ANALYSIS OF HEATING AND COOLING DAYS FOR BROILER HOUSING IN GAP REGION: EUPHRATES BASIN CASE

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Abstract. The degree-day method is one technique that allows to have information about the energy consumption of any building. Design and manufacturing of heating or cooling systems in buildings are based on climatic data. The climatic data used in the design of these systems for long years allow the results to be more accurate. In the study area, the Euphrates basin has been chosen as one of the hottest regions in Turkey. Long annual outdoor air dry-bulb temperature of four cities (Sanlıurfa, Adıyaman, Gaziantep, Kilis) in the Euphrates basin is taken from the General Directorate of Meteorology. A six-week period in the base temperature was determined for production of broiler house values. Long annual dry-bulb temperature values in the research area are determined by comparing the base temperature number of days in the heating and cooling temperatures. It was determined that the maximum heating day values were of Gaziantep city and minimum heating day values of Sanlıurfa city. During breeding broilers, the recommended six different base temperatures with between heating and cooling degree-day values regression coefficients are calculated for all provinces. In all provinces, the regression coefficients were found 0.999 and a positive aspect was determined at very high rates. As a result, it may be possible to use the degree-day method for knowledge about the energy requirement to be held in any region for broiler houses. In addition, knowledge can be obtained about whether it would be appropriate in terms of energy consumption in any region in broiler houses.

Keywords: broiler, heating degree-day, cooling degree-day, base temperature.

Introduction

The design of the air conditioning systems, energy analysis, and calculation of the values associated with heating and cooling in the buildings are based on meteorological data. There is a need for different climate values for energy analysis. Accurate and reliable climate data are of great importance for the accuracy of the results in energy analysis and the analysis of air conditioning systems as well as energy efficiency [1]. While obtaining the design and performance simulations of these systems, the use of the climate values of many years instead of the values of a few years randomly determined ensures more accurate and valuable results on a going-forward basis [2]. There are complex and advanced methods to perform an energy analysis in the buildings.

The simplest and most widespread method that can be defined to preliminarily predict the energy consumption of any buildings is the degree-days method. This method usually needs the data of either annual or monthly heating or cooling degree-days. HDD and CDD are the basic quantities for preliminarily estimating energy consumption of a building [3; 4]. The Degree-Day method supposes that the energy needs for a building are proportional to the difference between the base temperature and mean average temperature. The base temperature defines the outside temperature below or above when heating or cooling is required [4-6].

Heating and cooling degree-day values express the intensity of air temperature relative to a specific base (basic) value at a specific time. The number of heating degree-days or cooling degree-days expresses how the average air temperature in a day is cool or hot in proportion to the base value. In other words, high heating degree-day and cooling degree-day values mean that there is a high heating and cooling need in that area [7].

In our country, studies performed using the degree-day methods on animal livestock are very rare. The aim of this study was carried out to determine the number of heating and cooling degree-days, and the extent of heating and cooling needs for broiler breeding establishments to be operated in the Euphrates Basin. By means of this kind of studies, manufacturers may have some prior knowledge about energy consumption before starting their agricultural production activities.

Materials and methods

The Southeastern Anatolia Region is the leading one among the hottest regions of the country. The Euphrates Basin was selected as the study area, for it is in this region (Sanlıurfa, Adıyaman, Kilis, Gaziantep cities). At the same time, the number of broilers bred in the study area is around 700.000 [8]. The annual outdoor dry-bulb thermometer temperatures for a long period of four provinces in the Euphrates Basin were obtained from the Turkish State Meteorological Service. As a production period of broiler breeding takes an average of six weeks, the basic temperature values were determined for six-week periods (Table 1) [9-12]. Heating and cooling degree-days were determined for each province in the study area using 6 different indoor temperature values given in Table 1.

Table 1

Recommended weekly base temperature for broiler chicken

Weeks	Base Temperature, ºC
1	31
2	27
3	25
4	23
5	21
6	18

The cumulative number of heating and cooling degree-days for a year using as the base temperature can be determined using the following equations 1 and 2; [2;5;7;13-15].

$$\text{For } (T_O < T_b),\ HDD = \sum_{i=1}^{n} (T_b - T_O), \tag{1}$$

$$\text{For } (T_O > T_b),\ CDD = \sum_{I}^{n} (T_O - T_b), \tag{2}$$

where HDD and CDD – cumulative sum of the heating and cooling degree-days for n days;
n – total number of days in the period;
T_b – base temperature recommended for broiler chicken;
T_o – mean outdoor air temperature.

These equations indicate that only positive values are summed.

Total Heating Degree-Day Number (*HDDN*) and Cooling Degree-Day Number (*CDDN*) can be determined using the following equations 3 and 4 [5;15].

$$HDDN = \sum_{i=1}^{n} HDD, \tag{3}$$

$$CDDN = \sum_{i=1}^{n} CDD, \tag{4}$$

where n – total number of days, which were *HDD* and CDD during the selected period.

Results and discussion

Cumulative heating and cooling degree-days reflecting six different base temperature values for the provinces located in the EuphratesBasin, which is the research area, are shown in Figure 1. These values were determined and prepared according to the equation described in the materials and method section. It can be said that the heating degree-day values increase more linear as the temperature values of the principal balance point increase. Moreover, it can also be said that the heating and cooling degree-day values of four provinces are different from each other. In a study conducted by Bulut et al. [1] it was stated that the heating and cooling degree-day values showed a linear increase dependently on the base temperature values. As a result of the calculations made for the provinces in the research area, the highest heating degree-day value was determined in Gaziantep, and the highest

cooling degree-day value was determined in Sanlıurfa. Bayram and Yesilata [16] stated that determination of the heating degree-day (HDD) and cooling degree-day (CDD) values for a specific region separately was important for determination of the capacity and cost of the heating and cooling systems. On the other hand, Ulupınar [17] stated that knowing the total number of heating or cooling degree-days was important for calculation of the energy needed to heat or cool the buildings.

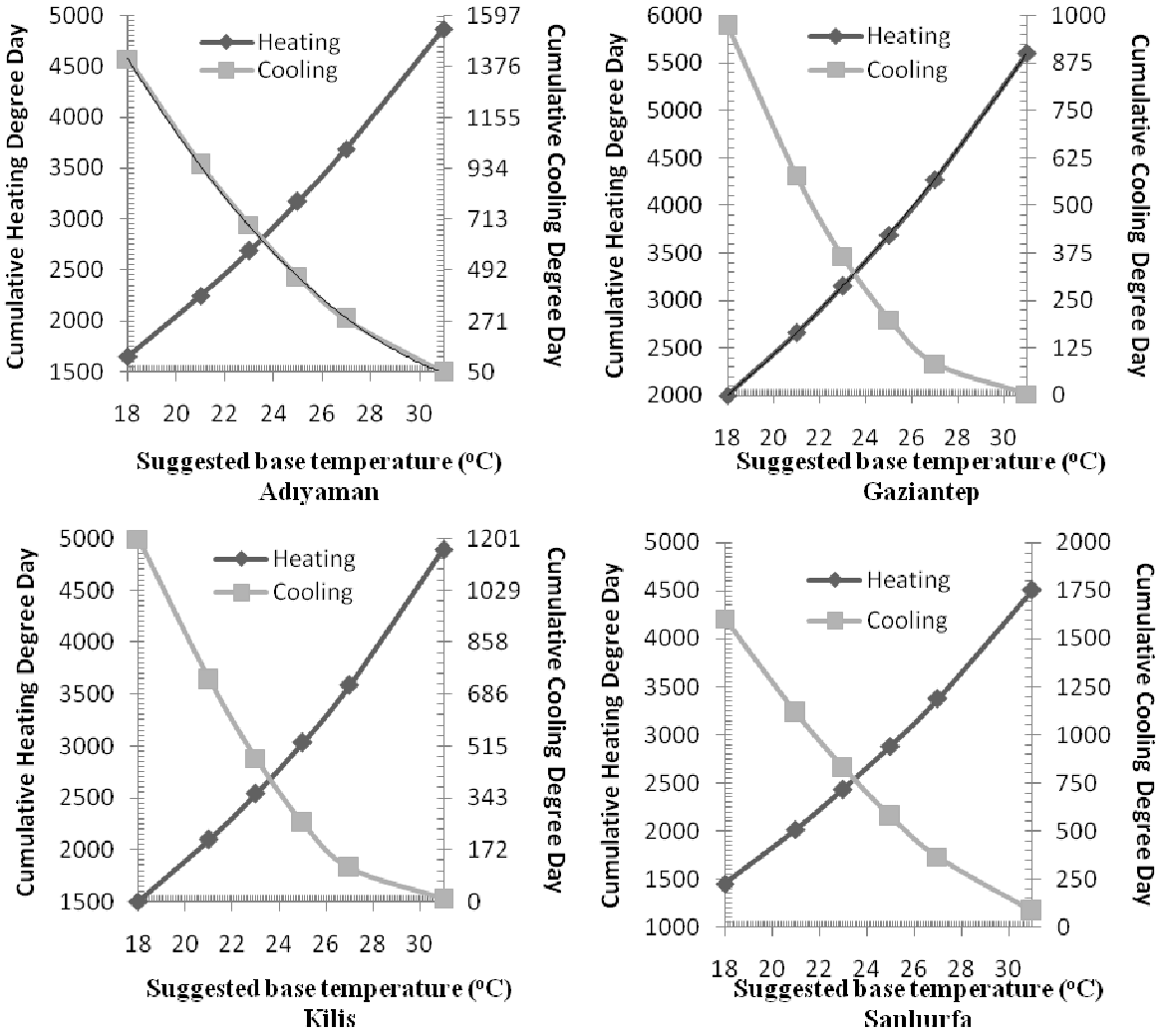

Fig. 1. **Number of cumulative heating and cooling degree-days according to the base temperature values**

The equations and regression coefficients of the relationships in the graphics obtained from six different base temperature valuesproposed for the production periods for the broiler breeding (independent variable), and cumulative heating and cooling degree-daysvalues (dependent variable) are given in Table 2. When Table 2 is examined, it can be seen that the regression coefficient (R^2) between the independent variable and dependent variable is 0.999 for all provinces, and there is a very strong relationship in a positive way. This shows that the independent variable in the equations given in Table 2 explains the dependent variable at a ratio of 99.9%. Therefore, it was thought that it could not explain only 0.1 % of the relationships between the independent variable and dependent variable and it was based on various factors (measurement errors, lack of meteorological stations installed in a suitable place, human factors, topography, etc.).

The number of the average annual heating and cooling degree-days for six provinces located in the research area based on six different base temperature values proposed for broiler breeding are shown in Figure 2. The highest amount of average heating degree-day numbers was determined in Gaziantep, and the highest amount of average cooling degree-daynumbers was determined in Sanlıurfa.

Table 2

Prediction equations and regression coefficients for cumulative heating and cooling degree-day values depending on the base temperature values

City	Degree-Day Variable (DD, °C*day)	Equation
Adıyaman	*HDD*	$= 277.8T^2 - 36.31T + 1695$
	CDD	$= 278.1T^2 - 19408T + 33694$
Gaziantep	*HDD*	$= 326.9T^2 - 792.9T + 18602$
	CDD	$= 326.9T^2 - 20151T + 31056$
Kilis	*HDD*	$= 380.9T^2 - 4400T + 39108$
	CDD	$= 380.9T^2 - 23759T + 37058$
Sanlıurfa	*HDD*	$= 273.3T^2 - 506.4T + 700$
	CDD	$= 273.3T^2 - 19864T + 35764$

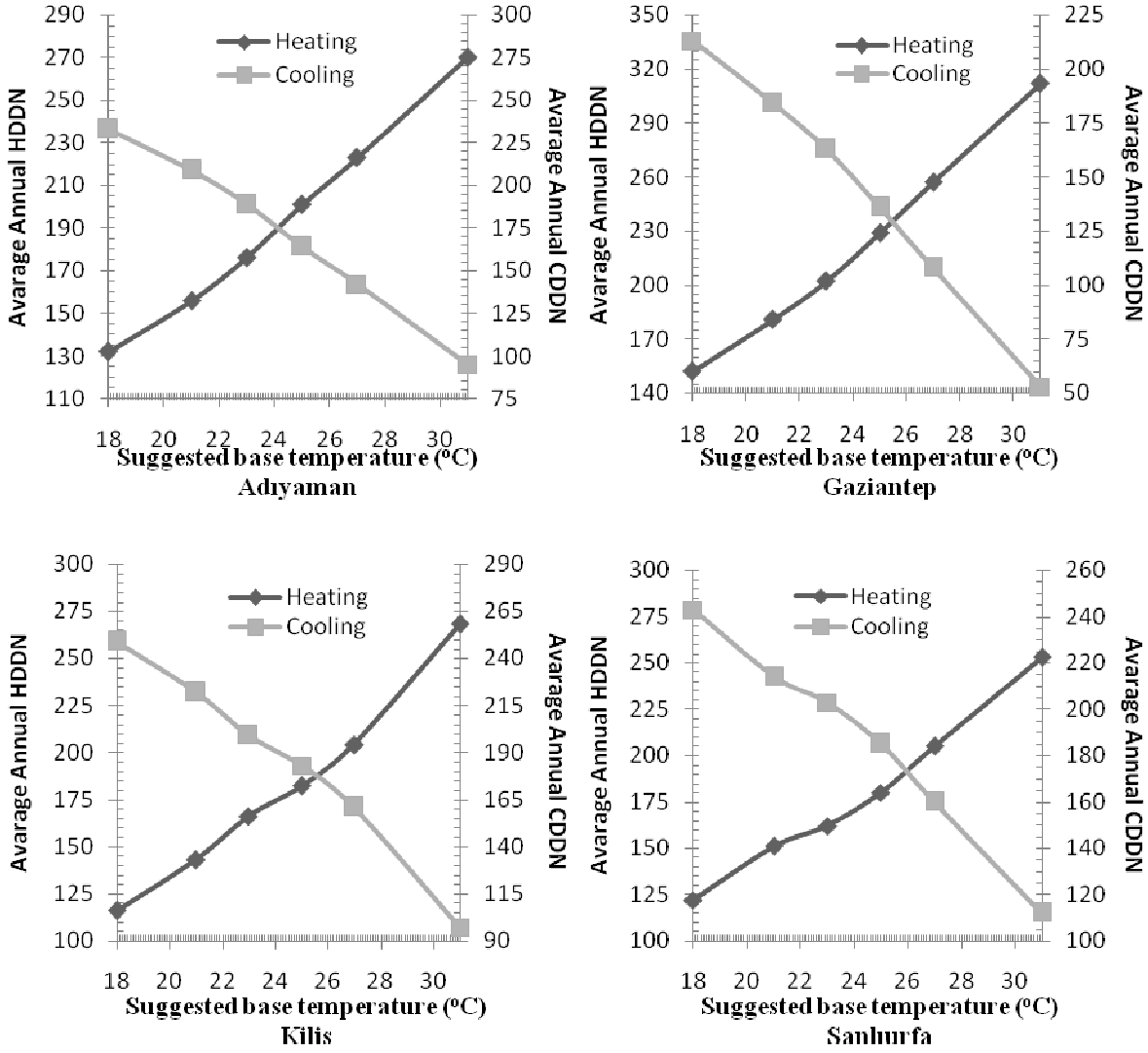

Fig. 2. **Number of average annual heating and cooling degree-day numbers according to the base temperature values**

The values showing the prediction equations and regression coefficients obtained from the graphics of the average annual amount of heating and cooling degree-daynumbers are given in Table 3. When Table 3 is examined, it can be seen that the regression coefficient (R^2) between the independent variable and dependent variable varies between 0.996 and 0.999 for all provinces, and there is a strong relationship in a positive way. This shows that the independent variable in the

equations explains the dependent variable at a ratio of 99.6-99.9%. So, it is understood that it could not explain only 0.1-0.4 % of the relationships between the independent variable and dependent variable.

Table 3

Prediction equations and regression coefficients for average annual heating and cooling degree-day numbers depending on the base temperature values

City	Degree-Day Number (DDN, day)	Equation	R^2
Adıyaman	*HDDN*	$= -0.169T^2 - 2.474T + 333.7$	0.998
	CDDN	$= 0.169T^2 + 2.474T + 31.23$	0.998
Gaziantep	*HDDN*	$= -0.231T^2 - 1.077T + 308.3$	0.999
	CDDN	$= 0.231T^2 + 1.077T + 56.69$	0.999
Kilis	*HDDN*	$= -0.337T^2 + 5.104T + 264.7$	0.996
	CDDN	$= 0.337T^2 - 5.104T + 100.2$	0.996
Sanlıurfa	*HDDN*	$= -0.246T^2 + 2.178T + 281.9$	0.996
	CDDN	$= 0.246T^2 - 2.178T + 83.07$	0.996

Conclusions

The amount of annual heating and cooling degree-days based on the six different base temperature values proposed for broiler breeding was determined for the Euphrates Basin based on the meteorological data for the 55-year period. The equations for the annual heating and cooling degree-days for each province in the research area were obtained, and the results were examined. It is thought that using the obtained data it will be possible to have prior knowledge about energy consumption for broiler breeding and have information on whether animal livestock will be suitable in terms of energy consumption. As a result, it can be said that the lower HDD and CDD values occur in any region, the less energy will be needed.

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