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Study on the Quantification of the Influence of the Temperature–Humidity Index (THI/ITU) on the Growth of Broiler Chickens in an Extensive (Household) System

By

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Abstract

Chicken meat is a valuable and essential food both on regular and festive menus. The aim of the paper is to establish practical measures and recommendations to be used by breeders to maximize economic efficiency. The paper traces the influence of the evolution of the temperature-humidity index (ITU) of the 45 days of the growth cycle in broiler households on welfare (health status) and growth performance (average daily gain). The simultaneous action of temperature and humidity on the thermoregulatory function of broilers, created a heightened thermal discomfort in each analyzed period. This discomfort was observed by decreasing the average daily gain, when the UTI values were very high (above 90%), or were low values (below 60%). For the spring period in Romania, the evolution of the growth rate of chickens in the household system is clearly economically satisfactory and has certain sustainability advantages in terms of feeding and waste recovery.

Key words*: *temperature-humidity index, average daily increase, well-being, sustainability of the activity

INTRODUCTION

In recent years, the global poultry meat market has been steadily growing. Particularly, chicken meat production continues to increase (Beck, 2022). In the European Union (EU) alone, approximately 6 billion broiler chickens are raised each year, representing 13.3 million tons of poultry meat (EFSA AHAW Panel, 2023). At the same time, consumers and non-governmental organizations, such as the 30 European organizations that have signed the European Broiler Commitment, are demanding higher standards for broiler production.

Under these circumstances, raising broiler chickens in household systems can contribute to meeting the growing demand while fully respecting welfare requirements and quality standards demanded by consumers. Moreover, by harnessing the beneficial influence of natural environmental factors, economic efficiency of production significantly increases while ensuring certain fulfillment of sustainability principles and environmental protection.

MATERIALS AND METHODS

The biological material consisted of 280 one-day-old Ross 308 broiler chickens (Figure 1).

Figure 1: Ross 308 Broiler Chickens (source: agroland.ro)

Source: Original photograph

To harness the beneficial action of natural airborne environmental factors, the chosen experimental growth period was from June 1st to July 15th, 2022.

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The experiment was conducted in a rural household located in the hilly area of Prahova County, Romania (Coordinates: 45°8′11″N 25°38′13″E), in a shelter with an area of 10 m². For the first week, protection and heating with a local source (infrared radiation heater) were provided for 4 m². After the first 10 days, artificial heating was discontinued, and the chicks were allowed to roam freely over the entire shelter area during the night and during the day in periods without significant precipitation, with direct access to a grassy courtyard (approximately 200 m²).

The experiment, lasting a total of 45 days, was organized into three distinct periods, commonly recognized in intensive broiler chicken production:

- June 1st-10th: starter period, during which the chicks received local air heating, ad libitum feeding with combined starter feed (produced by S.C. Metitex Agrofood), and continuous light exposure with an intensity of 20 lux.
- June 11th-30th: growing period, during which artificial air heating and artificial lighting were gradually discontinued over the first three days. Feeding continued ad libitum, transitioning gradually from combined growth feed to a mixture of grains and legumes (wheat+corn+pea), initially ground and then as whole grains.

July 1st-15th: finishing period, characterized by ad libitum feeding with a mixture of whole grains, with corn representing 50%. Throughout the entire period, the chicks were provided ad libitum access to drinking water using bell-type drinkers.

Figure 2: Chickens during the finishing period

Source: Original photograph

When calculating the Temperature-Humidity Index (THI), the relationship proposed by Drăghici C et al., 1991, adapted for broiler chickens, was utilized:

$$THI = 1{,}8\ t + 32 - (1 - R)\ (t - 15{,}5)$$

where:

t - the daily average temperature was calculated using the formula:

$$t = n - k\ (n - Min)$$

where:

n - the arithmetic mean of the absolute atmospheric temperature values obtained from readings taken at 8:00, 14:00, and 20:00,

Min - the minimum temperature during the diurnal interval.

The meteorological archive from the city of Câmpina was used as a source for these temperature values (https://rp5.ru/Arhiva_meteo_în_Câmpina).

k - an experimentally determined coefficient (research conducted by the National Meteorological Administration of Romania) for each calendar month and corresponding to each geographical area: June - 0.215; July - 0.217.

R - The average relative humidity was obtained based on hourly values recorded through direct measurement (objective) using a hygrograph (Figure 3) located in close proximity to the chickens.

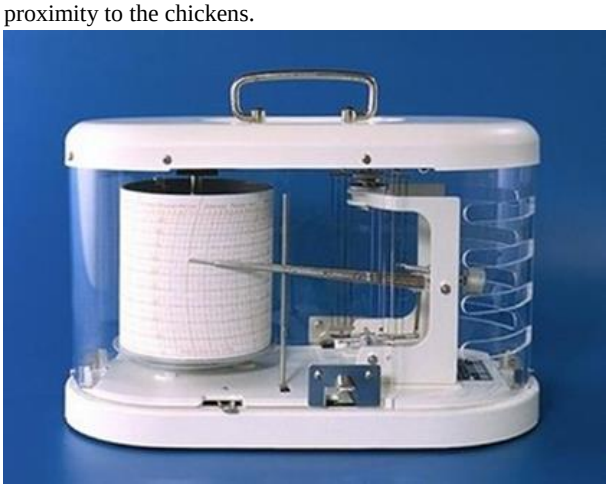

Figure 3: Weekly Hygrograph

Source: Original photograph

To monitor growth and quantify the influence of THI on the growth rate, the chickens were individually weighed on a daily basis, but without individual identification, using a kitchen scale with a precision of 1g (Figure 4).

Figure 4: Digital Electronic Scale

Source: Original photograph

The weighings were conducted every morning, before feeding and allowing the chicks to roam freely, as well as upon their

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manipulation from the shelter area for the night to the accommodation surface for the following time interval (during the first ten days). After handling the chicks, daily cleaning and necessary sanitation actions were also performed.

RESULTS AND DISCUSSIONS

The evolution of Temperature-Humidity Index (THI) values, as well as the daily average temperatures and relative humidity considered for the duration of the experiment, are depicted in Figure 5. Throughout the experiment period, the daily average air temperature varies relatively little, ranging between 19°C and 29°C, thereby aligning with the welfare requirements of broiler chickens (18...29°C), except during the starter period when local artificial heating with infrared radiation heaters is employed to meet welfare requirements (31-36°C). The diurnal average relative humidity exhibits significant and rather abrupt variations (from 35% to 100%) during the analyzed period, attributed to precipitation, significant evaporation, and rapid air mass circulation. The wide and abrupt variation in air humidity induces a similar variation in THI, ranging from 27% to 98%.

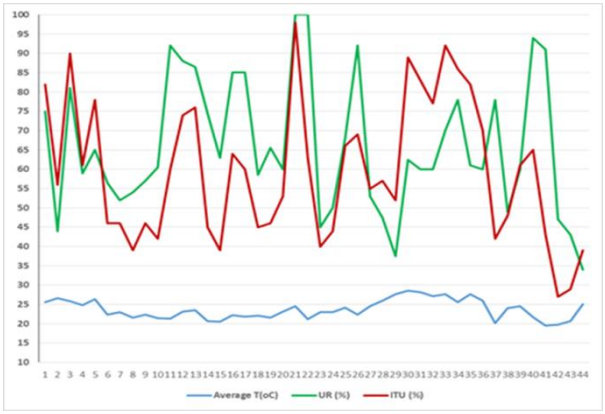

Figure 5: Evolution of Temperature-Humidity Index (THI), daily average temperatures, and relative humidity

Source: Own calculation.

Analyzing the daily evolution of the influence of THI (%) on the growth rate (g/day) during the Starter period (June 1st-10th, 2022) (Figure 5 and Table 1), we observe an upward trend in weight gain with a consistently increasing daily growth rate until the 6th day, a period when THI values are relatively within the comfort zone (60 – 90%) with relatively small variations from day to day.

Table 1: Evolution of Average Individual Weight (g) and Average Daily Gain (g/day) during the Starter period (June 1st-10th, 2022)

Day	1	2	3	4	5	6	7	8	9	10
Average Weight (g/chick)	47,9	50,1	53,6	58,4	65,1	73,7	83,8	94,9	103,2	115,3
Average Daily Gain (g/day/chick)	0,0	2,2	3,5	4,8	6,7	8,7	10,1	11,1	8,3	12,1
THI (%)	82	56	90	61	78	46	46	39	46	42

Source: Own calculation.

After the 6th day, there is initially a reduction in the growth rate of the average daily gain, which peaks on the 9th day with a significant decrease. We attribute this situation to a significant decrease in THI to values below 50% (even 39%) and stabilization in the discomfort zone for 5 successive days. On the 10th day, a significant upward trend in the average daily gain is observed, coinciding with the slight previous increase in THI towards the comfort zone. A time lag of approximately 24 hours in the depressive or positive influence can be observed, likely due to the time required for metabolizing and utilizing transformable energy, as well as the monitoring rhythm of growth evolution. Thus, the influence of low THI can be considered as growth stress for the analyzed period.

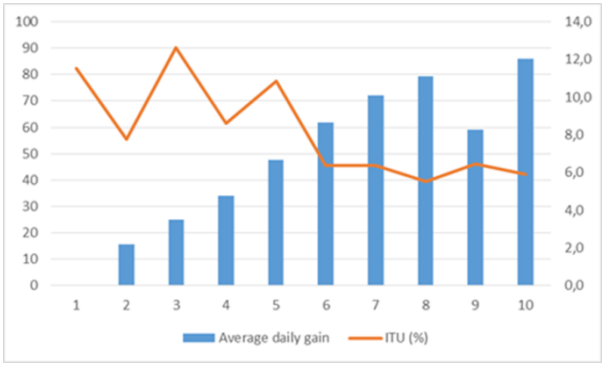

Figure 6: Influence of THI (%) on the growth rate (g/day) during the Starter period (June 1st-10th, 2022)

Source: Own calculation.

During the growth period, the influence of THI on the growth rate is significant (Figure 6; Table 2, Table 3):

- On days 11, 12, and 13, when THI is close to the comfort zone (60...76%), the daily average gain of the chicks tends to increase.
- On days 14 and 15, THI decreases to values of 45% and 39%, respectively, leading to a significant decrease in the daily average gain of the chicks (from 19.2 g/day to 15.9 g/day).
- From days 16 to 20, the daily average gain increases significantly, with variations ranging from 22.1 g/day to 38.3 g/day.
- A very important decrease in the daily average gain (from 35.4 g/day to 7.1 g/day) is observed on day 21, undoubtedly due to THI values of 99% on day 20 and 98% on day 21.
- On days 22 and 23, the calculated daily average gain increases significantly to 39 g/day, as THI decreases towards comfort values of 60...80%.

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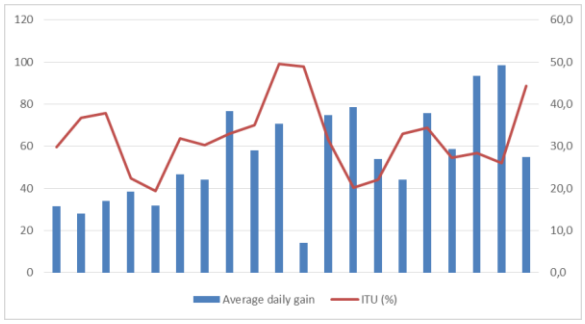

Figure 7: Influence of THI (%) on the growth rate (g/day) during the Growing period (June 11th-30th, 2022)

Source: Own calculation.

- Days 24 and 25 are marked by a decrease in the recorded gain (27 g/day and 22.1 g/day) due to the continued decrease in THI to values of 40% and 44%.
- On days 26, 27, 28, and 29, THI evolves towards welfare values (55-69%), resulting in achieving maximum values of daily average gain during the growing period (46.7 g/day and 49.3 g/day).

Table 2: Evolution of Average Individual Weight (g), Average Daily Gain (g/day), and THI (%) in the first decade of the Growing period (June 11th-20th, 2022)

Day	11	12	13	14	15	16	17	18	19	20
Average Weight (g)	131,0	145,0	161,9	181,2	197,1	220,4	242.4	280,8	309,8	345,1
Average Daily Gain (g/day)	15,7	14,0	16,9	19,2	15,9	23,3	22,1	38,3	29,0	35,4
THI (%)	60	74	76	45	39	64	60	66	70	99

Source: Own calculation.

Table 3: Evolution of Average Individual Weight (g), Average Daily Gain (g/zi), and THI (%) in the second decade of the Growing period (June 11th-20th, 2022)

Day	21	22	23	24	25	26	27	28	29	30
Average Weight (g)	352,2	389,5	428,7	455,7	477,8	515,7	545,1	591,8	641,1	668,5
Average Daily Gain (g/day)	7,1	37,3	39,2	27,0	22,1	37,9	29,4	46,7	49,3	27,4
THI (%)	98	63	40	44	66	69	55	59	52	89

Source: Own calculation.

- On the last day of the period, when THI again reaches a very high value (89%), a significant decrease in weight gain is observed, from 49.3 g/day to 27.4 g/day.

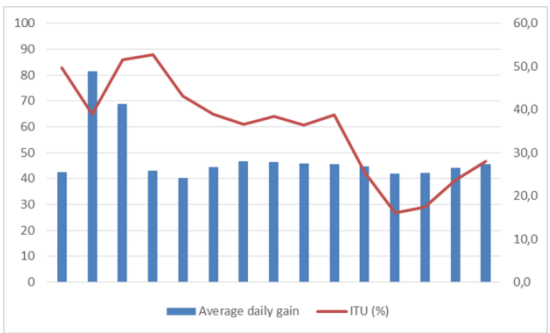

Figure 8: Influence of THI (%) on the growth rate (g/day) during the Finishing period (July 1st-15th, 2022)

Source: Own calculation.

During the finishing period, which coincides with the month of July, the evolution of THI influence on the growth rate of broiler chickens in household systems (Figure 7, Table 4) continued to exhibit similar patterns as in previous growth periods, at least in the first 5 days, leading to significant fluctuations in the daily average gain of the chickens. In the last 10 days of the experiment, the daily average gain stabilized around 27 g/day per chick, induced by a more stable THI value within the comfort zone (61-72%). In the last 5 days of the finishing period (days 41, 42, 43, 44, and 45), THI values decreased significantly to 27%-47%, but did not lead to a significant decrease in growth rate, probably due to the consolidation of the chicks' thermoregulatory function. It is noteworthy that in the last 10 days, the chicks were exclusively fed with a mixture of whole grains, with corn gradually increasing to 80%.

The average individual weights of the chicks ranged from 549 g to 1770 g, with an average weight of 1102 g achieved over 45 days.

Table 4: Evolution of Average Individual Weight (g), Average Daily Gain (g/day), and THI (%) during the Finishing period (July 1st-15th, 2022)

Day	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Average Weight (g)	693,9	742,9	784,1	809,9	834,0	860,6	888,6	916,4	943,9	971,2	998,1	1023,2	1048,5	1074,9	1102,2
Average Daily Gain (g/day)	25,5	48,9	41,3	25,8	24,1	26,6	27,9	27,8	27,6	27,3	26,9	25,1	25,3	26,4	27,3
THI (%)	83	65	86	88	72	65	61	64	61	65	43	27	29	39	47

Source: Own calculation.

CONCLUSIONS

Temperature and humidity are two critical factors in raising chicks in a household. These factors influence the health, behavior, and productive performance of the chicks, significantly impacting their growth and development.

By closely monitoring the Temperature-Humidity Index (THI) over the course of 45 days, during which the broiler chickens were monitored, the following conclusions can be drawn:

- The simultaneous action of temperature and humidity on the thermoregulatory function of broiler chickens created significant thermal discomfort in each analyzed period. This discomfort was observed through a decrease in the average daily gain when THI values were very high (over 90%) or low (below 60%). Although artificial heat sources were used in the first 10 days to meet temperature requirements due to minimal or almost nonexistent equipment in the household system, external temperature and humidity still had an influence that could not be neglected on the actual temperature felt by the chicks.
- It was observed that the influence of THI led to an imbalance in the growth of more sensitive chicks, slowing down their growth or even causing weight loss.

Chicks that start to lose weight have a high mortality rate.

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- In the last analyzed period, the finishing period, a clear balance in the growth rate was observed, reducing the influence of THI.

In general, the growth rate of chicks in the household system is economically satisfactory and has several advantages worth mentioning:

- During the first two weeks of life, chicks require a small space where an appropriate microclimate can be achieved with minimal costs.
- Feeding is also done with reduced costs if the recipes are balanced and supplemented with household food scraps (green fodder). Knowing the nutritional needs of broiler chicks, as recommended by the genetic material producer, will result in healthy growth even over a relatively longer period (6-8 week growth cycle).
- The control we have over the entire growth process allows us to adapt chick growth according to the resources and specific needs of the household.
- The poultry meat obtained in this way represents a source of high-quality, tasty, and healthy food for the entire family and beyond, at a relatively low cost, especially if the household can produce cereals through cultivation.
- The investments and expenses required are minimal and involve the purchase of biological material (day-old chicks), the arrangement of the shelter (coop and pen), the procurement of combined feed for the starter period, and possibly the preparation of the cereal mixture required during the growing period.
- The waste (feces) resulting from the growth process represents a valuable resource for organic fertilizer through composting, mixed with other biomass sources from the household.
- Labor is provided by individuals within the household (family members).

Based on the conducted study, several practical recommendations can be outlined:

- Seasonal planning of the growth period to overlap with periods of the year where the actual air temperature felt by the chicks closely matches their average temperature requirements, specifically spring-summer and summer-autumn.
- Adequate preparation of the space where the broiler chicks will be raised by constructing or arranging a suitable shelter that provides protection against external factors (predators, precipitation, strong air currents), as well as sudden and significant temperature drops.
- Ensuring sufficient space for the number of chicks to be purchased to provide housing area that respects their behavioral welfare.
- Selection of biological material by purchasing from reliable sources, ensuring that the chosen chicks are healthy and from quality genetic lines. Consider opting for broiler breeds adapted to local conditions and with good growth rates.
- Feeding should be done with specific high-quality feed for broiler chicks that meet their nutritional needs in all three stages of growth. Choose between recommended commercial feed or prepare feed at home using locally available cereals and other ingredients (soybean/sunflower meal, peas, etc.).
- Maintaining high hygiene standards in the chick-rearing area through regular/permanent cleaning and washing, especially of feeding and watering surfaces, to prevent the onset and transmission of diseases and podal disorders.
- Monitoring and managing growth by tracking body weight and growth rate, ensuring adequate food quantities according to their needs, and constant access to clean and fresh water.
- Choosing the optimal time for slaughtering the broiler chicks based on desired weight and family and market demands, ensuring slaughter is done hygienically and in compliance with regulations.

It can be concluded that the household broiler chick-rearing system, despite being significantly influenced by natural factors, offers the possibility of obtaining high-quality meat with good economic efficiency and full sustainability regarding feeding and waste management.

Figure nr. 8: Oven-baked chicken dish

Source: Original photograph

Nevertheless, it should be noted that this type of growth requires proper preparation, constant monitoring, and careful management of aspects related to maintaining the health and welfare of the chicks.

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