valves alternated water pressure to the three pipes to prevent overloading of the house water supply system. During this period, the maximum air velocity was maintained through the entire 400-ft length. Litter removal from all houses was via a farm tractor and pull behind single axle decaking machine (Lewis Brothers Mfg. Co., Model #2; Baxley, GA) capable of hauling 3,500 to 4,000 lbs per load.

Field Test Results

Table 1 shows the average daily mortality (dead chickens per day per house) from age 35 days until the day before harvesting. Average daily mortality was lowest in House 2 (direct sprinkling system) while House 4 (pad cooled house) had the next to highest mortality rate. The relative failure of House 4 was partially blamed on the low air velocity in part of that house. During Flocks 39 and 44, higher mortality in House 1 was probably averted by hand spraying with a garden hose.

Table 2 compares Houses 2 and 4 with respect to water used for cooling birds and loads of caked litter removed at the end of the grow-out period. While the average number of caked litter loads removed was approximately equal, House 2 used just over 85% less water to cool birds as compared to House 4. While fan electricity use was similar in both houses, feed conversion, average weight, and integrator pay rate showed a general trend in favor of the direct sprinkling system in House 2 as compared to House 4 (Table 3). These data suggest that, direct sprinkling of chickens was as effective at cooling birds as tunnel ventilation.

Observations

Tunnel ventilation is thought by many to be the best available management tool to prevent heat related stress and mortality in broiler flocks. Such houses have been reported to reduce the effective ambient temperature in the vicinity of the birds by more than 35°F on a typical summer day. However, water usage in tunnel houses is nearly double that of conventional houses on warm days (Lacy and Czarick, 1992). Water usage in the direct sprinkler house was about 85% lower than that used in the tunnel house, while loads of caked litter removed at the end of the flock were approximately equal (Table 2).

Random temperature observations with the direct sprinkler house suggest that this approach typically reduced the temperature of the ventilation air by less than 2°F. This is primarily because much of the water was applied directly to the birds. The lack of association between inside air temperature and the cooling benefits of the direct sprinkler system meant that the system benefits were not obvious to the casual observer unless he was actually sprinkled. In addition, inside air temperature could not be used to provide feedback for controlling water application rates. Instead, water application rates were based on outside air temperature and predicted body temperatures of birds using the previously presented algorithm. Earlier testing with the direct sprinklers has suggested that the system effectively removes heat directly from the birds (Xin et al., 2001). However, the increasing growth rates of broilers, solid sidewall housing and improvements in production methods suggest that an updated algorithm will be necessary under current production conditions. This work is currently underway.

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Summary

Cool cell pad systems use large volumes of water to cool the air temperature inside poultry houses during hot weather. Producers are increasingly concerned about the availability of their water supply and the cost of water, especially on large farms that may have 5 to 10 houses or more. An experimental method of cooling broilers in hot weather utilizing a low cost sprinkling system that consumes only a fraction of the water of a pad system was field tested at the ABRF with promising results. Such a system developed commercially could possibly offer an effective, viable, inexpensive alternative to current strategies used for summer cooling of broiler chickens.

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Table 1. Average Daily Mortality of Chickens during Summer Flocks.[1]

Flock No.	Length (Days)	Dates	Average Daily Mortality[2]			
			House 1	House 2	House 3	House 4
27	41	June 29 - Aug. 9, 1995	8.00	8.00	9.17	20.67
33	42	May 9 - June 20, 1996	12.43	8.86	9.43	10.71
34	43	July 4 - Aug. 16, 1996	9.00	5.50	6.00	7.50
39	53	June 26 - Aug. 18, 1997	16.19	12.00	11.44	22.56
43	50	April 16 - May 26, 1998	30.25	26.92	23.25	23.67
44	55	June 12 - Aug. 6, 1998	65.28	21.33	16.72	27.89
49	57	May 31 - July 27, 1999	18.05	9.20	22.45	46.30
50	55	Aug. 5 - Sept. 29, 1999	10.11	14.94	16.28	16.56
54	56	May 16 - July 11, 2000	34.74	27.05	21.42	75.95
55	53	July 21 - Sept. 12, 2000	20.00	12.82	15.82	29.35
60	42.5	May 18 - June 30, 2001	40.89	18.38	19.86	11.00
61	43	July 5 - Aug. 17, 2001	16.13	18.37	16.63	18.38
67	45	June 4, - July 19, 2002	41.60	11.40	37.20	20.10
73	42	June 19 - July 31, 2003	36.29	16.71	26.71	38.85
79	44	June 3 - July 17, 2004	35.67	24.56	42.44	31.67
80	41.36	Aug. 22 - Oct. 11, 2004	20.33	24.33	33.00	28.17
85	39	June 13 - July 22, 2005	69.25	55.25	65.75	43.25
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[1]Mortality is calculated for age 35 days until the day before the harvest.
[2]Houses 1 and 3 were conventionally ventilated with mist systems, while House 4 was a pad-cooled, tunnel-ventilated house and the cooling system in House 2 sprinkled water directly on the birds.

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Table 2. A Comparison of Summer Cooling Water Usage and Caked Litter Removal from House 2 (Direct Sprinkler System) and House 4 (Pad Cooled).

Year	Flock #	Cooling H20 (gal)		Cake removed (loads)[1]	
		House 2	House 4	House 2	House 4
1995	27	18289	42950	7	8
1996	33	1599	6193	0	0
	34	2905	12834	0	0
1997	39	4828	62945	2	1
1998	43	1200	33425	2	3
	44	13224	133349	0	2
1999	49	9653	114337	2	1
	50	128	2320	5	3
2000	54	5271	35510	8	6
	55	13578	33604	4	5
2001	60	142	4567	2	3
	61	4996	40010	2	2
2002	67	2677	12800	5	4
2003	73	1731	18337	4	4
2004	79	1064	12222	2	3
	80	0	5895	4	3
2005	85	2456	6706	0	3
Ave.	--	**4926**	**34000**	**2.88**	**3**

[1]Total annual cleanout performed on Flock 33 and total cleanout of experimental bedding on Flock 34 in 1996.

Table 3. Production Figures, Flock Water Consumption and Fan Electricity Use for Summer Flocks.

Flock No.	Feed Conversion		Avg. Wt. (lbs)		Pay/lb. (cents)		Water Consumption/flk (gals)		Fan Electricity/flk (kwh)	
	House No.		House No.		House No.		House No.		House No.	
	2	4	2	4	2	4	2	4	2	4
27	1.81	1.90	3.80	3.70	4.92	4.21	32,955	35,378	3,671	3,252
33	1.84	1.91	3.80	3.81	4.93	4.42	34,589	37,453	1,288	1.736
34	1.91	1.95	3.83	3.80	4.45	4.15	35,321	37,488	1,939	1,838
39	2.05	2.06	4.99	5.04	4.12	4.05	41,931	45,735	3,961	4,585
43	2.03	2.09	4.89	5.10	4.07	3.99	36,655	40,046	1,939	1,694
44	2.08	2.02	5.15	5.46	4.62	4.60	40,737	41,069	4,824	4,370
49	2.22	2.32	6.29	6.02	5.23	4.37	55,193	51,705	5,049	4,842
50	2.13	2.11	6.26	6.08	3.57	3.60	55,924	52,711	4,038	3,128
54	2.08	2.18	6.24	5.77	4.71	3.81	54,349	53,569	4,350	4,217
55	2.07	2.04	5.75	5.59	3.88	3.88	55,207	53,348	6,412	5,777
60	1.80	1.92	4.37	3.94	4.42	3.36	42,699	40,926	3,247	3,218
61	1.86	1.86	4.31	4.43	4.19	4.33	46,833	49,252	5,458	5,987
67	1.93	2.04	4.64	4.39	4.94	4.15	48,190	51,994	5,592	5,347
73	1.86	1.79	4.17	4.60	3.88	4.56	34,688	36,458	3,204	3,624
79	1.95	1.94	4.63	4.44	4.04	3.65	38,621	35,717	2,765	3,457
80	1.72	1.66	4.79	4.93	4.93	5.32	42,913	42,574	3,151	3,379
85	1.80	1.78	4.09	3.92	4.26	4.12	36,028	35,767	3,311	3,729
Avg.	**1.95**	**1.97**	**4.82**	**4.77**	**4.42**	**4.15**	**43,108**	**43,599**	**3,776**	**3,775**