H&N INTERNATIONAL

The key to your profit

ENG

Technical Tip

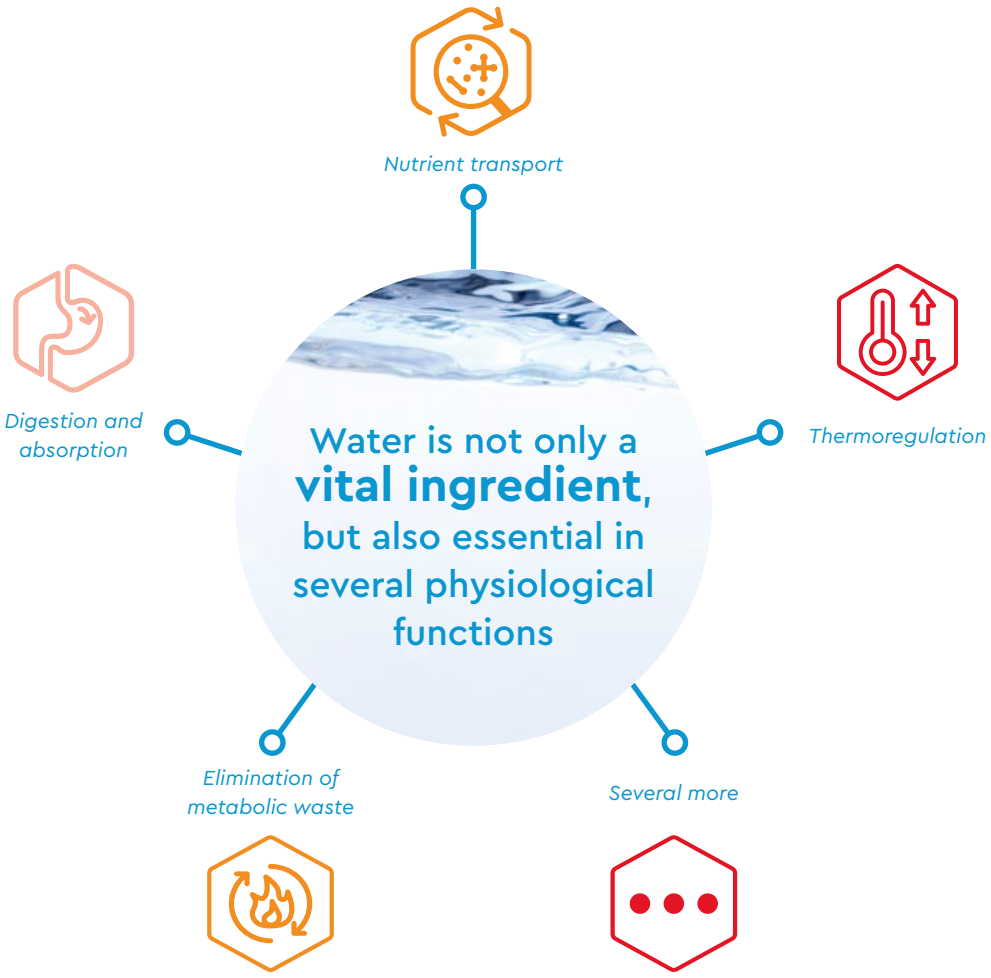
Water quality for laying hens

Every professional who is working in poultry must understand that providing good quality water is one of the most important factor to achieve good production parameters in our laying hens. The importance of water shouldn't be limited to the effects on performance but also its influences in birds welfare.

A reliable source of good quality water is critical to have a good production, healthy birds, and an optimal hen's welfare.

H&N INTERNATIONAL

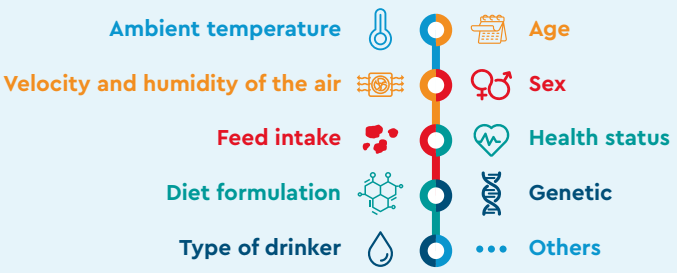
Of all the water in earth, less tan 1% is accessible for human use and 70% of that water is utilized by agriculture. Water plays a fundamental role in the world economy. **Therefore, is our duty as livestock professionals, understand and use this vital nutrient in the best possible way.**



Bird management

Birds typically drink 1.6 to 2 times the equivalent in weight of the feed consumed, therefore if water consumption is limited, so will feed.

There are many factors influencing on water intake such as:



Poor water quality and/or supply means lower performance even if birds are eating the best feed. It must always be remembered that 90% of the egg correspond to water, so problems with the quality or access will affect production, quality, and egg weight. ***Therefore, is the duty of every poultry professional to understand that water requirements are as important as the nutritional requirements of the diet.***

Quality of drinking water

The quality of drinking water should be known; therefore, a complete analysis must be performed including:

- **Mineral quality**
- **pH value**
- **Microbiology quality**
- **Optimal supply**

The monitoring must be focused on quality and quantity. The sampling method must be systematic, based on a schedule and following written procedures.

If we found that one or more parameters are not within the optimal range, procedures must be stablished to correct the issue.

It is important to notice that literature indicates that modern laying hens are in general less susceptible than broilers to high mineral concentrations in water, hence the effect on eggshell quality and performance are lesser and not so common.

However, this doesn't mean that we don't have to pay attention and control their levels and keep them within the optimal range, always provide water free of pathogens and in the sufficient quantity. Now, we will review the most important factors influencing on water quality.

Mineral Quality

It is very important to know the levels of the different minerals that can be found in the drinking water and could impact on bird's performance, because depending on the concentration of one or more, the effects on the birds could vary.

Therefore, samples should be taken from each source of water in the site, from water lines at the farm and must be sent for a complete mineral analysis, which could be repeated annually or bi-annually.

In the next page you find a table indicating the maximum levels, effects on the bird and the options to control some of the most important mineral in egg production.

Table 1. Maximum recommend levels of minerals in the drinking water, effects, and treatments

Watkins, 2007. Chen and Balnave1, 2001, Tabellini, 1992. Carter and Sneed, 1996; Bellostas, 2009.

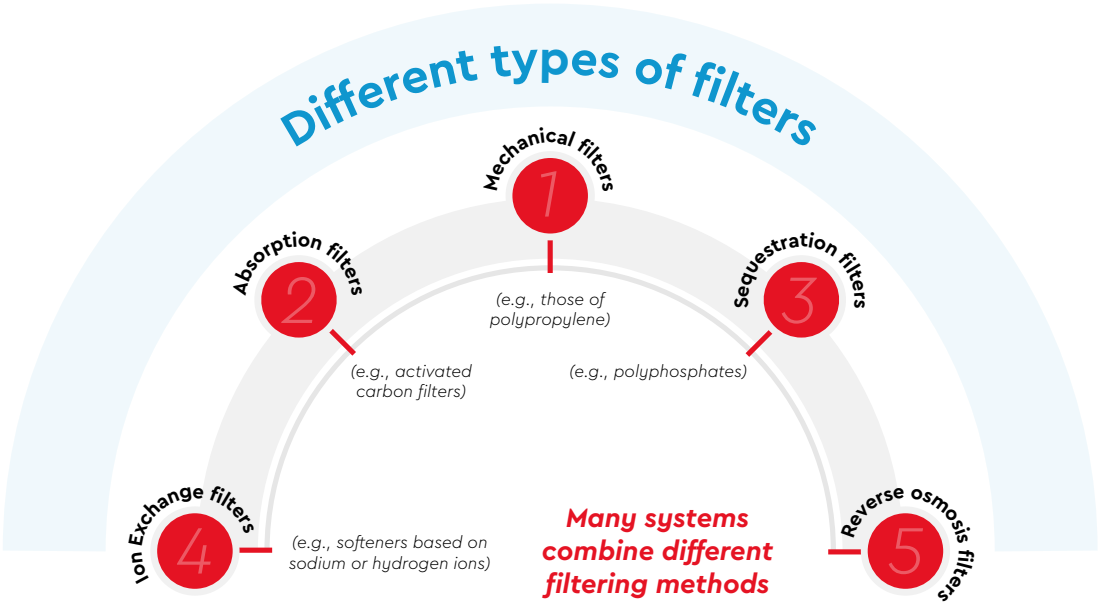
Mineral	Recommended level in poultry	Effects	Treatments
Calcium	< 75 mg/L	There is no maximum limit. However, > 110 mg/L could cause scale buildup.	See treatment for water hardness.
Copper	< 0.6 mg/L	Its origin is probably by corrosion of pipes and joints. High levels could change the taste of water, produce oral or gizzard lesions.	
Iron	< 0.3 mg/L	Metallic taste of water, gastrointestinal disorders, decreases efficiency of vaccine and medications. Blockage of water pipes, bad smell and/or taste, encourages bacterial growth.	Treatments include the addition of some oxidant such as chlorine, chlorine dioxide or ozone then aerate and filter through an appropriate mechanical filtration process.
Magnesium	< 125 mg/L	>125 mg/l could cause wet manure due to its laxative effect. Level above 50 mg/l in conjunction with high levels of sulfate or chloride could also produce a laxative effect.	See treatment for water hardness.
Manganese	< 0.05 mg/L	Can be deposited in the form of black granules in filters and drinkers.	Similar to iron but can be more difficult to remove due to the slow reaction it has with chlorine. Therefore, It needs a long contact time with chlorine prior to filtration unless an iron ion exchange resin is used when pH is 6.8 or higher. The filtration should be done at a pH around 8.5. Another option is green sand filters with a pH greater than 8.0.
Nitrate (nitrites <1 mg/L)	< 15 mg/L	Very high levels reduce the absorption of oxygen (apathic birds, violaceous combs, and wattles), low fertility, lower feed intake, lower weight gain and production. .	Reverse osmosis; ion exchange.
pH	5 – 8	Less than 5 can produce metal corrosion. Higher than 8 can affect the performance of disinfectants and the taste of water.	Organic or acid minerals to lower the pH. Basic agents to raise pH.
Phosphorus	0.1 mg/L		

Mineral	Recommended level in poultry	Effects	Treatments
Potassium	< 300 mg/L	Effects will depend on water alkalinity and pH.	
Chlorides-chlorine	< 250 mg/L	Laxative effect, wet manure, reduced feed intake and increased water consumption. Keep in mind that levels of 14 ppm can cause problems if sodium is > 50 ppm.	
Sodium	50 – 300 mg/L	Together with high levels of chlorine or sulfate can cause diarrhea. In addition, it can promote the growth of Enterococci. Level > 600 mg/l could produce alterations in eggshell quality. There may be problems when lower concentrations (< 50 mg/l) are accompanied by chlorides ≥ 14 ppm or sulfates > 50 ppm.	Reverse osmosis, lower dietary salt level blend with non-saline water, keep water clean and permanently use sanitizers such as hydrogen peroxide or iodine to prevent bacterial growth.
Sulfate	< 200 mg/L	Laxative effect. If high levels of magnesium and chloride or sulfate are also present (> 50 mg/l), a decrease in performance can occur. The presence of rotten egg odor can mean that there is a high concentration of hydrogen which is a byproduct of sulfate-reducing bacteria.	Aerate water in a storage tank to prevent air bubbles from entering water lines. Apply chlorine shots into the well, without stopping the normal disinfection program.
Alkalinity	< 100 mg/L	It is a value associated with bicarbonate, sulfates, and calcium carbonate. It can give a bitter taste to water which can reduce water intake and be corrosive to evaporative panels. High alkalinity levels make more difficult to lower the water pH.	Acidification (pH target < 6,5), anion exchange to reduce the water alkalinity and aeration.
Water hardness	< 150 mg/L	Water hardness can produce scale that deposit on the inner surface of pipes. Main factors are calcium and magnesium. Iron and manganese can also contribute but in lesser extent. Very high levels can also impact on medications and vaccines.	Water softeners (do not use if sodium levels are high unless potassium chloride is used instead of sodium chloride). Polyphosphates sequester the ions involved in hardness and keep them in solution. Acidify to a pH < 6,5.
Zinc	< 1.50 mg/L	Higher levels are toxic.	Filtration methods.
Fluor	< 2 mg/L	High levels can induce soft bones.	
Total dissolved solids	< 1500 ppm (< 3 weeks of age). < 3000 ppm (> 3 weeks of age)	Levels between 4000 to 7000 ppm can produce diarrhea. Concentration > 7000 ppm isn't recommended for drinking water.	Filtration methods.

Control of mineral levels in water

Once the mineral profile of water is known; you must determine if is necessary to control the levels of one or more minerals and define which is the best method for its reduction.

There are different solutions to control the mineral's level in drinking water. The one that would work best in your farm will depend on the analysis results.



The importance of analyzing the pH of water

As we will see next, it is critical to know the pH values of drinking water. **The sampling must be at least directly from the origin (for example, well) and prior to the entry of water into the drinking line in each laying house. Because this analysis is simpler than the one for minerals level, it can be performed more frequently (for example, weekly).** There are reactive strips or digital methods which allow us a fast and easy on-site reading.

An ideal pH is between 6.0 to 6.8 but laying hens can tolerate a wider range with values between 4.8 to 8.0. **In fact, less than 5.5 can even produce an improvement in growth parameters**.

pH levels greater than 8.0 can impact on water consumption (bitter taste), cause gastrointestinal disorders, promote bacterial growth, affect the effectiveness of sanitizers (for example, chlorine activity which works best between 4.5 to 6 pH), drugs and vaccines.

Ph levels below 4.0 can harm vaccines, medications, water consumption and productive performance.

pH > 7,0 —> add either organic or mineral acids.

pH < 4,0 —> add basic agents, such as sodium bicarbonate.

It is recommended to acidify water when the pH is above 7.0. To do an efficient acidification process there are some important points to consider:

- Along with the pH value you must know the alkalinity of the water.
- Acidifiers are not sanitizers (see ***Table 3***).
- Most acidifiers need a long contact time to kill bacteria.
- When the water consumption is high (for example high environmental temperature) the contact time is minimal, so the bactericidal effect is low.
- Some bacteria can become resistant.
- The doses and type of acid (organic or mineral) depend on the pH of the water and its alkalinity.
- The effect of the water acidifiers on the pH of the gastrointestinal tract is limited only to the pH of the crop and gizzard.
- When possible, the use of organic acids is preferred as they have a positive effect on gut health and integrity.
- Implementing a protocol that combine acid and a sanitizer is an excellent synergic management (must follow the label instructions). Always apply first the acid and then the sanitizers. Never mix them in the same tank.
- It is recommended to use an acidifier throughout the life of the flock. The application could be either intermittent or permanent.

Table 3. *Effect of pH on bacteria count*

Watkins, 2008. 5-minute exposure to citric acid.

Product	pH	Aerobic plate count APC/ml
Control	8	8.2 mil
Citric acid (CA)	7	5.6 mil
CA	6	4.4 mil
CA	5	4.0 mil
CA	4	2.3 mil

There is no doubt that, the lower the pH the lower the bacterial growth (Salmonella spp, *E. Coli* and *Clostridium*). However, as can be seen in ***Table 3***, it never reaches a level close to zero, showing the limited effect of acids as sanitizers.

In addition, need to consider that too low levels of pH (< 4) affect the water and feed intake. Best is the combination of acid and sanitizers.

The acidifying effect on the digestive system, although it does not go beyond the gizzard, contributes to control de proliferation of pathogenic organism in the crop.

Table 4. *Effect of pH of the drinking water on the pH of crop and gizzard*

pH	3	4	5	6	Control
Crop	4.33^{c}	3.34^{c}	4.62^{b}	4.95^{b}	5.57^{a}
Gizzard	3.62	3.72	3.70	3.95	4.16

Microbiological Quality

Parameters	Unit	Optimal	Upper limit
Total mesophilic aerobic count	In 1 ml	0	< 1000
Total coliforms	In 1 ml	0	< 50
Fecal coliforms	In 1 ml	0	0
Escherichia coli	In 1 ml	0	0
Pseudomonas	In 1 ml	0	0

Table 5. *Optimal and upper limit of bacteria in the drinking water*

It is critical **to know the microbiological quality of water**, to achieve this, is important to carry out a correct sampling at several points of the system:

- **At the source of water**
- **At the end of the drinking line**
- **In addition to other hot areas of contamination such as blind spots, regulators, etc.**

In general, a GOOD SAMPLING METHOD must involve, the source (for example, direct from the well), the outlet of the farm's storage tank and at the end of the drinking line. It is important to take the samples by two procedures: running water (dripping method) and swabs (sponge) from the inside of the drinker line.

An important point to consider, is that the common method for water sampling is to place running water into a glass bottle. While this method helps to analyze the quality of water (mineral and microbiological) cannot identify the challenge from the biofilm.

What substances promote Biofilm

Minerals such as iron, manganese, sulfides.

Electrolytes.

Organic acids.

Vaccines and vaccine stabilizers.

Probiotics.

Etc.

Source: Selko feed additives

Biofilm

Biofilm is the mixture of fungi, algae, bacteria, and other organic contaminants which adhere to the inner surface of pipes and other structures in a water system.

Effects of biofilm

Reduces the water flow.

Increase the water pressure inside the system.

Negative impact in medications and vaccines delivered through the drinking water.

It is the perfect environment for the growth of pathogens (salmonella, campylobacter, etc.) as it provides them with food and protection.

For all the reasons described above, it is necessary to perform a swab sampling from the interior of the drinking lines (S. Watkins). This method tells us the real threat of the biofilm.

Insert a sponge inside the drinking line (8 a 10 cm)

Source: S. Watkins.

Place the sponge in 25 ml of *BPD or distilled water.

**Butterfield's phosphate diluent*

Source: S. Watkins.

How to interpret the result: Aerobic Plate Count.

Optimal results: 0–100 CFU/ml.

Margin levels of contamination: 1,000–10,000 CFU/ml.

System must be completely cleaned: > 100,000 CFU/ml

How to reduce or eliminate biofilm, bacteria, and other microorganisms?

Chemical treatments

- Sodium hypochlorite or calcium hypochlorite.
- Hydrogen peroxide.
- Chlorine dioxide.
- Organic acids (not completely effective against microorganisms).
- Others

Physical treatments

- Electromagnetic methods.
- Ultraviolet light or ozone (limited effect on biofilm).
- Laser (only effective at the point of treatment)).
- Application of pressure pulses removal and prevention of Biofilm).

Table 6. *Characteristics of an ideal sanitizer*

Chemicals

- **Its concentration is easy to measure on the field**
- **Low or no interference with common compounds in drinking water**
- **Produces little or no disinfection by-products**
- **It has residual effect**
- **Selective reaction (minimum corrosion or reaction with metals, water pipes, etc.)**

Biocidal capacities

- **Effectively and efficiently inactivates a wide range of microorganisms (bacteria, viruses, protozoa, algae, and fungi)**
- **Effectively inactivates microorganisms present in the biofilm**
- **Reaches optimal levels of inactivation of microorganisms at doses that are safe to be consumed through the water**

Operational/physical

- **Highly soluble in water**
- **Safe to transport, store and apply**
- **The application and operation of the product is cost-effective (independent of whether large or small scale)**

Organoleptic

- **It reaches levels of inactivation of microorganisms without producing odors or flavors**
- **Overdose can be detected by a change in the water taste, smell and/or color**

Maharjan, 2018

Table 7. Common chemical sanitizers that can be used in drinking water

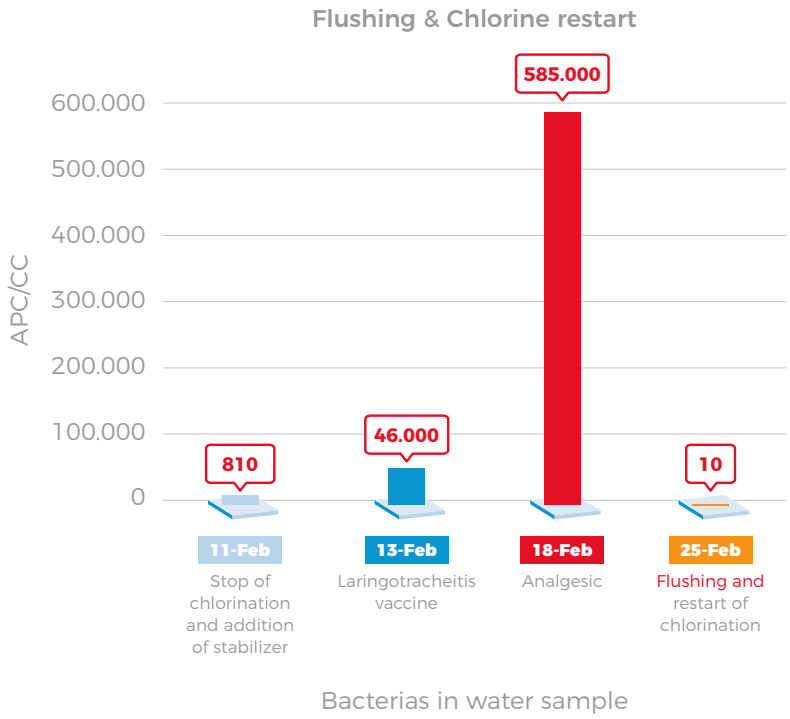
Product	Optimal residual level in drinking water (ppm)	Comments
Liquid or solid chlorine	2–4 ppm of free chlorine	Liquid chlorine is easier to apply. Most effective between pH 5 to 7. Acidify the water if pH is greater than 7 and never mix chlorine and acid in the same container. Use tests that measure free chlorine. It requires more contact time > 15 min. Cost is low.
Chlorine dioxide.	0,8 ppm	Effective in a wider Ph range of 4 to 9. Could use tests strips that measure chlorine dioxide. Excellent sanitizer. Shorter contact time > 5 min. Higher cost than chlorine.
Hydrogen peroxide	25 – 50 ppm	Ideal pH is < 8. It works very well when injected after an ozone treatment and as when it is used in a protocol together with peracetic acid. It eliminates biofilm. There are test strips for a fast and easy monitoring. Contact time > 10 min. Higher cost than chlorine.

Watkins, 2008; HdosO consultores, 2009

Flushing of water lines

Flushing is a management that should be regularly done in every poultry farm because is critical to maintain a good water quality and prevent the buildup of biofilm. Some important points when flushing are:

1. **First step is to rinse the inside of the drinker line with water + sanitizer at the appropriate concentration to release the dirt. Very good option is hydrogen peroxide in a 3% solution.**
2. **Rinse at a ratio of one minute for every 30 meters of water line.**
3. **Then allow the disinfectant to reach the biofilm and let it act for an appropriate period (follow product labeling).**
4. **High pressure rinse to release all substances attached to the pipe.**
5. **Always flushing after the application of any product in the water line** (see ***Figure 1***).
6. **In case of hot weather and/or low water intake, flushing must be performed more frequently.**



Watkins, S. 2008

Figure 1. *Behavior of bacterial growth in a water line when applying products in the drinking water*

Adequate water supply

As important as having water of good quality is that the quantity is sufficient for our birds. The critical points to ensure a right supply are:

Design the system so can supply water during times of maximum demand (high temperatures, operation of cooling pads, adult birds, etc.).

Daily check the presence of water in each water line (morning and afternoon).

There MUST be water meters in each house and if possible, in each water line.

Always monitor de daily water consumption.

Daily record the water: food ratio.

Follow the drinker's space and water. Follow recommendations according to the age of the birds. This information can be found in the management guide and drinker's provider brochures.

The water flow (ml/minute) must follow the recommendation from the drinker's manufacturer.

Measure water flow (ml/minute) periodically.

Adjust the water flow according to the flock age, body weight, environmental temperature, ventilation, among others so that it does not limit growth and/or production. Always follow the manufacturer's instructions.

Always keep an eye on the height of the water column of each water line.

Always pay attention to the humidity conditions of the litter and the presence of water on the manure belts.

Adjust the water line height according to the age of the flock.

Check and maintain the proper water pressure in the system.

Must have a water profile
Minerals
pH
Bacteria
Develop procedures to optimize the water quality

Daily
Check/adjust height and level of drinkers
Check/adjust water pressure regulators
Check that both outlet and inlet pressures are optimal and stable
Check for presence of water in all drinking lines (better to do it at the end of the line)
Check the condition of the hoses that carry water to the drinking lines
Monitor water consumption (ml/bird)

Table 9. *Checklist of an optimal water management program*

Weekly

- **Backwash water filters**
- **Flushing water lines**
- **Clean dust on surface of pipes**
- **Monitor the concentration of water sanitizer**
- **Monitor water quality (by a fast method: pH, hardness, etc.)**
- **Check the condition of water storage tanks**

Monthly

- **Check water Flow (every 2–3 weeks during rearing)**

Quarterly

- **Clean and disinfect the entire system**
- **Check the presence of bacteria**

Yearly

- **Check the water quality (complete analysis)**

Conclusions

The importance of providing water of excellent quality is sometimes underestimated, to prevent this to happen is critical to have written procedures comprehending the evaluation, control and verification that water quality is optimal.

The access to fresh, good and clean water must always be guaranteed.

Bibliography

Ariyamuni, D. (2015). Evaluation of pH Levels or High Content of Calcium, Magnesium and Sulphate in Drinking Water on Production Performance, Egg Quality, Bone Quality and Mineral Retention of Laying Hens. Theses and dissertations. Dalhousie University. Halifax, Nova Scotia

Bellostas, A. (2009). Calidad del agua y su higienización: Efectos sobre la sanidad y productivdad de las aves. XLVI Symposium cientifico de avicultura. Zaragoza, Espana.

CONASA (2018). Manejo de la calidad del agua de bebida en granjas avícolas. Manual de procedimientos. Dirección Nacional de Sanidad. Argentina.

Carter, T (1987). Drinking Water Quality for Poultry, Poultry Science and Technology Guide No. 42, Extension Poultry Science, North Carolina University.

Carter, T.A y Sneed, R.E (1996). Drinking water guidelines for poultry. Poultry Science and Technology Guide No. 42, North Carolina State University.

Chen, J. y Balnave, D (2001). The Influence of Drinking Water Containing Sodium Chloride on Performance and Eggshell Quality of a Modern, Colored Layer Strain. Department of Animal Science, University of Sydney, 425 Werombi Road, Camden, New South Wales, Australia 2570 2001 Poultry Science 80:91–94

Fairchild, B (2007). Water System Check-ip. Poultry Housing tips. Volume 19 Number 8 July, The University of Georgia, Cooperative Extension Service, College of Agricultural and Environmental Science/Athens, Georgia 30602-4356

Fairchild, B. D., y C.W. Ritz. 2009. Poultry drinking water primer.

Hamid, H. Q., Shi, G. Y. Ma, Y. Fan, W. X. Li, L. H. Zhao, J. Y. Zhang, C. Ji, and Q. G. (2018) Influence of acidified drinking water on growth performance and gastrointestinal function of broilers H. State Key Laboratory of Animal Nutrition, College of Animal Science and Technology, China Agricultural University, Beijing, China. Poultry Science 97:3601–3609.

Hardin, By Roney C.C. No Date. Effects of pH on Selected Poultry Bacterial Pathogens, Alabama Department of Agriculture and Industries State Diagnostic Lab

Kirkpatrick, K. y Fleming, E. (2008) Water quality update. Arbor Acres.

Maharjan, P. (2013). Evaluation of Water Sanitation Options for Poultry Production. Theses and Dissertations. 895. http://scholarworks.uark.edu/etd/895

Tabellini, R. (1992). Rivista di Avicolfura, 61, 4, 31–34.

UK Ag Extension. (no date). Chapter 12 – Water quality. Poultry Federation Kentucky. University of Kentucky.

Watkins, S. (2007). Higiene de las condiciones de agua de bebida. Ross Tech.

Watkins, S (2008) Optimize water quality. Arkansas Cooperative Extension Service. Center of Excellence for Poultry Science. Fayetteville, Arkansas.

Watkins, S (2008). Water: Identifying and Correcting Challenges. 5M Editors. University of Arkansas. Division of Agriculture. Center of Excellence for Poultry Science. Fayetteville, Arkansas.

Watkins, S (no date). Problem Solving water challenges. University of Arkansas. Division of Agriculture. Center of Excellence for Poultry Science. Fayetteville, Arkansas.

Watkins, S; Cornelison, J; Tillery, C; Wilson, M. y Hubbard, R (2004). Effects of Water Acidification on Broiler Performance. Center of Excellence for Poultry Science • University of Arkansas. AVIAN Advice, Vol. 6, No. 2

The key to your profit

H&N International GmbH
Am Seedeich 9 | 27472 Cuxhaven | Germany
Phone +49 (0) 4721 564-0 | Fax +49 (0) 4721 564-111
E-mail: info@hn-int.com | www.hn-int.com