

The Effects of Harvested Rainwater on the Performance and Some Slaughter Parameters of Broilers[&]

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Abstract

This study was organized to examine the effects of the use of rainwater lost from roofs as the water source for broilers on the performance and some of the basic carcass and meat quality parameters. In the research, day old 96 Ross 308 broiler chicks were used. In the experiment, the birds were separated to two treatment groups and the birds given harvested rainwater were distributed to 4 pens and the birds given deep-well water were kept in other 4 pens in the research house. Performance criteria were analyzed from birds with mixed sex, where the carcass and meat pH were analyzed from the data obtained from male broilers. According to the findings obtained from the research, there was no statistically significant difference between the groups in terms of feed consumption, water consumption, live weight, live weight gain and feed conversion ratio. Also, there was no significant differences between the groups in terms of edible internal organs and meat pH as well ($P>0.05$). According to the results of the experiment, it can be stated that harvested rainwater can be used as a substitute for deep-well water and causes no change in terms of performance and carcass characteristics. It is thought that organizing detailed studies including economics and animal health will be positive in terms of academic knowledge and industry soon.

Key words: Harvested rainwater, broiler, performance, meat quality, edible giblets

Hasat Edilmiş Yağmur Suyunun Etlik Piliçlerde Performansa ve Bazı Kesim Parametrelerine Etkileri

Öz

Çatılardan kaybolan suların etlik piliç yetiştiriciliğinde kullanılma olanaklarının performansa ve temel karkas ve et kalite parametrelerinden bazılarına etkilerini incelemek amacıyla bu çalışma düzenlenmiştir. Araştırmada, 96 adet günlük yaşta Ross 308 etlik piliç civcivi kullanılmıştır. Hasat edilmiş yağmur suyu verilen 4 ve kuyu suyu verilen 4 bölme olarak düzenlenmiş olan denemede karışık cinsiyetten etlik piliçlere bakılmış, performans kriterleri bu veriler üzerinden; karkas ve et kalite parametreleri de erkek piliçler üzerinden incelenmiştir. Araştırmadan elde edilen bulgulara göre, performans kriterlerinden yem tüketimi, su tüketimi, canlı ağırlık, canlı ağırlık artışı ve yem dönüşüm oranı verileri bakımından gruplar arasında istatistik açıdan önemli bir farklılığa rastlanmamıştır. Bununla birlikte karkas özellikleri, yenilebilir iç organlar ve et pH'sı bakımından da gruplar arasında önemli bir farklılık tespit edilmemiştir ($P>0.05$). Deneme sonuçlarına göre, yağmur suyunun kuyu suyuna ikame olarak kullanılabilmesi, performans ve karkas özellikleri bakımından herhangi bir farklılığa neden olmadığı ifade edilebilir. Bununla birlikte, ekonomiklik, hayvan sağlık durumunu da içine alan ayrıntılı çalışmaların düzenlenmesi akademik bilgi ve sektör açısından olumlu olacaktır.

Anahtar kelimeler: Hasat edilmiş yağmur suyu, etlik piliç, performans, et kalitesi, yenilebilir iç organlar

Introduction

Chicken meat production and consumption has increased rapidly both in the world and in our country in recent years compared to previous years. Annual chicken meat consumption in Turkey vary according to zone, yearly income status, marital status, living in a rural or urban and consumers' lifestyle, is reported to be 22 kg per capita (Anonymous, 2020b).

It is important to provide fresh, clean water freely to the birds in production in order to achieve the desired performance in broiler breeding. (Leeson and Summers, 2008).

In our daily life, drinking and utility water is obtained from underground sources, natural and artificial lakes, rivers, wells and, although it is expensive in terms of making it usable, by treating sea water in some compulsory cases. However, the most important of these water resources we have mentioned is precipitation falling on the earth (Bayramoğlu et al., 2013).

Water is the most critical nutrient in chicken breeding to meet the needs of animals and to gain mass by utilizing the optimum amount of feed. As it is known, water is the largest component of the body and constitutes approximately 70% of the total body weight. The water content in the body is directly related to the protein content. As the animal ages, the amount of fat in the total weight gained increases and the percentage of water in the total body weight decreases. Poultry obtain this amount by drinking water, feed, and catabolism of body tissues as a natural part of growth and development. (Leeson & Summers, 2008; Eleroğlu and Sarıca, 2004).

Actually, there are two solutions to ensure the sustainability of fresh water consumption in terms of physical alternatives, as the existing fresh water resources are rapidly polluting and depleting. First is to find alternative or additional water resources that are currently being used. Second is to use the limited amount of water resources more effectively and efficiently. The collection and reuse of rainwater from rainfall surfaces is one of these methods. This method used is called rainwater harvesting. Rainwater harvesting is an important development among the methods performed at lower costs recently (Tari, 2009; Örs et al., 2011; Silkin, 2014).

Harvested rainwater is used in some skyscrapers for grey water (usage water in sinks and lavatories) in high populated cities, some animal farms breeding cattle and swine for cleaning water which is needed in great mass in some countries. Therefore great savings are made

in terms of water and budget. Different countries are trying to implement different methods, laws and supports in order to ensure and spread the use of rainwater harvesting (Karahan, 2011; Şahin and Manioğlu, 2011).

Rainwater falling on the roof surface is transferred to the water tank located on the ground surface or to water tanks located or built underground through the grooves on the structure and stored. Storage structures are usually made of plastic, fiberglass, concrete or stainless steel (Kantaroğlu, 2009). Rainwater can be used to serve different purposes by harvesting from building roofs or harvesting from other surfaces. It can be used as domestic water (cleaning, shower, bath, sink, etc.) in houses, as irrigation water in plant breeding, in watering in animal breeding, in areas such as disinfection of facilities (Alparslan et al., 2008).

The surface where rainwater is collected is called the collection surface. Building roofs, balconies and courtyards have the most suitable surfaces to collect rainwater, so rainwater can be collected from these areas. The systems direct the rainwater collected from the roofs, balconies and similar surfaces of the buildings to the rain water collection tank. The most preferred building materials for rain gutters are galvanized steel, vinyl, aluminum and PVC, which is frequently used today. Leaf and sand holder filters prevent leaves or larger materials brought by rainwater from the collection surfaces from entering the gutters. All of the rainwater coming to the filters from the collection areas cannot be transferred to the tanks, but more than 90% can be transferred. This transfer rate varies according to the filter quality and efficiency. Leaf catchers used in transfer hold the leaves and leaf fragments brought by the rainwater, while other filters in the gutters lubricate the smaller pieces and thus enable cleaner rainwater to be transmitted to the storage tanks (İncebel, 2012).

The rainwater is collected from the rainwater tank with sieves and separator materials by flowing from the collection areas. It is important to keep the harvested water at an appropriate temperature to reduce bacterial growth. For this reason, storage tanks are usually installed under the ground close to the buildings (İncebel, 2012).

Rainwater harvesting system, as data of the rainfall capacity of Turkey as seen in Figure 1 illustrates that it is particularly suitable for poultry production in relation to rainfall patterns. The precipitation rate per square meter is particularly high in mountainous coastal areas (1,000-2,500 mm/year), and as we continue towards inland, the precipitation rate per square meter decreases as

seen in Figure 1. The need for water used as irrigation water has recently increased to a considerable amount and has become an important issue in terms of the reduction and disappearance of non-renewable scarce resources both in economically and environmentally. For this reason, efforts to bring the wastewater, which are currently tried to be reused in some communal living areas, to be used by people by recycling are

currently very insufficient. When these situations are taken into consideration, it is obvious that the water obtained with rainwater harvesting in regions where the rainfall regime is suitable together with other water obtaining methods used will provide high benefits both economically and environmentally (Tanık, 2017).

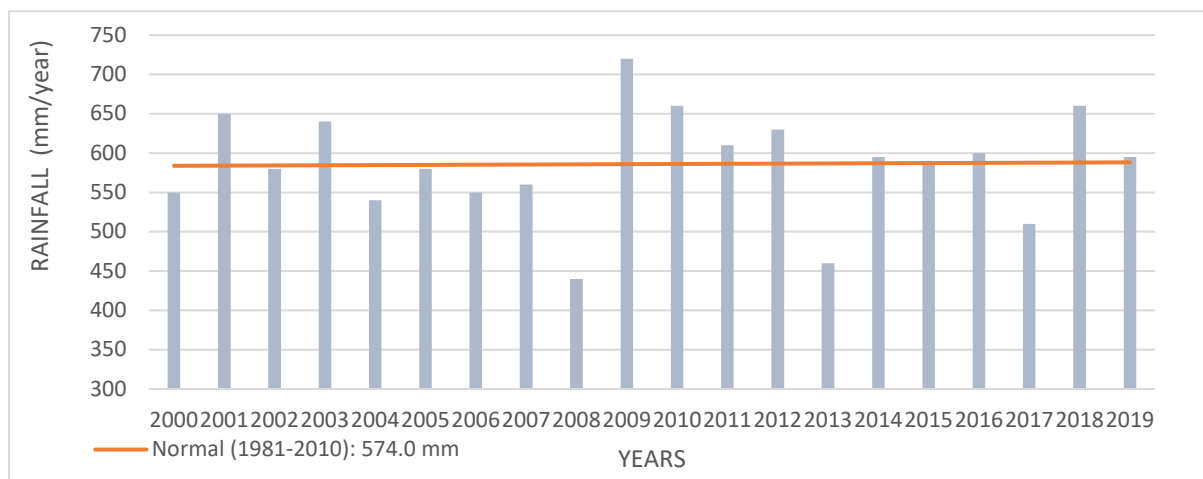


Figure 1. Rainfall in Turkey for the years 2000-2019 (Anonymous, 2020a)

Material and Methods

Water Material

In the research, two groups were used as drinking water, deep well water (75 m) and harvested rainwater (from rooftop). The water resources were previously analyzed by provincial directorate of agriculture laboratories with standard methods and found to be within acceptable limits in terms of nitrate, nitrite and other heavy metals and not containing any bacteria and coliforms, conclusively found to be drinkable.

Live Material

The live material of the experiment was composed of Ross-308 broiler chickens of mixed sex obtained from a private sector company founded in Bolu province. The trial layout was divided into two groups using harvested rainwater (R) and well water as the control group (C), and each group had a total of four trial pens and a total of 96 chicks with 12 chicks in each pen with actual rearing conditions. In order to compensate deaths for acquiring the actual stocking density, 12 chicks were kept ready to be used in the experiment in a separate compartment under the same conditions for R and C.

Feed Material

Broiler chick feed between days 0-10, grower feed between days 11-21, finisher feed

between days 22-35 days and pre-slaughter diet was used in the last week before slaughter (days 36-42). The chemical composition of the feeds used during the trial is given in Table 1.

Rearing Conditions

The experiment was carried out in the trial unit of Bolu Abant İzzet Baysal University, Faculty of Agriculture, Department of Poultry Science. The research and development house is 60 m² in size, and it is a prefabricated building insulated with sandwich panel. It has automated ventilation, heating, cooling and lighting system. For heating electric radiators (Flavel R 3000, Turkey) were used, for ventilation two 1100 m³/hour capacity minimum ventilation fans (Gardener BPP 30 Turkey) and for cooling 4000 m³/hour capacity (Gardener BSM 400, Turkey) fan was used. For illumination, 9-watt LED bulbs with 6500 lumens lighting capacity were used right above each pen. The building has been designed in a way that fully meets the industrial conditions. 3 broiler (broiler) nipple drinkers attached to a 50 cm nipple pipe as a drinker were organized separately for each compartment. Separate water tanks with a capacity of 20 liters were placed in each compartment and the water was refreshed daily and as needed. Each time the water was added, the consumption amount was recorded. 10kg capacity bucket type hanging feeders were placed

separately in each compartment. During the process of adding the feed daily, the consumption amount was calculated. A digital precision balance with ± 1 mg precision was used for weighing feeds and animals (Radwag AS220R2, Poland).

The pens in the house were 2 * 2 m in width and 1.25 m high, with doors 0.75 m - 1.25 m in size and were surrounded by steel wire mesh (chicken wire). The chicks were placed in these pens randomly in order to ensure that the animals from the experimental and control groups had

equal conditions. Also it was ensured that the animals from both groups were evenly distributed in the house considering fan side, entrance door side and north and south sides of the house. Sawdust of suitable size was used as litter material. The house and the equipment were disinfected properly before the trial period to avoid any health problems.

Table 1. Chemical composition of the feed materials used in the trial.

	Chick	Starter	Finisher	Pre-slaughter
Crude Protein (%)	22.49	21.53	19.25	17.97
Crude Cellulose (%)	3.00	3.00	2.72	2.93
Crude Fat (%)	6.11	8.10	7.89	8.26
Crude Ash (%)	4.38	4.27	3.36	3.21
Calcium (Ca)	1.00	0.93	0.64	0.60
Total Phosphorus (P)	0.73	0.70	0.52	0.53
Sodium (N)	0.19	0.18	0.22	0.19
Lysine (%)	1.56	1.44	1.23	1.17
Methionine (%)	0.78	0.58	0.50	0.53
Vitamin A (IU)	12500	10000	5000	5000
Vitamin D3 (IU)	5625	4500	2250	2250
Iron (Ferrum Sulphate Monohydrate %30, mg)	20	20	15	10
Copper (Copper Sulphate Pentahydrate, mg)	16	16	12	8
Zinc (Zinc Oxide %72, mg)	110	110	83	55
Manhane (Mangane Oxide %62, mg)	120	120	90	60
Iodine (Calcium iodide %10, mg)	1.25	1.25	0.94	0.63
Selenium (Sodium selenite %4,5, mg)	0.30	0.30	0.25	0.15

Equipment Material

The wing numbers were used to get data individually from the birds (National Band & Tag, Zip 890, USA). Special plier (National Band & Tag, Zip 890S HD) was used. Numbering was done in the first arrival of the chicks. Water storage containers of 20 liters are used in a way that they can be connected to nipples. Drinkers had the opportunity to be adjusted in height (Day-Tav Nipples suluguni Broiler, Turkey). 8 kg hanging feeders were used as feeders (Day-Tav Hanging feeders 10 kg Turkey). Digital precision scales were used to weigh both the feed to be given and the animals routinely (Radwag AS220R2, Poland). Glass probe pH probe (WTW Sentix 31, Germany) pH meter was used (WTW 3110, Germany) to measure the hot and cold pH of meat of the birds slaughtered in the experiment in the industrial plant.

Methods

The chicks obtained from the company, providing the live and feed material for the study

were transferred to the house where the trial was carried out. Following weighing and numbering they were placed in the previously prepared pens. Well water was filled in four of the 20-liter water containers connected to the drinkers in the pens and rainwater was filled in the other four. After the labeling process, 5 kilograms of broiler starter feed was added to the hanging bucket type feeders in the compartments, and the necessary lighting and ventilation systems were arranged.

Body weight and water consumption data were measured at 1, 2, 3, 4, 5 and 6 weeks. Mortality was determined daily and replaced from a backup pen with similar conditions to keep stocking density effect stable on trial material. The daily feed and water consumption of the chicks were determined as a group and birds were individually weighed and recorded on a weekly basis.

At the end of the 6th week, live weights were taken and slaughtered by subjecting to the halal standard slaughter procedure in the slaughter unit of the company. After the blood flow of the

slaughtered animals was completed, the head, internal organs and skin were separated from their carcasses and the carcass weights, and then the heart and gizzard weights were measured and recorded individually. After the weight determination, from the thigh and breast pH values were measured and recorded with a digital pH meter (WTW 3110, Germany) after slaughter (hot carcass) and 24 hours later (cold carcass).

Harvesting of water was done from a galvanized steel roof with the help of plastic pipes and stored in a tank of 1 ton volume. The water stored was filtered with standard dust filter after application of UV lighting for 30 minutes.

Statistical Analyses

The study was designed by randomized plot trial plan. Collecting all data and making sure

that they are homogeneous. After performing homogeneity tests (skewness and kurtosis analysis followed by the Shapiro-Wilk test), statistical analyses were performed using ANOVA method and Tukey test with SPSS 22 software (SPSS 2013, USA). The findings were shown as means \pm standard error of the means (SEM).

Results and Discussion

In order to find if harvested rainwater has an effect on performance and some carcass characteristics in broiler rearing; weekly feed, water, individual water, individual feed consumption and weekly feed conversion rates were compared in broilers slaughtered 42nd day (Table 2).

Table 2. The effect of deep well (DW) and harvested rainwater (HR) use on performance in broilers.

Week		1	2	3	4	5	6
Performance Criteria							
Live Weight (g)	DW	169.896 \pm 2.780	430.088 \pm 13.500	973.513 \pm 22.500	1498.575 \pm 53.600	2229.585 \pm 63.800	2883.585 \pm 47.600
	HR	166.500 \pm 2.970	443.981 \pm 6.560	1058.777 \pm 34.700	1514.450 \pm 13.800	2221.931 \pm 20.300	2891.548 \pm 35.300
	P	0.436	0.389	0.085	0.784	0.913	0.898
Weekly Live Weight Gain (g)*	DW	119.896 \pm 2.780	260.192 \pm 13.100	543.425 \pm 20.600	525.063 \pm 55.200	731.010 \pm 32.200	654.000 \pm 86.600
	HR	116.500 \pm 2.970	277.481 \pm 4.460	614.796 \pm 30.400	455.673 \pm 42.300	707.481 \pm 9.280	669.617 \pm 31.900
	P	0.436	0.258	0.100	0.357	0.509	0.871
Weekly Feed Consumption (g)	DW	2500.000 \pm 0.000	6487.500 \pm 94.400	13987.500 \pm 68.800	25075.000 \pm 274.000	39200.000 \pm 862.000	53450.000 \pm 994.000
	HR	2500.000 \pm 0.000	6600.000 \pm 106.000	14125.000 \pm 231.000	26125.000 \pm 1401.000	40000.000 \pm 1405.000	53500.000 \pm 1871.000
	P	1.000	0.458	0.590	0.490	0.645	0.982
Weekly Water Consumption (ml)	DW	6125.000 \pm 315.000	16375.000 \pm 898.000	32375.000 \pm 1248.000	59250.000 \pm 1665.000	88500.000 \pm 1860.000	119500.000 \pm 2300.000
	HR	5450.000 \pm 210.000	17700.000 \pm 1175.000	33700.000 \pm 1175.000	60975.000 \pm 1874.000	89725.000 \pm 2022.000	120725.000 \pm 2419.000
	P	0.125	0.405	0.469	0.517	0.671	0.726
Individual Feed Consumption (g)	DW	208.333 \pm 0.000	336.111 \pm 7.860	625.000 \pm 5.890	912.500 \pm 26.700	1152.778 \pm 49.200	1222.222 \pm 39.900
	HR	208.333 \pm 0.000	336.111 \pm 8.840	636.111 \pm 17.500	1055.556 \pm 120.000	1152.778 \pm 35.600	1111.111 \pm 53.800
	P	1.000	0.458	0.746	0.459	0.743	0.387
Individual Water Consumption (ml)	DW	510.417 \pm 26.200	854.167 \pm 52.400	1333.333 \pm 48.100	2239.583 \pm 42.900	2437.500 \pm 62.500	2583.333 \pm 48.100
	HR	454.167 \pm 17.500	1020.833 \pm 92.400	1333.333 \pm 34.000	2272.916 \pm 80.900	2395.833 \pm 39.900	2583.333 \pm 58.900
	P	0.125	0.168	1.000	0.728	0.595	1.000
Feed Conversion Ratio	DW	1.227 \pm 0.020	1.260 \pm 0.034	1.199 \pm 0.024	1.400 \pm 0.058	1.469 \pm 0.056	1.545 \pm 0.019
	HR	1.252 \pm 0.022	1.239 \pm 0.017	1.114 \pm 0.028	1.436 \pm 0.065	1.500 \pm 0.047	1.541 \pm 0.038
	P	0.433	0.599	0.061	0.695	0.689	0.929

When the data obtained were examined, close numeric body weight and weekly live weight gain were detected between chickens raised with harvested rainwater and chickens raised with deep-well water where water consumption was also found to be parallel.

Live weight (LW) values obtained from the study (Table 2) are in parallel with the LW values they obtained by breeding Hybro broiler genotypes in the studies (Vedet, and Anak 2000; Yetişir et al., 1994) for 7 weeks, respectively 2211.9, 2095.2 and 2048 g. Although Yıldız and Özbey (2000) reported in their studies on the Ross 208, Ross PM3 and Hybro genotypes, it was found to be lower than the LW values our trial. It is thought that the reason for the high LW values of trial data is due to the different line used (Ross 308) and good management. On the other hand, in the studies conducted by Sarıca (1997) with the Ross PM3 genotype, the results of the trial were found to be lower than the 2970.66 and 3516.35 g LW values reported at 7th week, and this difference is thought to be due to the slaughter age difference.

The weekly live weight gain (WLWG) data obtained from the trial groups are similar to the 118.2, 242.7, 433.02, 525.3 g values reached by Çetin and Yıldız (2017) and was found to be lower than the LWG values reported by Altan et al. (1989). The reason for the low LWG findings obtained in the trial is that Altan et al. (1989) has been using continuous lighting and the feed consumption of animals was higher during the rearing period.

The individual feed consumption amounts (IFC) obtained in the trial performed are similar to the values reported by Karaman and Öcal (2018) and the data reported by Öztürk and Sarıca (1999) in their study. Since the stocking density used by the researchers was higher than our trial, it is thought that the data obtained from LWG was slightly higher.

Individual water consumption (IWC) was found to be higher than the weekly 795.2 ml water consumption data reported by Winchell W (2001), and the reason for this is thought to be due to the application of water restriction in the researcher's study. It was determined that the 2450 ml water consumption findings of Lott (1991) reached in the research findings were higher than the trial findings. The difference was probably arising from the high environmental temperature used by the researcher in his study.

Katelaars (1984) reported the feed conversion rate (FCR) as 1.90. These findings reported by the researcher do not correspond to the findings obtained in the experimental groups. It is estimated that the reason for the

inconsistency of the trial findings with the findings of the researcher was due to the high quality of management and stable and good environmental conditions in the study. On the other hand, Viktor et al. (1979) had 1.52 FCR and İşcan (1996) 1.59 which are similar to the findings of the research.

In the trial, weekly body weight, slaughter weight, carcass weight, breast and thigh pH and edible giblets' (heart, gizzard) weights were determined and compared between the groups in order to examine the carcass characteristics and meat quality (Table 3 and Table 4).

Table 3. The effects of using deep well (DW) and harvested rainwater (HR) in broilers to some carcass parameters.

Meat Quality Criteria		
Carcass Weight (g)	DW	2360.000 ± 60.500
	HR	2297.500 ± 61.200
	P	0.508
Heart Weight (g)	DW	15.667 ± 0.833
	HR	13.667 ± 1.420
	P	0.292
Gizzard Weight (g)	DW	43.667 ± 2.240
	HR	47.000 ± 1.730
	P	0.305
Heart / Carcass (%)	DW	0.663 ± 0.021
	HR	0.593 ± 0.047
	P	0.240
Gizzard / Carcass (%)	DW	1.857 ± 0.140
	HR	2.047 ± 0.079
	P	0.302

As the data obtained from the experimental groups were analyzed, carcass weight (CW) values among the meat quality parameters were determined as 2360 g in birds given well water and 2297.5 g in birds given harvested rainwater. The research data obtained from İşcan et al. (1996) has been found to be higher than the 1365 and 1374 g data reported. The fact that the trial data is higher than the data of other researchers is predicted to have been caused by the lighting restriction practices in the trial studies of the researchers and the animals slaughtered in our study being males.

Heart and gizzard weights reported as 14.6 and 29.0 g, respectively in a trial done by Sarıca et al. (2014). From these findings, it was determined that the heart weight was similar to the heart weight obtained from the groups in the trial, and the gizzard was found to be lighter. The high weight of gizzard obtained in the trial should be as a result of slaughtering males. On the other hand, Şahin et al. (2020) reported heart and gizzard weights were 13.3 and 32.2 g, respectively, lower than of the data obtained from the trial. The

difference is thought to be arising from the fact that data collection and analyzes were carried out on male animals after slaughter and that other researchers used mixed sex live material.

The ratio of heart to carcass reported by Başer (2006) in the research findings is 0.67% similar to the findings obtained from the groups without trial, but the rate of gizzard to carcass reported 3.08% was higher than the trial data. On the other hand, it was determined that the heart and gizzard rate data reported by Üzüm (2011) were lower than the data obtained from the trial, 0.53% and 1.38%, respectively. It is thought that the differences in these two studies were higher or lower than the findings obtained from the experimental groups due to the use of restricted lighting applications.

Table 4. The effects of using deep well (DW) and harvested rainwater (HR) in broilers to breast and thigh meat pH in hot and cold carcasses.

Meat pH		Hot Carcass	Cold Carcass
Breast pH	DW	6.081 ± 0.032	5.785 ± 0.076
	HR	5.893 ± 0.091	5.865 ± 0.021
	P	0.125	0.335
Thigh pH	DW	5.825 ± 0.040	5.945 ± 0.016
	HR	5.885 ± 0.048	5.948 ± 0.016
	P	0.538	0.885

Breast and thigh pH values obtained from the experiment groups were similar to the data reported by Yetişir et al. (2008) as pH value of 5.80 for breast and 6.40 for thigh, and of Sarıca et al (2014) reported thigh pH value as 5.90 and breast pH value as 5.89. This similarity also supports the suitability of slaughtering and post-slaughter processes were in place.

Conclusion

In the study, it was determined that broilers raised with harvested rainwater and with well water exhibited similar values in terms of live weight and weekly live weight gain, carcass weight like the pH values in thigh and breast meat.

In the light of these findings, it can be told that the harvested rainwater can be used as an alternative to well water, which is widely used in broiler breeding, without adverse effects on performance and meat quality in general.

Especially in regions with abundant rainfall, where it is difficult to obtain well water and lack of water due to drought, harvested rainwater can be used as drinking water in broiler

rearing also thought to be economically beneficial by reducing electricity and other maintenance costs.

When all the findings are examined in general, it can be said that harvested rainwater can be used as drinking water in broiler breeding in terms of performance, inspected carcass and focused meat quality parameters. It has been found that there are very few and limited studies on this subject. It is considered and recommended to conduct more comprehensive new studies, including the health status, internal organ microbiology and economy level of the harvested rainwater with more detailed and higher quantity live material, taking into consideration of the findings of this study.

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