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Araştırma Makalesi

Evaluation of the Pad Cooling System Effectiveness Used in Hot Weather Conditions in Broiler Houses: Izmir Case Study

Hakan Bayraktar[1*], Metin Artukoğlu[2], Ali Altan[1]

[1]Ege University Faculty of Agriculture [1]Department of Animal Science [2]Department of Agricultural Economy 35100 Bornova, Izmir – TURKEY

*e-posta: hbayrak@ziraat.ege.edu.tr; Tel.: +90 (388) 40 00 - 1453 / 21

Abstract

The objective of this research was to determine the effects of pad cooling system on broiler production. High environmental temperatures impair the growth and feed conversion of broilers. Production losses and mortalities due to high summer temperatures are serious problems in warmer regions of Turkey like Ege and Akdeniz. Using evaporative cooling systems can be an effective way to protect from the detrimental effects of heat stress in the warmest part of the day. Maintaining the broiler house at more nearly optimum temperatures by pad cooling reduces production cost but increases utility, electricity and water cost. Broiler growers routinely make decisions to balance these costs and benefits due to the daily weather conditions. In the study, warm season climatologic data of Izmir have been analyzed to determine the daily-hourly average effective temperatures and pad cooling efficiency in this area. Regression equations based on effective temperature have been obtained and live weight, feed conversion and mortality equation plotted at 42 days old. Broiler performance grown in house with and without pad cooling system has been simulated to judge the feasibility of pad cooling in a model broiler house with 18 000 capacity. Cost and income analysis of the system for broiler integrations and producers have been made to determine the system profitability with thermostat or humidistat control options. Results have shown that using pad cooling systems by thermostats control are more profitable for producer. On the other hand humidistat controlled systems have been found more profitable than thermometer controlled systems for integrations.

Key words: pad cooling, temperature, humidity, live weight; feed conversion, mortality, profitability

Etlik Piliç Kümeslerinde Sıcak İklim Koşullarında Kullanılan Pad Cooling Sistem Etkinliğinin Değerlendirilmesi: İzmir Örneği

Özet

Araştırmanın amacı pad cooling sisteminin etlik piliç üretiminde karlılığa etkisinin belirlenmesidir. Yüksek çevre sıcaklığı etlik piliçlerde gelişme ve yemden yararlanmayı olumsuz etkilemektedir. Ege ve Akdeniz gibi Türkiye'nin sıcak bölgelerinde yüksek yaz sıcaklıklarına bağlı olarak gerçekleşen üretim kayıpları ve ölümler önemli boyutlara ulaşmaktadır. Buharlaşmayla serinletme sistemlerinin kullanımı sıcaklığın olumsuz etkisinden korunmak için etkin bir yoldur. Pad cooling kullanımıyla sıcaklığın optimum düzeyde tutulması üretim masraflarını azaltmakta buna karşın ekipman, elektrik ve su masraflarını artırmaktadır. Etlik piliç yetiştiricileri iklimsel koşullara göre günlük kararlar alarak fayda ve masraf dengesini sağlamaktadır. Çalışmada, pad cooling sisteminin yöredeki etkinliğinin belirlenebilmesi amacıyla, İzmir ili sıcak mevsim iklimsel verileri günlük ve saatlik olarak analiz edilerek etkin sıcaklıklar saptanmıştır. Etkin sıcaklığa bağlı olarak, 42. gün canlı ağırlığı, yemden yararlanma ve ölüm oranındaki değişimler ilgili regresyon denklemlerinden yararlanılarak hesaplanmıştır. Pad cooling sisteminin karlılığının belirlenebilmesi için sistemin kullanıldığı ve kullanılmadığı varsayılan, 18 000 kapasiteli model bir etlik piliç kümesinde yetiştirilen piliçlerin performansı simüle edilmiştir. Sistemin nem veya sıcak kontrol seçeneklerine göre kullanımının entegrasyon ve üretici açısından karlılığının belirlenebilmesi için gelir ve gider analizleri yapılmıştır. Sonuçlar sistemin termostatla kontrolünün üreticiler açısından daha karlı olduğunu göstermiştir. Diğer taraftan entegrasyonlar için humidistat kontrolünün daha karlı olduğu saptanmıştır.

Anahtar sözcükler: Pad cooling, sıcaklık, nem, canlı ağırlık, yemden yararlanma, ölüm oranı, karlılık

Introduction

Contract farming is the most common production model in Turkish broiler industry. Chicks, feed and veterinary service are supplied by integrated firms to producers in this production model. At the end of the growing period broilers are taken back and paid money to producer defined with the contract for each kilo of live weight and some extra payment or penalty are made according to the feed conversion better than 2 or not. Either firms or producers have similar aim such as higher live weight, better feed conversion and lower mortality to profitable production.

Nowadays genetically superior animals are fed by scientifically balanced rations in modern broiler industry. It's only with an optimum environment that the genetic potential of animals and maximum feed conversion can be realized (Oderkick, 1998). High environmental temperatures impair the growth and feed conversion of broilers (Charles, 1986). Production losses and mortalities due to hot weather are serious problems in many broiler producing areas of the world (Czarick and Lacy, 1994). Growers must balance the value received from improved production and feed conversion against the cost of obtaining the improved environment. The value received is derived from incremental improvement in growth rate and feed conversion per incremental change in the environmental conditions (May and Lott, 2000). Maintaining the correct temperature is a crucial factor in chick brooding. Heat stress can result in significant losses to producers with all types of poultry. The ideal temperature for the best weight gain and feed efficiency varies depending on age of birds, from 33-35 °C for day-old chicks to 18-21 °C just before catch (Vest, 1997). Failure to provide the optimum environment during the brooding period can reduce profitability because of reduced growth and development, poorer feed conversion and increased diseases, condemnation and mortality (Lacy and Czarick, 1992). In house temperatures going too high or too low will not only reduce broilers growth, and also can kill them. The most obvious loss is due to mortality at extremes. All are much more difficult to evaluate. Poultry production goes down every summer because of the high temperature. In some years, the death rate of chicken even reached 10% (Zhu, 1992). Poultry producers should be aware that losses in production efficiency will occur long before significant mortality rates are observed (Vest, 1997, Lacy and Czarick, 1992; Zhu, 1992). Feed is the most expensive component in the live production of broilers. Feed intake and growth rate decline as temperature increases above about 22-24 °C. Some feed energy is used to dissipate body heat during high temperatures (Charles, 1992).

High temperatures have an adverse effect when the relative humidity is 65% or higher. A relative humidity level of 60 to 70% is recommended for the first three weeks and 40 to 60% for the next four weeks or until the birds are marketed. Researches show that increased relative humidity results in depressed feed consumption, independent of dry-bulb temperature (Vest, 1997; Altan ve Bayraktar, 1999).

In commercial broiler growing operations, broiler houses are two major types. One is the open-sided conventional house with natural ventilation. In accordance with producers' financial ability, natural ventilation is the most popular in these type houses (Zhu, 1992). Some of these houses may use fans to move air and for ventilation purposes during the brooding period. House temperature tents to fluctuate as outside temperature changes. The other is the controlled environment house with mechanical ventilation system and enough insulation to maintain uniform house temperature despite fluctuation of outside temperature (Vest, 1997).

In hot weather conditions maximum ventilation is the only practical way to keep houses and birds from overheating. Tunnel ventilation is one of the forced ventilation options relatively new housing concept for the poultry industry. Tunnel ventilation is described as using fans to pull air through an inlet at the end of the house down the shed length and out through the fans at the opposite and like a wind tunnel (Runge, 1998). Tunnel ventilation is not only a method of minimizing heat stress related losses, but also a way to maximizes production efficiency by keeping the birds more comfortable throughout hot weather grow outs (Lacy and Czarick, 1992). System uses a more effective method for inducing wind chill effect to reduce the of heat stress on chickens. During the tunnel ventilation, wind chill means the temperature, the birds feel, is not the same as the temperature reading. It is sensed temperature which they respond to, not the temperature on the thermometer in shed. When the temperatures are above 22-24 °C, wind chill is used to cool the birds. When the temperatures are above 27-29 °C evaporative cooling should be used to provide additional cooling for growing chicks (Runge, 1998; Altan ve Bayraktar, 1999). But in some weather conditions it may be insufficient especially in conventional houses, and forced ventilation and evaporative cooling are needed. Evaporative cooling can be an effective way to provide birds some relief from the heat. An Evaporative cooling system works off the simple principle that as water evaporates into the air heat is removed from the air, thereby lowering its temperature. The limiting factor with this system is the outside humidity since the evaporation rate determines effectiveness (Donald, 1998; Altan ve Bayraktar, 1999). Evaporative coolers use heat from the air to vaporize water. This increases the relative humidity, but lowers the air temperature. The higher the humidity, the lower the amount of water which can be evaporated into the air and less cooling produced. System can be used in areas with high humidity because humidity levels tend to be the lowest during the warmest part of the day (Donald, 1998; 1999). Type of system needed depend on weather conditions.

Relative humidity can be determined by the hand held electronic instruments. Other way uses a sling psychrometer, twirling a thermometer wrapped in a wet cloth to get the wet- bulb (Wb) temperature. The lower the wet-bulb temperature, the lower relative humidity. The difference between the dry-bulb (Db) and wet-bulb temperature reading equals the maximum theoretical cooling potential of the evaporative cooling systems. Determining the practical achievable cooling show us how much of theoretical cooling potential will actually be achieved. Efficiencies of current EC systems range in practice from around 50% about 75% or so. For example, a 50% effective system will give half of the maximum potential cooling (Donald, 1999). This means the actually achievable temperature drop may range from as little as 5 °C to as much as 7.5 °C in the 30 °C range with 20 °C Wb temperature (30 – 20 = 10; 50% of 10 = 5 °C; 75% of 10 = 7.5 °C). In the West and Southwest of Turkey daytime temperatures above 30°C are common, but relative humidity is often in the 40-60% range with Db / Wb temperature spreads of not much more than 10 °C. This narrower gap between Db and Wb temperatures means that higher efficiency EC systems may be needed to keep birds in their comfort range or at least keep them out of critical heat stress range. So, in the last years broiler firms started to prefer producers who have pad cooling equipment in warmer regions like Ege and Akdeniz in Turkey.

One of the most efficient evaporative cooling systems is the "pad cooling" system, in which all incoming air passes through a moist pad. The typical evaporative pad cooling system draws outside air into the building through wet vertical pads. The major components of this system are: pad media, water supply, pump, distribution pipe, gutter, sump, and bleed-off line (Czarick and Lacy, 1996; Altan ve Bayraktar, 1999). As air flows past the moist pad surfaces, some of the moisture evaporates into the air stream. Heat is withdrawn from the air during this process and the air leaves the pad at a lower temperature with higher moisture content. To gain maximum benefit from this system, the material used to provide surface area from which the water evaporates should be properly maintained and properly wet at all times. Fans that provide air movement for evaporation should also be moving the correct volume of air. A well-maintained ventilation system with evaporative cooling can reduce incoming air 6 to 13°C (Donald, 1998; Czarick and Lacy, 1996; Donald, 1999). Cooler indoor temperatures can improve the environment for animals, plus significantly improve working conditions for employees. The most critical weather factor is prevailing pattern of high temperatures and coincident relative humidity. That is, how hot it is for how long and what relative humidity tends to be at this time. Maintaining the broiler house at more nearly optimum temperatures with pad cooling system reduces feed cost but increases utility and water cost. Electricity is required for ventilation and evaporative cooling during hot weather, and water is required for evaporative cooling (May et al., 1998). Broiler growers routinely make decisions to balance these costs and benefits. Unfortunately, decisions regarding ventilation and evaporative cooling are usually empirical because the actual value of an incremental change in temperature is not known.

Material and Methods

First of all warm season (months of May, June, July, August, and September) climatologic data of Izmir analyzed to determine of the daily distribution pattern of the average temperature and relative humidity (DMİ, 2002). For this aim daytime hourly dry-bulb and wet-bulb data belongs the last seven years in warm season available from the Izmir State Meteorology Station were statistically analyzed. Daytime hourly average wet-bulb temperatures were predicted from 07:00, 14:00 and 21:00 hour wet-bulb data by using microsoft excel trendline options with polynomial models for everyday (R^2=1). Daytime hourly average relative humidity values were calculated with predicted hourly average wet-bulb temperatures by using Munters' psychrometric calculator (Munters, 2002). Daily average pad cooling efficiency values have been calculated by using dry-bulb and wet bulb temperature according to the 75% effective system.

Secondly, to calculate the effective temperature at different temperature, relative humidity and air velocity values for broilers a model has been developed by using data Coob Technical News (Barnwell, 1997). The regression for this model is described by the following equation:

$$y=0.77531+0.71136Dbt+0.13181Rh-3.6814As \quad (R^2=0.96)$$

y = Effective temperature, Dbt = Dry-bulb temperature, Rh = Relative humidity, As = Air velocity.

Also models have been developed to simulate the effects of poultry house conditions on live weight, feed conversion and mortality ratios at different effective temperature for broilers from 21-42 day old by using data USDA Poultry Research Laboratory, Mississippi State University (Czarick et al., 2000) with microsoft excel trendline options, polynomial model for live weight, feed conversion and linear model for mortality. These models have been used in profitability analysis. The Regression was described for live weight by the equation:

$y = 0.0807x^3 – 0.5975x^2 + 1.0658x + 2.131$ (R^2=1)
y = Average live weight,

x = Average effective temperature (Figure 1).

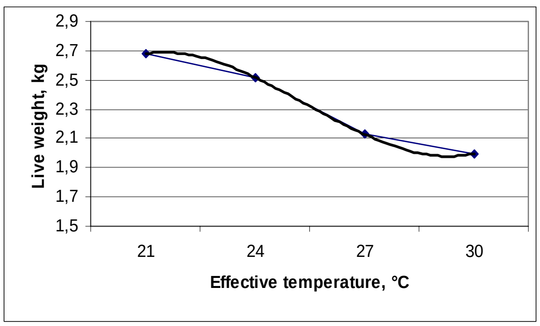

Figure 1. Differences in average broiler live weight at 42 days old with effective temperature.

The equation for feed conversion regression was:

$y = 0.0417x^3 – 0.23x^2 + 0.4683x + 1.62$ (R^2=1)

y = Feed conversion,
x = Average effective temperature (Figure 2).
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x = Average effective temperature (Figure 2).

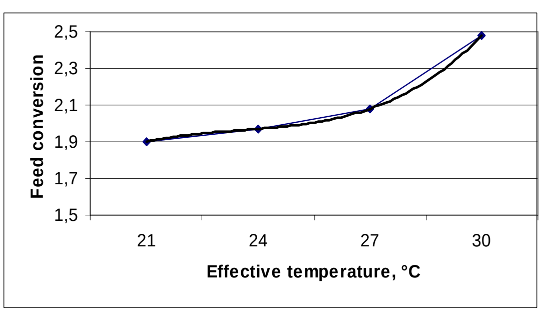

Figure 2. Feed conversion differences at 42 days old with effective temperature.

The regression for mortality was described by the following equation:

$y = 0.01x + 0.02$ (R^2=1)

y = Average mortality ratio
x = Average effective temperature (Figure 3).

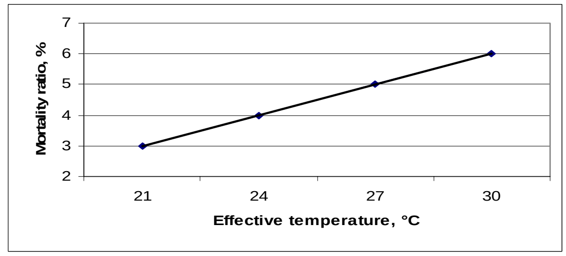

Figure 3. The effects of effective temperature on broiler mortality ratio.

broiler performance with and without pad cooling systems were determined by using predicted live weight, feed conversion and mortality ratios. Also cost and income analysis of the system were made in a model broiler house (12 x 100 m) with 18 000 capacity to determine the system profitability with thermostat or humidistat control options. Technical concepts about the model broiler house as follows: 7 fans are used to provide 2 m/s air velocity in the house with 40 000 m^3/h capacity each them. Electricity consumption for one fan is 1.1 kWh and electricity price is 105 000 TL/kWh. Water usage in pads for 1 °C temperature decrease per hour is 280 liters and cost of water is 50 TL/liter. Average fan life is 20 year and average pad life is 5 year.

Results

Prepared daily distribution patterns according to the predicted average temperature and relative humidity have been shown that because of the absence of average temperature above 27 °C there is no need to evaporative cooling in May, if thermostat control option used (Figure 4). On the other hand there are temperatures above 21 °C with relative humidity lower than 60% between 09:00 to 19:00 hours and evaporative cooling can be used with humidistat control options (Table 1).

Average temperatures start to be seen above 27 °C in June between 10:00 to19:00 hours and relative humidity goes on below 50% at same time part. So the evaporative cooling can be used efficiently in this time range (Figure 5). Table 1 has been shown that evaporative cooling can also be used in early morning (07:00) and late evening (21:00) because of relative humidity values are below 60%. Temperature increases go on through July and range of evaporative cooling using time wider to between 08:00 to 21:00 hours (Figure 6). Because of relative humidity values go on

60% in early morning and late evening like June, evaporative cooling can be used more time if wanted (Table 1).

Comparison August with the July, nearly same time range above 27 °C is seen (09:00 - 21:00) but relative humidity values are a bit higher especially early in the morning before 08:00 (Table 1). So evaporative cooling should not be used early in the morning (Figure 7).

At the end of August temperatures start to decrease and only between 12:00 to 16:00 temperatures are above 27 °C in September (Figure 8). The relative humidity values are higher than 60% out of between 09:00 to 18:00, so evaporative cooling shows poorer efficiency at these time rage (Table 1).

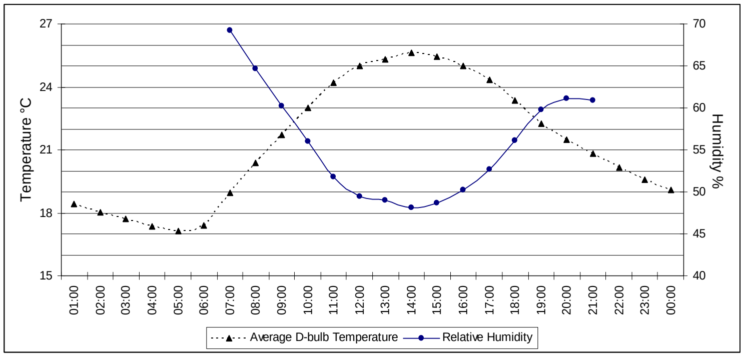

Figure 4. Daily distribution patterns of average temperature and relative humidity in May.

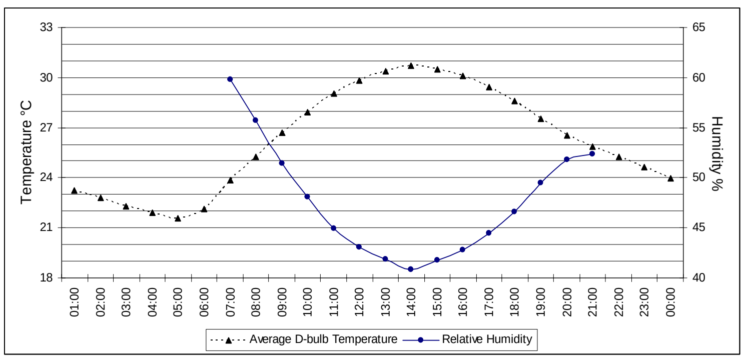

Figure 5. Daily distribution patterns of average temperature and relative humidity in June.

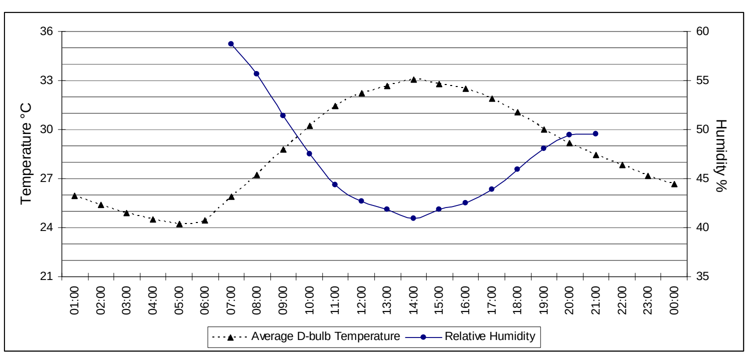

Figure 6. Daily distribution patterns of average temperature and relative humidity in July.

Table 1. Monthly average climatologic values and some predicted parameters of pad cooling efficiency between 07:00 to 21:00.

Month	Specification	Hours														
		07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00
May	D-bulb Temperature, °C	18.9	20.4	21.7	23.0	24.2	25.0	25.3	25.6	25.5	25.0	24.3	23.3	22.2	21.5	20.8
	Relative Humidity, %	69.3	64.7	60.3	56.0	51.8	49.5	49.0	48.1	48.7	50.3	52.7	56.2	59.8	61.1	60.9
	Wet-bulb Temperature, °C	15.4	16.1	16.7	17.1	17.5	17.8	18.0	18.0	18.0	17.9	17.7	17.4	17.1	16.6	16.0
	Cooling Efficiency, °C	2.6	3.2	3.8	4.4	5.0	5.4	5.5	5.7	5.6	5.3	4.9	4.4	3.9	3.7	3.6
	Wind-chill Effect, °C	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.3
	Effective Temperature, °C	15.1	16.0	16.7	17.4	18.0	18.4	18.7	18.9	18.8	18.6	18.2	17.7	17.1	16.6	15.9
June	D-bulb Temperature, °C	23.8	25.3	26.7	27.9	29.1	29.8	30.4	30.7	30.5	30.1	29.5	28.6	27.6	26.6	25.9
	Relative Humidity, %	59.8	55.7	51.4	48.1	44.9	43.1	41.8	40.8	41.8	42.8	44.4	46.6	49.5	51.8	52.4
	Wet-bulb Temperature, °C	18.4	19.0	19.5	19.9	20.3	20.5	20.7	20.8	20.8	20.7	20.5	20.2	19.9	19.5	18.9
	Cooling Efficiency, °C	4.1	4.7	5.4	6.0	6.6	7.0	7.2	7.5	7.3	7.1	6.7	6.3	5.8	5.3	5.2
	Wind-chill Effect, °C	1.1	1.0	1.0	0.9	0.8	0.7	0.6	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.0
	Effective Temperature, °C	18.7	19.5	20.3	21.1	21.7	22.2	22.5	22.7	22.6	22.4	22.0	21.5	20.9	20.3	19.7
July	D-bulb Temperature, °C	25.9	27.2	28.8	30.2	31.4	32.2	32.7	33.0	32.8	32.5	31.9	31.0	30.0	29.2	28.5
	Relative Humidity, %	58.7	55.7	51.4	47.5	44.4	42.7	41.9	41.0	41.8	42.5	43.9	45.9	48.0	49.5	49.6
	Wet-bulb Temperature, °C	20.0	20.7	21.2	21.7	22.1	22.3	22.5	22.6	22.6	22.5	22.3	22.0	21.7	21.2	20.6
	Cooling Efficiency, °C	4.4	4.9	5.7	6.4	7.0	7.4	7.6	7.8	7.6	7.5	7.2	6.7	6.2	6.0	5.9
	Wind-chill Effect, °C	1.0	0.9	0.8	0.6	0.5	0.4	0.3	0.3	0.3	0.4	0.4	0.6	0.7	0.8	0.8
	Effective Temperature, °C	20.5	21.4	22.3	23.2	23.9	24.4	24.7	25.0	24.8	24.6	24.3	23.7	23.0	22.4	21.8
August	D-bulb Temperature, °C	24.7	26.1	27.6	29.0	30.3	31.1	31.7	32.0	32.0	31.6	31.0	30.0	28.9	28.2	27.7
	Relative Humidity, %	64.0	60.8	56.3	52.4	48.8	46.9	45.8	45.1	46.2	46.2	47.9	50.5	53.7	54.3	53.6
	Wet-bulb Temperature, °C	19.9	20.5	21.1	21.6	22.0	22.3	22.5	22.7	22.7	22.6	22.4	22.1	21.8	21.3	20.7
	Cooling Efficiency, °C	3.7	4.2	4.9	5.5	6.2	6.6	6.8	7.0	7.0	6.8	6.4	5.9	5.4	5.2	5.2
	Wind-chill Effect, °C	1.0	0.9	0.9	0.8	0.6	0.6	0.5	0.4	0.4	0.5	0.6	0.7	0.8	0.8	0.9
	Effective Temperature, °C	20.1	21.0	21.9	22.7	23.5	24.0	24.3	24.5	24.6	24.3	24.0	23.4	22.8	22.2	21.6
September	D-bulb Temperature, °C	20.5	22.0	23.7	25.1	26.4	27.3	27.9	28.0	27.7	27.2	26.2	24.9	24.1	23.5	23.0
	Relative Humidity, %	69.0	64.5	58.6	54.5	50.5	48.1	47.1	47.2	48.6	50.5	54.6	59.8	62.0	62.1	61.0
	Wet-bulb Temperature, °C	16.7	17.5	18.1	18.7	19.1	19.5	19.7	19.9	19.9	19.8	19.6	19.4	19.0	18.5	17.9
	Cooling Efficiency, °C	2.8	3.4	4.2	4.8	5.5	5.9	6.1	6.1	5.9	5.6	4.9	4.2	3.8	3.8	3.9
	Wind-chill Effect, °C	1.1	1.1	1.1	1.1	1.0	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.1	1.1
	Effective Temperature, °C	16.6	17.5	18.4	19.2	19.9	20.5	20.9	21.0	21.0	20.7	20.3	19.7	19.2	18.7	18.1

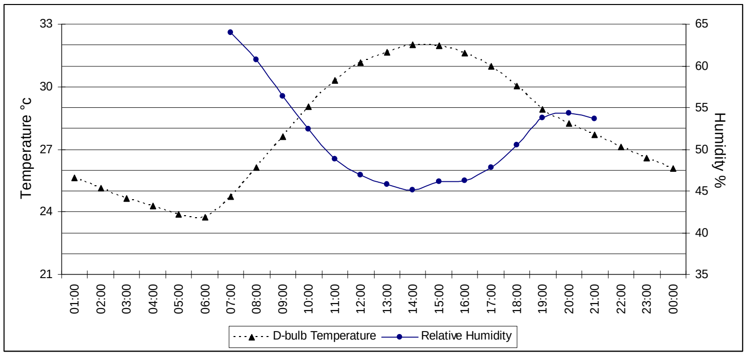

Figure 7. Daily distribution patterns of average temperature and relative humidity in August.

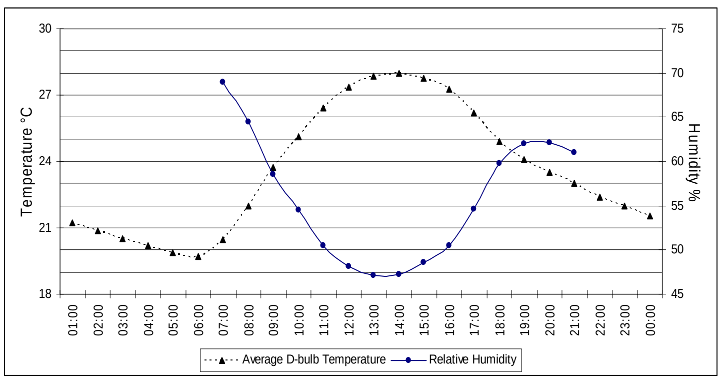

Figure 8. Daily distribution patterns of average temperature and relative humidity in September.

July and August have been found the most effective months in which pad cooling systems are used in Izmir area. June, September and May have fallowed them respectively in efficiency (Table 1). System can be used 121 hours in May, 450 hours in June, 465 hours in July, 434 hours in August, 300 hours in September and 1 770 hours totally by humidistat control options. If thermostat control options preferred system can be used 300 hours in June, 434 hours in July, 403 hours in August, 125 hours in September and 1 262 hours totally.

Incomes and costs of 18 000 broiler capacity model house with and without pad cooling system have been calculated by using the developed live weight, feed efficiency and mortality at different effective temperatures to make profitability comparison. Broiler performance values and incomes have been given in Table 2.

Differences in broiler performance, producer and firm incomes system have been summarized in Table 3 when the system controlled by humidistat.

When the system is controlled by humidistat in the same broiler house performance, producer and firm incomes will change as Table 4.

Table 2. Broiler performance and producers, firm incomes without evaporative cooling.

	May	June	July	August	September
Live Weight, kg	2.520	2.238	2.087	2.075	2.332
Feed Conversion	1.97	2.05	2.18	2.17	2.01
Mortality, %	3.94	4.74	5.27	5.28	4.48
Producer Income, Billion TL*	4.371	3.818	3.496	3.475	4.007
Firm Income, Billion**	52.288	46.052	42.710	42.445	48.126

* : Live weight payment = 100 000 TL/kg; Feed payment = ± 10 000 TL/kg
** : Live broiler price = 1 200 000 TL/kg, Feed cost = 350 000 TL/kg

Table 3. Predicted broiler performance, producer and firm profitability by using evaporative cooling with humidistat control (RH is equal or below 60%).

	May	June	July	August	September
Live Weight, kg	2.619	2.421	2.422	2.372	2.428
Feed Conversion	1.95	1.99	1.99	2.01	1.99
Mortality, %	3.64	4.25	4.17	4.30	4.23
Producer Income, Billion TL	4.564	4.178	4.181	4.181	4.191
Firm Income, Billion TL	54.518	50.071	50.133	49.028	50.216
Cooling Cost, Million TL	342.583	349.736	355.959	335.782	309.888
Net Producer Profit, Million TL	-149.813	9.889	328.473	271.466	-125.750
Net Firm Profit, Billion TL	2.230	4.019	7.422	6.582	2.090
Net Monthly Average Profit for Producer	66 853 209 TL				
Net Monthly Average Profit for Firm	4 468 559 437 TL				

Table 4. Predicted broiler performance and producers, firm profitability by using evaporative cooling with thermostat control (Db temperature is equal or above 27 °C).

	May	June	July	August	September
Live Weight, kg	2.520	2.367	2.406	2.372	2.380
Feed Conversion	1.97	1.99	2.00	2.01	2.00
Mortality, %	3.94	4.42	4.21	4.30	4.36
Producer Income, Billion TL	4.371	4.075	4.150	4.083	4.098
Firm Income, Billion TL	52.288	48.864	49.784	49.027	49.162
Cooling Cost, Million TL	-	270.604	348.823	326.808	200.610
Net Producer Profit, Million TL	-	13.614	305.127	280.440	-108.708
Net Firm Profit, Billion TL	-	2.811	7.074	6.582	1.036
Net Monthly Average Profit for Producer	92 648 990 TL				
Net Monthly Average Profit for Firm	3 500 562 043TL				

Discussion

A general rule, evaporative cooling should be started when the outside air temperature hits 27 °C, but only if relative humidity is below 60%. Early in the morning on a typical day in Izmir relative humidity will be close to 60%, but temperature will be in low 24 °C. As the day goes on the air heats up, so the relative humidity drops. By the time the temperatures reaches 27 °C the humidity is almost always below 60% making evaporative cooling possible. Under Izmir conditions, pad cooling systems can usually keep in house temperatures from going over the 27 to 30 °C range. Net monthly average profit for producer and firm with humidistat or thermostat control options have been found that nearly 3 700 TL/bird and 250 000 TL/bird; 5 150 TL/bird and 195 000 TL/bird respectively. These results have been shown that using pad cooling systems by thermostats control are more profitable for producer. On the other hand humidistat controlled systems have been found more profitable than thermometer controlled systems for integrations. If the firms do not pay extra money to producers used pad cooling system by humidistat, thermostat control should be preferred.

Izmir is one of the most important broiler production centers of Turkey with nearly capacity of 20 000 tons broiler meat per year. This value is equal nearly 2.5 millions broilers per period. So **additional economical values** of the pad cooling system for producer and firm with humidistat controlled systems will be 9.25 billions TL/period and 625 billions TL/period respectively. When the thermostat controlled systems are used these values will change as 12.875 billions TL/period and 487.5 billions TL/period for producer and firm respectively. Every year at least two growing period carried out in summer considered these values will be doubled.

This research can be used as model for other regional hot weather studies. Data will be useful for the evaluation of various hot weather management scenarios to determine the inputs that are profitable in this area.

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