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The Study of Water Quality in Poultry Farms in Ardestan, Iran

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ABSTRACT

Introduction: The quality of drinking water is of vital importance in breeding chickens. High levels of bacteria, minerals, or other contaminants in the water of poultry farms can have adverse effects on the natural physiology of chickens. Therefore, this study aims to investigate the physical, chemical, and microbial quality of water used in poultry farms in Ardestan, Iran.

Materials and Methods: This descriptive cross-sectional study was conducted on water sources (Wells and Qanats) of 35 poultry farms in Ardestan during the summer of 2021.Water samples were randomly taken and send to laboratory for analysis of physical, chemical, and microbial parameters according to Standard Methods. SPSS 16 software was applied for statistical analysis.

Results: With the exception of sodium, sulfates, and total hardness (TH), all other parameters fell within acceptable standard limits. Some water samples showed elevated levels of total coliforms exceeding the prescribed limits. Furthermore, the mean concentrations of heavy metals, including iron, lead, chromium, and cadmium remained within acceptable levels in all samples.

Conclusion: Although the majority of water quality parameters in the studied poultry farms were compatible with standards limits, testing and monitoring the chemical and microbial quality of water in poultry farms is recommended on a regular basis.

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Introduction

Poultry meat comprises a major part of the diet of people all around the world. Per capita consumption of turkey meat in the United States has remained constant since 1960, and the global per capita consumption of chicken has increased by 16% during 2008 to 2017[1]. In 2006, Iran ranked 11th in the production of chicken meat in the world by producing 1,152,929 tons of this product [2].

Water is one of the most important and abundant natural resources of the Earth, and water resources development is often used as an indicator for the economic, social, and health status of many countries worldwide [3].Water is also a vital substance for all birds, and improving the quality of drinking water can help maintain the health of poultry. Most of the chicken's body (55-75%) is made up of water. Therefore, water consumed by poultry should be safe for humans [4]. Chickens can survive longer without food than water, and they consume 1.5 to 2 times more water than food. Therefore, it is expected that contaminated or low-quality water will affect chickens more than low-quality or contaminated food [5].

Chickens that are not provided with appropriate drinking water (in terms of quantity and quality) tend to eat less food and do not grow properly [6]. When the temperature is high, water consumption increases three-fold, and water quality has to be considered as one of the explanatory factors of water use [7]. In many cases, poultry farms experience problems with the health of chickens without specific reasons. In most of these cases, the problem is related to water quality and hygiene [8].

Out-of-range values for some chemical and physical properties of water, such as pH, total dissolved solids (TDS), nitrite content, and salinity affect the amount of feed consumption and lead to a decrease in the body weight of chickens [4]. In addition, the bacterial load in water sources has a serious effect on chickens. Grizzle et al. reported that exposure of chickens to water contaminated with *Escherichia coli (E. coli)* leads to a decrease in their body weight at 4-6 weeks of age [9].Van Der Sluis found in his study that the low quality of water leads to a decrease in the efficiency of vaccines and drugs in the water supply systems [10].

Infected chickens can also infect humans directly and indirectly [6]. Many poultry farmers do not have the necessary education, so they have relatively little knowledge of the effect of improper hygiene on chickens and people. They place little emphasis on clean water for their chickens and disregard regular daily cleaning of water supply system. They merely ensure that water is available for them to drink [11]. Disinfection is essential for commercial poultry farms, and the efficiency of this operation greatly affects the quality of the final poultry products [12]. It has been reported that disinfecting drinking water sources has an effective role in reducing microbial pollutants in water sources [13]. Hubbard et al. found in their study that poultry litter is a source of environmental pollution due to limited nutritional additives in poultry farms, and groundwater is also sensitive to pollution from poultry. Antibiotic-resistant bacteria were isolated from samples of poultry litter, as well as underground water and surface water contaminated by it. Also, pathogens were significantly more common in underground water than in surface water [14]. Frank et al.'s study showed that the water used in chicken farms has various adverse physical and chemical characteristics and can also be a potential source of pathogenic organisms. In order to prevent the use of contaminated water for poultry drinking, the quality of water used in poultry farms should be regularly monitored [15].

Given the importance of water in poultry nutrition and its effect on chicken meat as one of the most important human food products, unfortunately, water hygiene does not receive due attention in poultry farms, and studies in this field are very limited in Iran. Therefore, physical and chemical parameters of water in Ardestan poultry farms were measured in this study.

Materials and methods

Selection of poultry farms:

In this cross-sectional descriptive study, the sample volume was calculated using the following formula:

$$n = \frac{1.96^2 \times \delta^2}{d^2}$$

According to the study conducted in Egypt [4], d, variance(d^2), and δ were regarded as 0.003, 0.01, and 0.05, respectively. Thus, 35 chicken farms were randomly sampled from a total of 100 chicken farms in Ardestan.

Sampling method

To take water samples from the water source of the chicken farms, water was allowed to drain for 30 seconds after opening the tap, then after washing the bottle with water, samples were collected in 1.5-liter clean plastic bottles for analyzing the physical and chemical parameters. Also, analysis, and sterile glass bottles were utilized for microbial tests. Before sampling, the water tap was sterilized by flame. After collecting the samples, the bottles were placed in a coolbox on ice at -4°C and sent to the laboratory.

Physical, chemical, and microbial tests

After transferring the samples to the laboratory, physical and chemical parameters including total hardness, alkalinity, electrical conductivity (EC),

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pH, turbidity, and mineral content (including nitrate, sulfate, sodium, potassium, phosphate, iron, lead, cadmium, and chromium) as well as microbial parameters, including total coliforms were measured according to Standard Methods for the Examination of Water and Wastewater[16] (Table 1). The concentration of TDS was also calculated using EC.

Statistical analysis

SPSS 16 software was used for statistical analysis. Mean and standard deviation of water quality parameters were calculated using descriptive analysis. Then, the mean score was compared with the allowable and recommended values by Watkins using the t-test[17]. T-test analysis was applied for checking the difference between the averages and standard values (Watkins standard).

Ethical issue

The present study has been approved by Kashan University of Medical Sciences with the ethics code IR.KAUMS.REC.1400.031.

Results

Quality specifications of water used in poultry farms in Ardestan region is presented in Tables 2-4. The mean and standard deviation of pH and phosphate were 7.6 ± 0.26, 1.3 ± 0.5, respectively, and the rest of the parameters are reported in Table 2. According to the independent t-test, the amounts of all parameters except TDS were significantly different from the standard limits.

The mean concentration of Pb, Cd, Cr, sodium and sulfate were 0.0002, 0.002, 0.027, 332.,4 and 23.7 mg L^{-1}, respectively, and the concentration of TH was 215.6 mg L^{-1} $CaCO_3$ (Table 2).

Table 1: Analytical technique for water quality determination in poultry farms of Ardestan.

Parameter	Unit	Analytical technique	Method	Model
Electric conductivity	(μmoh/cm)	Potentiometric	2510 B	Metrohm 644
Hardness	mg L^{-1} $CaCO_3$	EDTA Titrimetric Method	2340 C	-
Nitrate	(mgL^{-1})	Ultraviolet Spectrophotometric screening Method	4500 B	PD- 303 UV
Alkalinity	(mgL^{-1})	Titration Method	2320 B	-
Sulfate	(mgL^{-1})	Turbidimetric Method	4500 E	DR 2010
Na	(mgL^{-1})	Flame Emission Photometric Method	3500 B	Flame Photometer 410
Pd, Cd, Cr	(mgL^{-1})	Inductively Coupled Plasma (ICP)	3120 B	2400 DV Optima
Total coliforms	MPN	Multiple tube fermentation technique for members of coliform	9221 A	-
Fe	(mgL^{-1})	Phenantheroline method	3500 D	DR 2010
Turbidity	MPN	Nephlometric method	2310 B	-

Table 2: Statistical indicators of water used in poultry farms according to physical, chemical, and microbial factors

Parameter (unit)	$X \pm SD^{*}$	Watkins Standard	P-value
TH (mg L^{-1} $CaCO_3$)	215.6 ± 115.2	110	< 0.001
Alkalinity (mgL^{-1})	118.6 ± 46.7	300	< 0.001
EC (μmoh/cm)	1407.8 ± 530.1	5000	< 0.001
TDS (mgL^{-1})	913.7 ± 341.6	1000	0.144
Turbidity** (NTU***)	1.13 ± 0.6	5	< 0.001
Nitrate (mgL^{-1})	6.4 ± 2.6	25	< 0.001
Sulfate (mgL^{-1})	237.1 ± 77	200	< 0.001
Na (mgL^{-1})	332.4 ± 144.3	150	< 0.001
Total coliforms (MPN)	19.84 ± 24.01	50	< 0.001
Fe (mg L^{-1})	0 ± 0	0.3	< 0.001
Pb (mgL^{-1})	0.0002 ± 0.0068	0.05	< 0.001
Cd* (mgL^{-1})	0.002 ± 0.0008	0.003	< 0.001
Cr* (mg L^{-1})	0.027 ± 0.007	0.05	< 0.001

* Mean ± Standard Deviation
** The parameters of cadmium, chromium, turbidity were compared with the drinking water standards of the World Health Organization (WHO).
*** Nephelometric Turbidity Unit

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Table 3: Frequency distribution of water used in poultry farms according to physical, chemical, and microbial factors

Parameters	Well (15)				Qanat (20)			
	Compatible with standard		Non compatible with standard		Compatible with standard		Non compatible with standard	
	Number	percentage	Number	percentage	Number	percentage	Number	percentage
pH	15	100	0	0	20	100	0	0
TH (mg L^{-1} $CaCO_3$)	1	6.7	14	93.3	4	20	16	80
Alkalinity (mgL^{-1})	15	100	0	0	20	100	0	0
TDS (mgL^{-1})	10	66.7	5	33.3	11	55	9	45
Nitrate (mgL^{-1})	15	100	0	0	20	100	0	0
Sulfate (mgL^{-1})	3	20	12	80	12	60	8	40
Na (mgL^{-1})	0	0	15	100	4	20	16	80
Total coliforms (MPN)	13	86.7	2	13.3	16	80	4	20
Fe (mg L^{-1})	15	100	0	0	20	100	0	0
Pb (mgL^{-1})	15	100	0	0	20	100	0	0
Cd (mgL^{-1})	15	100	0	0	20	100	0	0
Cr (mg L^{-1})	15	100	0	0	20	100	0	0

Table 4: Classification of water quality in poultry farms according to total hardness (mg L-1 CaCO3)

Classification	Well (15)		Qanat (20)		Total (35)	
	Number	percentage	Number	percentage	Number	percentage
0-75	0	0	0	0	0	0
76-150	2	13.3	4	20	6	17.3
151-300	13	86.7	15	75	28	80
>300	0	0	1	5	1	2.9

Discussion

Almost all poultry farms use well or Qanat water as the main sources of drinking water. The water used for feeding chickens can inevitably be a potential source of infections and diseases in poultry farms. Therefore, using water with appropriate physical, chemical, and microbiological quality can significantly reduce its harmful effects and contribute to the future growth of the poultry industry and public health.

In the present study, the concentration of iron in all water samples of wells and Qanats was within the standard limit. Idriss et al. reported that the concentration of iron in one of the samples was higher than the standard, and the highest concentration of iron was observed in industrial areas, which could be due to metalworking and mining activities [18]. Iron concentrations of more than 0.3 mg/L in drinking water can cause unpleasant metallic taste and rust color [19].

In this study, the amount of cadmium and arsenic was within the standard limit. Idriss et al. reported that the concentration of heavy metals in some samples was higher than the standard and observed the highest concentration of cadmium, lead and chromium in industrial areas. They stated that the high concentration of cadmium can be attributed to industrial activities, waste disposal, and smelting in factories of the region [18]. A high concentration of cadmium may disturb the oxidative and antioxidative balance of adult birds and cause oxidative stress [18]. Also, lead poisoning significantly reduces the body weight of broiler chickens and leads to their poor growth and death [20].

In this study, the mean values for turbidity and alkalinity in all the samples of well and Qanat water sources were at the optimal level. Moreover, the pH of water in all the samples was within the standard limit. In general, pH indicates acidity or alkalinity when evaluating water quality. In the studies by Boumedous et al. and Angélique et al., the pH was within the permissible limit [6, 21].

Water salinity resulting from increased sodium, calcium, magnesium, potassium, and chloride sulfate is often measured by EC and TDS indicators. The amount of EC up to 5000 µm/cm

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does not cause problem for poultry, but at higher amounts, the usability for poultry decreases [17, 22]. In the present study, the amount of EC was less than the maximum permissible limit in all the samples.

The mean TDS was within the standard range of drinking water for poultry. Also, its amount in 10 wells (66.7%) and 11 Qanats (55%) samples was within the optimal range. In the study conducted in Isfahan city, the amount of EC in the samples was less than the maximum standard limit, but the amount of TDS in some areas was higher than the standard, which is consistent with the present study[23]. In poultry farms, water with TDS of less than 1000 mgL^{-1} is considered a healthy water, and higher concentrations cause temporary diarrhea in poultry[24].

In addition, high TDS can lead to reduced absorption of nutrients, reduced consumption of poultry feed and sedimentation in facilities and water pipes [22]. The reason for the high TDS in some samples can be attributed to the geological characteristics of the sampling locations [25].

The mean concentration of sulfate was higher than the standard limit for poultry drinking water, and in 3 well water sources (20%) and 12 Qanat water sources (60%), the amount of sulfate was within the permissible limit. In the study by Idrissa et al., the amount of sulfate in some areas was reported to be higher than the standard limit due to industrial wastes[18]. However, in the study of Irandoost and Mohammadzadeh in Isfahan, the mean concentration of sulfate was at the standard level, and in some areas it was higher than the standard, which is in line with the present study [23]. High sulfate in water may be expected due to contamination with bird droppings and feed particles. Sulfate is also one of the main soluble components in rainwater[26]. Using high sulfate water may cause coccidiosis in poultry [27].

The mean concentration of sodium in this study was more than the standard limit, and its amount in all the samples of well water sources and 16 (80 percent) samples of Qanat water sources was more than the standard limit. In the study conducted by Irandoost and Mohammadzadeh in Isfahan, the mean total value of sodium in the province was reported to be higher than the standard limit, which is consistent with the present study[23]. This high concentration of sodium in drinking water is not suitable for poultry and can significantly reduce their feed consumption, growth, and reproduction [28].

The mean total hardness was higher than the maximum permissible for poultry drinking water (110 mgL^{-1}). Table 3 reveals that 86% of the water samples had hardness higher than the standard; that is 80% of the Qanat water sources and 93% of the well water sources.

Irandoost and Mohammadzadeh also reported that the hardness of water in most areas of Isfahan province was higher than the standard, which is in line with the current study [23].

According to Table 4, 17.3% of the samples were in the range of moderately hard, 80% in the range of hard, and 2.9% were in the range of very hard.

Scandurra conducted a study to investigate the dissolution kinetics of products containing oxytetracycline and tylosin at 0 and 24 hours in drinking water samples in order to investigate the effect of physical and chemical factors of drinking water on the dissolution of the above drugs. The study reported that the inherent properties of water such as pH, hardness, conductivity, and calcium concentration may affect the dissolution of tested drugs in water [29]. In addition, evidence indicates that high hardness of water causes interference with some drugs, reduces the effect of disinfectants and detergents, and also reduces water quality and thus reduces water consumption by poultry [22].

It should also be noted that, in general, high hardness of the water source significantly increases the risk of bacterial contamination of the water source in poultry farms by promoting the growth of organisms such as coliforms, E. coli, salmonella, and streptococci[9]. A previous similar experiment conducted by Cherifa et al. in 2017 reported a hardness of more than 15°F (recommended by the WHO, 1998) for well water. However, they stated the excess amount of iron, calcium, magnesium, nitrate, and manganese as the main reason for such a difference in total hardness compared to sodium excess in the present study [6]. Obviously, the high amount of total hardness could be due to sodium excess in the present study. In the study conducted by Di Martino et al., the amount of total hardness was more than 200 mgL^{-1} [30], which is consistent with the current study.

On the other hand, nitrate and iron levels in water sources are often measured as indicators of chemical pollution. In the present study, the amount of nitrate was within the desired level. Martino et al. reported water nitrate levels below the standard limit for most turkey farms. They stated that high levels of nitrates can be related to pollution with residential, industrial or agricultural wastes[30]. A study conducted on water quality in poultry farms showed that both bacterial load and nitrate level in different water sources have a negative correlation with body weight [31]. Grizell et al. confirmed the adverse effect of low nitrate levels on water quality as well as growth rate or egg production. This can be due to digestive problems and changes in the function of thyroid hormones, which negatively affect the growth rate of poultry [32].

They also reported the negative effects of water contaminated with *E. coli* on the growth performance of chickens. They found weight loss in chickens exposed to water source contaminated with coliforms and *E. coli* at 4-6 weeks of age. This result may be due to the less willingness of chickens to drink water as a result of the inflammatory response that may endanger the function of the immune system of chickens[9]. This finding is consistent with the results of the bacteriological study conducted by Bomdos et al. In 2017, they investigated the adverse effects of water with increased bacterial load (total coliforms, *E. coli*) on the growth rate of poultry and their production performance and found that it was associated with a significant weight loss from the 7^{th} to the 42^{nd} days of age. These results may indicate that contaminated drinking water causes these adverse effects by increasing the pressure on the immune system of chickens[6]. Unlike these studies, in the present study the bacterial load in most water sources was favorable. The total amount of coliforms in 13 wells (86.7%) and 16 Qanats (80%) samples was optimal.

The high number of coliform bacteria in water sources of a number of poultry farms is probably due to the problems of wastewater disposal in the surrounding areas, the use of animal manure in the surrounding agricultural lands, the lack of proper improvement of water sources, and the development of livestock and cattle farms around the poultry farms. In addition, the high concentration of some salts and metals in the drinking water of some poultry farms is related to the geological structure of the region and their location in desert areas and the salinity of the soils in the region.

Conclusions

In the majority of our samples, water quality in terms of chemical and microbial load was compatible with Watkins standard in poultry farms in the studied region. For safer and better breeding of chickens in poultry farms, water quality monitoring is recommended on a regular basis by responsible organizations. Furthermore, Water resources sanitation and limiting agricultural activities around the poultry farms is important for possible pollution control.

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Conflict of interest

The authors declare that there is no conflict of interest.

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