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Bersama ini kami kirimkan Laporan Akhir Penelitian dengan judul **"Evaluating The Efficacy of Panasonic WPS in Enhancing Water Quality and Chicken Farming Performance (Boiler and Layer Chicken)"** sebagaimana terlampir.

Demikian kami sampaikan, atas perhatian dan kerjasamanya diucapkan terima kasih.

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IPB – PANASONIC COLLABORATIVE RESEARCH

FINAL REPORT

IPB University
Bogor Indonesia

EVALUATING THE EFFICACY OF PANASONIC WPS IN ENHANCING WATER QUALITY AND CHICKEN FARMING PERFORMANCE (BROILER AND LAYER CHICKEN)

FACULTY OF ANIMAL SCIENCE
IPB UNIVERSITY
AUGUST
2024

APPROVAL SHEET

Project Name	:	IPB – Panasonic Collaborative Research
Project Title	:	Evaluating The Efficacy of Panasonic WPS in Enhancing Water Quality and Chicken Farming Performance (Broiler and Layer Chicken)
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Bogor, 3 September 2024

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I. INTRODUCTION

Poultry productivity in general is influenced by genetic factors, microclimate, feed quality, and management practices. Weather conditions in Indonesia are one of the challenges in poultry farming, especially for commercial chickens. High environmental temperatures and humidity above the comfortable zone for chickens (20-24 °C and 50-70%) not only reduce their productivity but also allow microorganisms, particularly pathogens, to thrive rapidly in such environments.

Such conditions in commercial chicken farming require careful management practices. Pathogenic microbes often expose livestock through feed and drinking water. This can result in a decline in chicken productivity, both in production performance and the quality of the products produced, ultimately impacting the economic viability of commercial chicken farming. This is the background for the research collaboration between the Faculty of Animal Science at IPB and PANASONIC. The aim of this study is to evaluate the provision of drinking water for commercial chickens filtered with a Panasonic Water Purification System (WPS) on their productivity.

The treatment in this study involves comparing the drinking water filtered with the Water Purification System (WPS) against unfiltered drinking water (No WPS). This report presents the results of the above treatment on commercial chicken. The study was conducted over 30 days on 2000 ISA Brown laying hens aged 57 weeks for the layer chicken study and on 7.700 broiler chickens, reared from DOC (day old chick) for the broiler chicken study. The results include aspects of water quality, chicken production performance, and product quality (egg and carcass).

II. STUDY ON LAYER CHICKEN

METHOD

The study on the effect of the Panasonic WPS on commercial laying hens was conducted from June 5, 2024, to July 5, 2024. This study took place at Cisadane Pradana Layer Farm, a privately owned laying hen farm located on the riverbed of the Cisadane River in Semplak, Bogor. The farm uses water sourced from wells without any filtration or treatment.

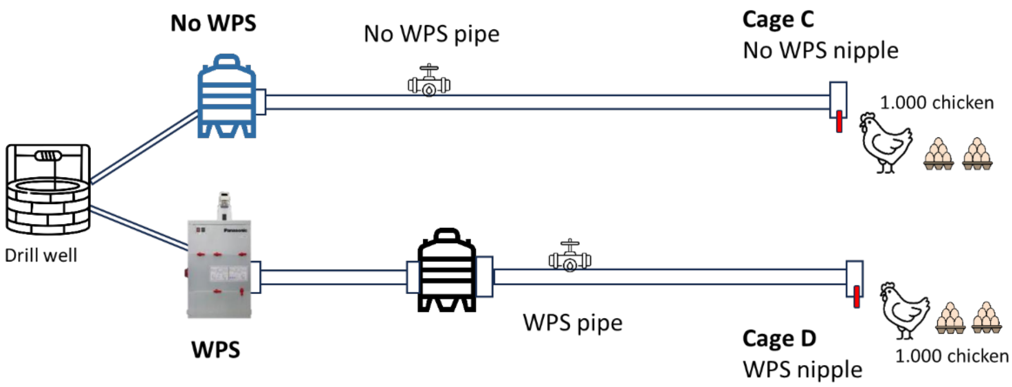


Figure 1. Experiment design on layer farm

This study compares the effects of drinking water filtered using the Water Purification System (WPS) with unfiltered drinking water (No WPS). The study was carried out over a 30-day period on 2.000 ISA Brown laying hens aged 57 weeks (1.000 for control and 1,000 for treatment). Sampling were done on Day 0, Day 15, and Day 30. The results cover aspects of water quality, production performance, and egg quality. The experiment design on layer farm is shown on Figure 1.

Water Quality Analysis

Water quality measurements include physical quality parameters such as color, TDS, TSS, ammonia (NH_3), COD, BOD, free chlorine, pH, and DO. The microbial quality of the water will focus on key pathogens, including qualitative coliform, *E. coli*, *Enterobacter*, *Salmonella*, and *Shigella*. The analysis procedures follow the International Standard AOAC (2005) and SNI. Physical quality analysis and microbial analysis were done using three replications for each treatment.

Production Performance Analysis

The parameters observed for production performance included chicken population (mortality), hen-day production, FCR, egg mass, and total egg production. All parameters were observed daily for a total of 30 days. The collected data were then subjected to statistical analysis. Random sampling for Avian Influenza was done using RT-PCR.

Egg Quality Analysis

Egg quality measurements include physical quality parameters such as Haugh unit, egg yolk percentage, egg white percentage, and eggshell percentage. Nutritional quality parameters were obtained using proximate analysis, which comprised water, ash, fat, and protein percentages. Residual chloride (mg/100g) was also measured. Egg microbial quality measures qualitative coliform, *E. coli, Enterobacter, S. aureus, S. epidermidis*, *Salmonella,* and *Shigella*. The analysis procedures follow the International Standard AOAC (2005) and SNI. Analyses were done using thirty replications for nutritional and microbial analysis, while physical analysis used twenty replications.

RESULTS AND DISCUSSIONS

Water Physical Quality

The water source used for supplying drinking water to the chickens in the coop is well water, which has not undergone any special treatment. This means that the water is used directly as a clean water source without any physical or chemical treatment. In this study, water samples were taken from several points on different days. Water sampling was conducted on days 0, 15, and 30 during the afternoon under clear weather conditions. Nine parameters were analyzed, namely color, TDS, TSS, ammonia, COD, BOD5, free chlorine, pH, and DO. The results of the water quality analysis were compared with government regulations, specifically PP No. 22 of 2021, Appendix 6 on River Water Quality Standards, Class 3, for Fisheries and Livestock Purposes.

Water sampling points were selected from water that had not been treated with the WPS device, water that had passed through the WPS device, and water exiting from the nipple. Four sampling points were defined as follows: untreated water in the pipe on day 0 (D-0-Control-Pipe); untreated water at the nipple on day 0 (D-0-Control-Nipple); water treated with WPS in the pipe on day 0 (D-0-WPS-Pipe); and water treated with WPS at the nipple on day 0 (D-0-WPS-Nipple). Sampling on day 15 was labeled as D-15-Control-Pipe; D-15-Control-Nipple; D-15-WPS-Pipe; and D-15-WPS-Nipple. Similarly, sampling on day 30 was labeled as D-30-Control-Pipe; D-30-Control-Nipple; D-30-WPS-Pipe; and D-30-WPS-Nipple.

The results of the water quality analysis on day 0 for the physical and chemical parameters of the water samples, both untreated and treated with WPS, showed that all measured parameters were below the referenced quality standards (Table 1). However, there were a few parameters of concern due to differing values, namely TSS, DO, and BOD. The TSS parameter at the D-0-Control-Nipple and D-0-WPS-Pipe points had higher values compared to the other two points.

Table 1. Layer farm water quality Day-0

No.	Parameters	Regulation	Unit	Result			
				D-0 Control-Pipe	D-0 Control-Nipple	D-0 WPS-Pipe	D-0 WPS-Nipple
1	Color	100	TCU	11	10	9	11
2	TDS +	1.000	mg/L	93	99	93	93
3	TSS +	100	mg/L	<2	10	23	<2
4	Amonia (NH_3) +	0,5	mg/L	<0,1	<0,1	<0,1	<0,1
5	COD	40	mg/L	1	<0,78	4	3
6	BOD 5	6	mg/L	3	2	4	6
7	Free Chlorine +	0,03	mg/L	0,01	0,01	0,01	<0,01
8	pH +	6-9	-	7	7	8	8
9	DO		mg/L	7,4	7,4	2,9	4,2

The sample on day 0 had a slightly cloudy appearance, indicating the presence of dissolved solids in the water. Meanwhile, the water treated with WPS had a lower DO value compared to the untreated water samples. This lower DO value corresponded to a higher BOD5 value, compared to the samples without WPS treatment. This is because the dissolved oxygen was used to oxidize the organic matter dissolved in the water. Additionally, the lower oxygen content in the water treated with WPS may be due to the new condition of the water storage tank and the recently installed WPS device, which caused a decrease in oxygen levels due to interactions with the new tank and the WPS device, leading to the oxidation process.

The results of the water quality analysis on day 15 for the physical and chemical parameters of the water samples, both untreated and treated with WPS, showed that all measured parameters were below the referenced quality standards (Table 2). The TSS values in all samples were lower compared to the analysis results on day 0. This is consistent with the appearance of the water samples taken on day 15, which appeared clear, resulting in lower TSS values.

Table 2. Layer farm water quality Day-15

No.	Parameters	Regulation	Unit	Result			
				D-15 Control-Pipe	D-15 Control-Nipple	D-15 WPS-Pipe	D-15 WPS-Nipple
1	Color	100	TCU	11	10	9	11
2	TDS +	1.000	mg/L	93	99	93	93
3	TSS +	100	mg/L	<2	10	23	<2
4	Amonia (NH_3) +	0,5	mg/L	<0,1	<0,1	<0,1	<0,1
5	COD	40	mg/L	1	<0,78	4	3
6	BOD 5	6	mg/L	3	2	4	6
7	Free Chlorine +	0,03	mg/L	0,01	0,01	0,01	<0,01
8	pH +	6-9	-	7	7	8	8
9	DO		mg/L	7,4	7,4	2,9	4,2

The DO value at the D-15-WPS-Pipe point was still different from the control, with a lower DO value. This lower DO value was also directly proportional to the higher BOD value at that sampling point. For the D-15-WPS-Nipple point, the DO content was higher, and the BOD value was lower.

The pattern of lower DO and BOD values at the sampling points on the pipe after WPS treatment (D-0-WPS-Pipe and D-15-WPS-Pipe) is similar to the results from the sampling on day 0. As previously explained, the oxygen content is still unstable due to the new water storage tank and the new WPS condition. Therefore, it is necessary to conduct further water sampling to determine whether the influence of the water storage tank and the WPS device no longer affects the dissolved oxygen content in the water.

The results of the water quality analysis on day 30 for the physical and chemical parameters of the water samples, both untreated and treated with WPS, showed that all measured parameters, except for BOD5, were below the referenced quality standards. The BOD5 values in all samples were higher compared to the analysis results on days 0 and 15. The results for Day-30 water quality analysis were displayed on Table 3 below.

Table 3. Layer farm water quality Day-30

No.	Parameters	Regulation	Unit	Result			
				D-30 Control-Pipe	D-30 Control-Nipple	D-30 WPS-Pipe	D-30 WPS-Nipple
1	Color	100	TCU	1	4	2	6
2	TDS +	1.000	mg/L	88	89	89	92
3	TSS +	100	mg/L	<2	<2	<2	<2
4	Amonia (NH_3) +	0,5	mg/L	<0,1	<0,1	<0,1	<0,1
5	COD	40	mg/L	<0,8	<0,8	<0,8	<0,8
6	BOD 5	6	mg/L	6	5	8	9
7	Free Chlorine +	0,03	mg/L	0,03	0,02	0,02	0,02
8	pH +	6-9	-	7	7	7	7
9	DO		mg/L	3,4	4	2,6	4

The trend of BOD5 values at the control and treated points on days 0 and 15 was lower compared to day 30. This could be due to the concentration of organic matter in the soil, resulting from lower rainfall, as it rained infrequently during the month of the experiment. In other words, the reduced groundwater flow led to an accumulation of dissolved organic matter in the well water.

This is consistent with the lower DO values observed on day 30 compared to days 0 and 15 at all sampling points. The lower measured DO values reflect a higher oxygen demand for decomposing the dissolved organic matter in the water samples. Similar to the results on days 0 and 15, after treatment with the WPS device, the BOD5 values were higher compared to the BOD5 content in the control samples. As is known, the source of clean water is an artesian well, which minimizes contact with the atmosphere. To increase the DO levels in the well water, aeration should be conducted so that the initial DO load is reduced, which would, in turn, lower the BOD5 values.

Water Microbial Quality

The microbial quality of the water will focus on key pathogens, including qualitative coliform, *E. coli*, *Enterobacter*, *Salmonella*, and *Shigella*. These bacteria are of significant concern due to their potential to cause diseases in both humans and chickens, leading to serious health and economic impacts. The following table (Table 4) outlines the diseases caused by these bacteria in humans and chickens.

Table 4. Diseases caused by various bacteria in humans and chickens

Bacteria	Diseases in Humans	Diseases in Chickens	Diseases in Both
E. coli	Urinary tract infections (UTIs), Gastroenteritis (food poisoning), Neonatal Meningitis, Hemolytic uremic syndrome (HUS)	Colibacillosis (infection in various organs)	Enteritis (intestinal inflammation)
Enterobacter	UTIs, Respiratory Infections, Bacteremia (bacteria in the blood), Meningitis (rare)	Opportunistic Infections	-
S. aureus	Skin Infections (boils, impetigo, cellulitis), Pneumonia, Endocarditis (infection of the heart valves), Toxic shock syndrome (TSS), Food Poisoning	Bumblefoot (foot infections), Joint Infections (arthritis)	-
S. epidermidis	Opportunistic Infections (in people with compromised immune systems)	Opportunistic Infections (rare)	-
Salmonella	Gastroenteritis, Typhoid Fever, Paratyphoid Fever	Salmonellosis	Salmonellosis (foodborne illness from contaminated poultry products)
Shigella	Shigellosis (bacillary dysentery), Severe diarrhea with blood and mucus	None	-

Four sampling points were used: untreated water with WPS at the pipe (No WPS-Pipe); untreated water with WPS at the nipple (No WPS-Nipple); treated water with WPS (WPS-Pipe); treated water with WPS at the nipple (WPS-Nipple). The results of the water microbial quality analysis were presented on Table 5.

Table 5. Layer farm water microbial quality

Parameter	Days	No WPS (Log CFU/mL)		WPS (Log CFU/mL)	
		Pipe	Nipple	Pipe	Nipple
Coliform	0	210	<3,6	7,4	27
	15	43	<3,6	<3,6	<3,6
	30	7.4	9.2	<3.6	<3.6
E. coli	0	Negative	Negative	Negative	Negative
	15	-0,40	Negative	Negative	Negative
	30	Negative	Negative	Negative	Negative
Enterobacter	0	1,53	1,02	Negative	0,91
	15	1,42	0,70	Negative	0,73
	30	0.13	1.23	Negatif	0.08
Salmonella	0	0,99	Negative	Negative	Negative
	15	Negative	Negative	Negative	Negative
	30	Negative	Negative	Negative	Negative
Shigella	0	1,20	0,97	Negative	0,45
	15	Negative	Negative	Negative	Negative
	30	Negative	Negative	Negative	Negative

On Day 0, the microbial quality of water samples from the layer farm showed the presence of several types of bacteria. Coliform levels were recorded at 210 MPN/mL in the pipe without the Panasonic water purifying system (WPS) and 74 MPN/mL in the pipe with WPS. Nipple samples showed lower coliform levels, with <36 MPN/mL in both systems. For *E. coli*, all samples tested negative regardless of the WPS presence. *Enterobacter* was found in higher concentrations in the pipes, with 153 Log CFU/mL without WPS and 91 Log CFU/mL with WPS. *Salmonella* was detected only in the pipe without WPS (99 Log CFU/mL). *Shigella* was also found in both the pipe (120 Log CFU/mL) and nipple (97 Log CFU/mL) without WPS but was absent in the WPS samples.

By Day 15, there was a significant reduction in the microbial counts. Coliform bacteria were reduced to 43 MPN/mL in the pipe without WPS and remained at <36 MPN/mL in all other samples. *E. coli* continued to test negative across all samples. *Enterobacter* levels decreased to 142 Log CFU/mL in the pipe without WPS and 70 Log CFU/mL in the nipple without WPS, while remaining undetected in samples with WPS. *Salmonella* and *Shigella* were both negative across all samples, indicating effective control measures or natural decline over time.

On Day 30, the microbial quality showed further improvement. Coliform levels were reduced significantly, with only 7.4 MPN/mL in the pipe and 9.2 Log MPN/mL in the nipple without WPS, while both remained at <3.6 Log MPN/mL with WPS. *E. coli* continued to be absent in all samples. *Enterobacter* levels were extremely low, with 0.13 Log CFU/mL in the pipe and 1.23 Log CFU/mL in the nipple without WPS, and remained undetectable in samples with WPS. Both *Salmonella* and *Shigella* were undetectable across all samples, showing effective elimination or control.

The study indicates that the Panasonic WPS effectively reduces the presence of harmful bacteria in farm water over time. By Day 30, most pathogens, including Coliforms, *Enterobacter*, *Salmonella*, and *Shigella*, were either undetectable or present at very low levels, especially in samples with WPS. The consistent absence of *E. coli* suggests the effectiveness of the purification methods in maintaining water quality. Overall, the use of WPS contributes significantly to improving the microbial quality of water in layer farms, ensuring safer conditions and clean drinking water for layer hens.

Layer Farm Production Performance

This research was conducted over a period of 30 days with 2000 commercial layer hens of the ISA Brown strain, aged 57 weeks. The report covers aspects of production performance and egg quality produced by the hens during the observation period of the first 15 days and at the end of the study on day 30. The results obtained are presented in Table 6.

From the table, the number of hens that died under the water filtering system (WPS) treatment decreased by 50% over the 15-day observation period. At the end of the observation period (30 days), the number of hens that died was 4. In the WPS treatment group, only 1 hen died (25%), whereas in the no water filtering (No WPS) treatment group, 3 hens died (75%). The deaths were characterized by dull plumage, emaciation, and sticky feathers around the cloaca. According to Ballo et al. (2023), these conditions are clinical symptoms of colibacillosis, a disease caused by *Escherichia coli* infection through drinking water.

Table 6. Average production performance of commercial laying hens during 15 days of rearing and 30 days of rearing

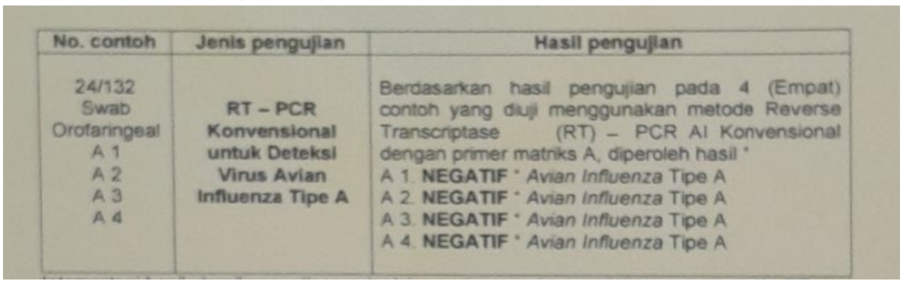
Variables	**15 days treatment**		**30 days treatment**	
	No WPS	**WPS**	**No WPS**	**WPS**
Mortality (bird)	2	1	3	1
Henday production (%)	87,14	89,06	86,78	88,86
Egg mass (g/egg)	63,78	63,81	64,08	63,83
Total egg production (kg)	56,10	57,50	56	57,4
FCR	2,12	2,07	2,13	2,08

The egg weight produced by hens receiving water filtering treatment and those without filtering is almost the same. Egg production and egg mass in hens with water filtering treatment (WPS) showed an increase compared to those in hens without filtering (No WPS) during both the first 15 days and up to the 30-day observation period. This resulted in a lower Feed Conversion Ratio (FCR) in hens receiving water filtering treatment (WPS), both at the 15-day mark and at the end of the observation period (day 30). At the end of the observation, the FCR value in the water filtering treatment (WPS) was lower (2.08) compared to that in the no filtering treatment (No WPS) which was 2.13. A lower FCR value indicates better feed efficiency. This suggests that the hens are healthier because the exposure to *E. coli* and other pathogens in drinking water is reduced due to the filtering process.

The results presented in Table 6 show that commercial layer hens treated with the Panasonic-produced WPS water filtering system exhibited positive performance in production. This could positively correlate with increased income for commercial layer poultry farmers.

RT-PCR sampling results from both untreated and treated cages revealed that Avian Influenza (AI) was not detected in any of the samples. This finding indicates that the presence of AI was absent in both conditions. Figure 2 illustrates the results of these RT-PCR tests.

Figure 2. RT-PCR results on Avian Influenza



No. contoh	Jenis pengujian	Hasil pengujian
24/132 Swab Orofaringeal A 1 A 2 A 3 A 4	RT – PCR Konvensional untuk Deteksi Virus Avian Influenza Tipe A	Berdasarkan hasil pengujian pada 4 (Empat) contoh yang diuji menggunakan metode Reverse Transcriptase (RT) – PCR AI Konvensional dengan primer matriks A, diperoleh hasil * A 1. **NEGATIF** * *Avian Influenza* Tipe A A 2. **NEGATIF** * *Avian Influenza* Tipe A A 3. **NEGATIF** * *Avian Influenza* Tipe A A 4. **NEGATIF** * *Avian Influenza* Tipe A

Egg Physical Quality

The results of laboratory tests on the physical quality of eggs produced by hens, which received treatment for 15 days and at the end of the study (day 30), are presented in Table 7.

Table 7. Average physical quality of eggs during 15 and 30 days of observation

Parameter	Day 0	Day 15		Day 30	
		No WPS	WPS	No WPS	WPS
Haugh Unit	84,61	88,87	95,99	83,55	81,78
Egg Yolk (%)	25,55	25,33	25,31	26,21	27,25
Egg White (%)	62,64	62,33	62,46	61,16	61,05
Egg Shell (%)	11,81	12,34	12,24	12,63	11,70

The HU (Haugh unit) values of eggs produced by the hens at the beginning of the observation, on day 15, and on day 30 were similar. All eggs produced in this study were of AA grade quality (USDA, 2002). Similarly, the percentage values of egg yolk, egg white, and egg shell across these observation periods were comparable between hens with water filtering treatment (WPS) and those without filtering (No WPS), and all fell within the normal range. This consistency is attributed to the fact that the age of the hens, the quality of the feed, and the microenvironment of the hens during the study were uniform.

Egg Nutritional Quality

The results of proximate analysis and chloride content analysis of eggs produced by chickens during the research period are presented in the following table:

Table 8. Results of proximate analysis and chloride content analysis of eggs

Parameter	Day 0	Day 15		Day 30	
		No WPS	WPS	No WPS	WPS
Water (%)	76,81	76,94	76,34	76,9	76,77
Ash (%)	0,83	0,82	0,84	0,89	0,84
Fat (%)	8,10	7,88	8,56	7,92	8,11
Protein (%)	13,10	10,48	11,81	12,98	12,23
Chloride (mg/100g)	65,11	65,35	63,43	80,91	78,78

The percentages of water, ash, fat, and protein in the eggs produced in this study, as determined by proximate analysis on days 0, 15, and 30, showed values that were similar and within the normal range. These nutritional values of the eggs are influenced not only by the feed and environmental conditions but also significantly by genetic factors.

Samsuar et al. (2017) stated that the regulation in Indonesia allows a maximum dose of chlorine, either from sodium hypochlorite or calcium hypochlorite, of 820 mg and 360 mg per 100 g of food, respectively. Without water filtering treatment, the hens produced eggs with increasing levels of chloride residue over the 30-day period. The water filtering treatment (WPS) significantly reduced chloride residue in the eggs. Therefore, the water filtering treatment for hens clearly results in healthier eggs.

Egg Microbial Quality

Egg microbial quality measures qualitative coliform, *E. coli, Enterobacter, S. aureus, S. epidermidis*, *Salmonella,* and *Shigella*. The results of the egg microbial quality analysis were presented on Table 9.

Table 9. Layer farm egg microbial quality

Parameter	Days	Non-WPS (Log CFU/mL)	WPS (Log CFU/mL)
Coliform	0	<3,6	<3,6
	15	<3,6	<3,6
	30	<3.6	<3.6
E. coli	0	Negative	Negative
	15	Negative	Negative
	30	Negative	Negative
Enterobacter	0	-0,16	0,17
	15	1,57	0,76
	30	Negative	Negative
S. aureus	0	0,14	0,15
	15	0,81	0,49
	30	Negative	Negative
S. epidermidis	0	0,32	0,35
	15	1,04	0,94
	30	1.02	0.82
Salmonella	0	Negative	Negative
	15	Negative	Negative
	30	Negative	Negative
Shigella	0	Negative	Negative
	15	Negative	Negative
	30	Negative	Negative

On Day 0, the microbial quality of eggs from laying hens that drank water from the untreated (non-WPS) and Panasonic water purifying system (WPS) sources showed minimal pathogen presence. Coliform bacteria were undetectable (<3,6 MPN/mL) in both the non-WPS and WPS groups. *E. coli* was absent in all samples. *Enterobacter* was detected in very low amounts in the non-WPS group (-0,16 Log CFU/mL) and slightly higher in the WPS group (0,17 Log CFU/mL). *Staphylococcus aureus* (*S. aureus*) levels were similar, with 0,14 Log CFU/mL in non-WPS and 0,15 Log CFU/mL in WPS samples. *Staphylococcus epidermidis* (*S. epidermidis*) was present at 0,32 Log CFU/mL in non-WPS and 0,35 Log CFU/mL in WPS samples. *Salmonella* and *Shigella* were not detected in any samples from either group.

By Day 15, the pathogen levels in the egg samples increased slightly but remained relatively low. Coliform bacteria continued to be undetectable (<3,6 MPN/mL) in both groups. *E. coli* remained negative across all samples. *Enterobacter* increased to 1,57 Log CFU/mL in non-WPS and 0,76 Log CFU/mL in WPS samples. *S. aureus* levels rose to 0,81 Log CFU/mL in non-WPS and 0,49 Log CFU/mL in WPS samples. *S. epidermidis* also increased, reaching 1,04 Log CFU/mL in non-WPS and 0,94 Log CFU/mL in WPS samples. *Salmonella* and *Shigella* continued to test negative in all samples, indicating no contamination from these pathogens.

On Day 30, there was a marked improvement in the microbial quality of the eggs. Coliform levels dropped further to <3,6 MPN/mL in both non-WPS and WPS groups. *E. coli* remained absent. *Enterobacter* became undetectable in both groups, as did *S. aureus*. *S. epidermidis* levels decreased significantly to 1,02 Log CFU/mL in non-WPS and 0,82 Log CFU/mL in WPS samples. *Salmonella* and *Shigella* continued to be absent, demonstrating the effectiveness of the water purifying system in reducing pathogen load over time.

The results suggest that using the Panasonic WPS for the drinking water of laying hens contributes to maintaining a lower pathogen load in eggs over time compared to untreated water. The SNI standard for good quality eggs requires a maximum population of $1x10^1$ CFU/g of *Enterobacteriaceae* and negative *Salmonella* spp. By Day 30, most pathogens, including *Enterobacter*, *S. aureus*, and *E. coli*, were undetectable, particularly in the WPS group, indicating a reduction in contamination risk. The consistent absence of *Salmonella* and *Shigella* throughout the study further supports the effectiveness of the WPS in enhancing microbial safety. Overall, providing hens with clean, filtered water using WPS can significantly improve the microbial quality of eggs, promoting food safety and public health.

CONCLUSIONS

For 30 days of drinking water treatment in laying hens with filtration (WPS) resulted in:

1. Improved water physical quality
2. Significantly enhances the microbial quality of water and egg (lower overall levels of coliform, *E. coli, Enterobacter, S. aureus, S. epidermidis*, *Salmonella,* and *Shigella*)
3. Improved egg production performance (FCR was reduced by up to 0,5 and mortality was reduced by up to 67%)
4. Produce healthier eggs (lower chloride residue levels, <360 mg per 100 g of food)

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III. STUDY ON LAYER CHICKEN

METHOD

The study on the effect of the Panasonic WPS on commercial laying hens was conducted from June 21, 2024, to July 21, 2024. This study took place at Wayan Broiler Farm, a privately owned broiler farm located on the Rancabungur, Bogor. The farm uses water sourced from natural spring. The collected water were then subjected to simple "kaporit" (chlorine/ $Ca(ClO)_2$) treatment before being fed to the chicken.

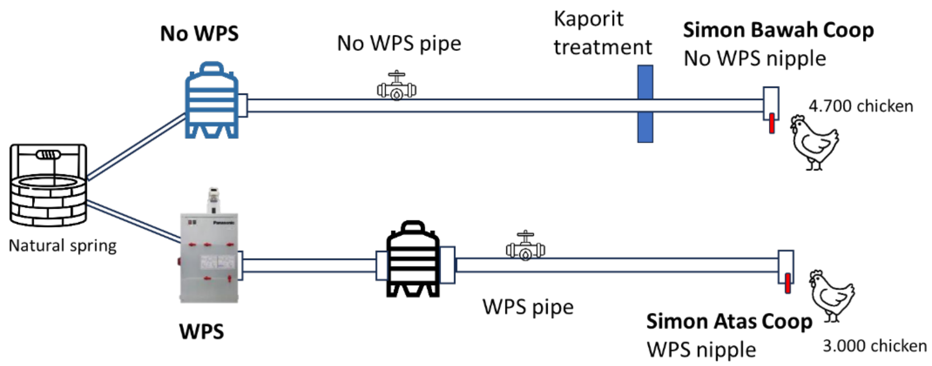

Figure 1. Experiment design on broiler farm

This study compares the effects of drinking water treated using the Water Purification System (WPS) with kaporit treated water (No WPS). The study was carried out over a 30-day period on 7.700 broiler chickens reared from DOC (4.700 for control and 3.000 for treatment). Sampling were done on Day 0, Day 15, and Day 30. The results cover aspects of water quality, production performance, and carcass quality. The experiment design on broiler farm is shown on Figure 1.

Water Quality Analysis

Water quality measurements include physical quality parameters such as color, TDS, TSS, ammonia (NH_3), COD, BOD, free chlorine, pH, and DO. The microbial quality of the water will focus on key pathogens, including qualitative coliform, *E. coli*, *Enterobacter*, *Salmonella*, and *Shigella*. The analysis procedures follow the International Standard AOAC (2005) and SNI. Physical quality analysis and microbial analysis were done using three replications for each treatment.

Production Performance Analysis

The parameters observed for production performance included feed consumption, total harvest weight, FCR (feed conversion ratio), mortality, and performance index. All parameters were observed daily for a total of 30 days. The collected data were then subjected to statistical analysis. Random sampling for Avian Influenza was done using RT-PCR.

Carcass Quality Analysis

Carcass quality measurements include nutritional quality parameters which comprised of water, ash, fat, and protein percentages, obtained through proximate analysis. Residual chloride (mg/100g) was also measured. Carcass microbial quality measures qualitative coliform, *E. coli, Enterobacter, S. aureus, S. epidermidis*, *Salmonella,* and *Shigella* from the chicken breast meat. In the initial proposal, we intended to analyze only the microbial content of chicken meat. However, during the research process, we hypothesized that pathogenic microbes could infect the gastrointestinal tract and impact mortality rates. Therefore, we also analyzed the pathogenic microbial content in the chicken intestine.

The analysis procedures follow the International Standard AOAC (2005) and SNI. Analyses were done using thirty replications for nutritional and microbial analysis.

RESULTS AND DISCUSSIONS

Water Physical Quality

In the broiler chicken coop, spring water is used as a clean water source for drinking and other needs, such as washing and spraying in the coop. This water is not subjected to special treatment, such as physical processes like sedimentation and filtration, or chemical treatments like the addition of coagulants for floc formation or aeration to increase dissolved oxygen levels in the water. However, the farmer adds chlorine at certain times, such as when there is an increase in the bacterial count in the water. Given that the water used comes from a spring with a relatively low water table, the potential for contamination from surrounding areas is high.

In this study, water samples were collected from several points at different times. Sampling was conducted on days 0, 15, and 30 during midday under clear weather conditions. Nine parameters were analyzed: color, TDS, TSS, ammonia, COD, BOD5, free chlorine, pH, and DO. The results of the water quality analysis were compared to government regulations, specifically PP No. 22 of 2021, Appendix 6, River Water Quality Standards, Class 3 for Fisheries and Livestock.

Water sampling points were selected from three different sources: untreated water, water that had passed through the WPS device, and water from the nipple drinker. Four sampling points were used: untreated water from the pipe on day 0 (D-0-Control-Pipe), untreated water from the nipple on day 0 (D-0-Control-Nipple), water treated with WPS from the pipe on day 0 (D-0-WPS-Pipe), and water treated with WPS from the nipple on day 0 (D-0-WPS-Nipple). For sampling on day 15, the labels were D-15-Control-Pipe, D-15-Control-Nipple, D-15-WPS-Pipe, and D-15-WPS-Nipple. Similarly, for day 30, the labels were D-30-Control-Pipe, D-30-Control-Nipple, D-30-WPS-Pipe, and D-30-WPS-Nipple. It should be noted that no chlorine was added on day 0, while the farmer added chlorine on days 15 and 30.

Table 1. Broiler farm water quality Day-0

No.	Parameters	Regulation	Unit	Result			
				D-0 Control-Pipe	D-0 Control-Nipple	D-0 WPS-Pipe	D-0 WPS-Nipple
1	Color	100	TCU	1	1	11	<1
2	TDS +	1.000	mg/L	44	45	44	54
3	TSS +	100	mg/L	<2	<2	<2	<2
4	Amonia (NH_3) +	0,5	mg/L	<0,1	<0,1	<0,1	<0,1
5	COD	40	mg/L	<0,8	<0,8	<0,8	<0,8
6	BOD 5	6	mg/L	3	4	7	3
7	Free Chlorine +	0,03	mg/L	0,02	0,01	0,02	0,01
8	pH +	6-9	-	5	6	5	7
9	DO		mg/L	4.3	4.5	5.4	5.0

The water quality analysis on day 0 (Table 1) for the physical and chemical parameters of the untreated and WPS-treated water samples showed that all measured parameters were below the referenced quality standards. However, there were some parameters of concern due to differences in their values, specifically pH and BOD. The pH levels at the D-0-Control-Pipe and D-0-WPS-Pipe points were one unit lower than the other two sampling points. Additionally, the BOD value at D-0-WPS-Pipe exceeded the quality standard, although the increase was relatively small. Despite this, the DO value was relatively high, indicating that the water contained sufficient oxygen to oxidize the dissolved organic matter.

The water quality analysis on day 15 (Table 2) for the physical and chemical parameters of the untreated and WPS-treated water samples showed differences in pH, free chlorine, BOD, and COD values compared to day 0. In contrast, the parameters for color, TDS, TSS, and ammonia remained below the quality standards. The DO levels remained relatively constant, with a high oxygen solubility, which is favorable for the oxidation of organic matter present in the water.

Table 2. Layer farm water quality Day-15

No.	Parameters	Regulation	Unit	Result			
				D-15 Control-Pipe	D-15 Control-Nipple	D-15 WPS-Pipe	D-15 WPS-Nipple
1	Color	100	TCU	1,0	1,0	2	15,0
2	TDS +	1.000	mg/L	42	50	50	61
3	TSS +	100	mg/L	2	<2	<2	<2
4	Amonia (NH_3) +	0,5	mg/L	<0,1	<0,1	<0,1	<0,1
5	COD	40	mg/L	<0,8	<0,8	<0,8	89
6	BOD 5	6	mg/L	7	5,0	7,0	12,0
7	Free Chlorine +	0,03	mg/L	0,02	0,02	0,01	0,91
8	pH +	6-9	-	5	4	4	4
9	DO		mg/L	5,6	5,8	5,60	5,45

However, it is important to note that there was a change in pH values, with a decrease of up to 2 units at three sampling points, bringing the pH below the established quality standards. This drop in pH may be due to the addition of chemicals, such as chlorine, which can contribute hypochlorite ions, making the water more acidic. This is consistent with the BOD values, which were more than double the standard limits, indicating an increase in organic matter content in the water. The spike in organic content was particularly evident at the D-15-WPS-Nipple point, as reflected by the COD value. The high level of organic matter may be attributed to dead bacteria resulting from the chlorine treatment. The addition of chemicals also contributed to the presence of free chlorine, which introduced a strong odor in the water. Compared to the water samples from day 0, the free chlorine levels increased sharply, rising up to 30 times the threshold limit set by the quality standards.

The water quality analysis on day 30 (Table 3) at the D-30-Control-Pipe and D-30-Control-Nipple sampling points showed that the parameters for color, TDS, TSS, ammonia, COD, and free chlorine were still below the quality standards. However, the BOD and pH values were below the required standards. The higher BOD compared to COD suggests that the dissolved oxygen (DO) in the water can naturally oxidize the organic matter present. This is further supported by the high DO levels measured at the D-30-Control-Pipe and D-30-Control-Nipple points. Nonetheless, the pH values were 2 units lower than the quality standards, which could be due to natural contamination by organic matter seeping into the spring.

Table 3. Layer farm water quality Day-30

No.	Parameters	Regulation	Unit	Result			
				D-30 Control-Pipe	D-30 Control-Nipple	D-30 WPS-Pipe	D-30 WPS-Nipple
1	Color	100	TCU	<1	<1	2	<1
2	TDS +	1.000	mg/L	41	56	56	56
3	TSS +	100	mg/L	<2	<2	<2	<2
4	Amonia (NH_3) +	0,5	mg/L	<0,1	<0,1	<0,1	<0,1
5	COD	40	mg/L	<0,8	<0,8	38	156
6	BOD 5	6	mg/L	10	9,0	6,5	5,0
7	Free Chlorine +	0,03	mg/L	0,01	0,01	0,40	3,23
8	pH +	6-9	-	5	4	4	4
9	DO		mg/L	6,25	6	5,90	6,3

At the D-30-WPS-Pipe and D-30-WPS-Nipple sampling points, parameters such as color, TDS, TSS, and ammonia were below the required quality standards. However, at these two points, the measured free chlorine levels spiked sharply compared to the two control points, reaching 13 to 108 times the threshold set by the quality standards. This increase in free chlorine was due to the addition of chlorine at these points to prevent a rise in coliform bacteria in the water. Additionally, the strong chlorine odor detected in these water samples further indicated high free chlorine content. As previously explained, the addition of chlorine can lead to a decrease in pH, which was observed here, with pH values dropping by 2 units compared to the required quality standard.

The increase in coliform levels in the water contributes to a higher organic content, which is reflected in the elevated BOD and COD values. This can be observed at the D-30-WPS-Nipple point, where the COD value increased by up to four times the required quality standard. When compared to the COD values at the two control points, the COD at this point surged by 195 times. Similarly, at the D-30-WPS-Pipe point, although the COD value was close to the upper limit of the required standard, it showed a sharp increase compared to the control point, nearly 50 times higher.

As known, the clean water source is a spring, which means there is a significant chance of exposure to the atmosphere, resulting in consistently high DO levels. However, it is important to note that the relatively low water table increases the potential for contamination from surrounding sources, such as organic waste, which can stimulate bacterial growth in the water.

Water Microbial Quality

The microbial quality of the water will focus on key pathogens, including qualitative coliform, *E. coli*, *Enterobacter*, *Salmonella*, and *Shigella*. These bacteria are of significant concern due to their potential to cause diseases in both humans and chickens, leading to serious health and economic impacts.

Four sampling points were used: untreated water with WPS at the pipe (No WPS-Pipe); untreated water with WPS at the nipple (No WPS-Nipple); treated water with WPS (WPS-Pipe); treated water with WPS at the nipple (WPS-Nipple). The results of the water microbial quality analysis were presented on Table 5.

Table 5. Broiler farm water microbial quality

Parameter	**Days**	**No WPS (Log CFU/mL)**		**WPS (Log CFU/mL)**	
		Pipe	**Nipple**	**Pipe**	**Nipple**
Coliform	0	Negative	43	Negative	Negative
	15	9.2	Negative	Negative	Negative
	30	3.6	3.6	Negative	Negative
E. coli	0	Negative	Negative	Negative	Negative
	15	Negative	0.70	Negative	Negative
	30	Negative	Negative	Negative	Negative
Enterobacter	0	2.28	2.23	0.94	1.44
	15	Negative	Negative	Negative	Negative
	30	Negative	Negative	Negative	Negative
Salmonella	0	Negative	1.60	Negative	Negative
	15	Negative	Negative	Negative	Negative
	30	Negative	Negative	Negative	Negative
Shigella	0	Negative	1.84	Negative	Negative
	15	0.40	Negative	Negative	Negative
	30	Negative	Negative	Negative	Negative

On Day 0, the microbial quality of water samples from the broiler farm showed varying levels of bacteria depending on whether the water was treated with the Panasonic WPS or left untreated (no WPS). Coliform bacteria were detected only in the nipple samples without WPS at 43 MPN/mL, while all other samples, including those with WPS, were negative. *E. coli* was absent in all samples regardless of WPS presence. *Enterobacter* was present in both pipe and nipple samples without WPS at 2,28 Log CFU/mL and 2,23 Log CFU/mL, respectively, and at lower levels in WPS samples (0,94 Log CFU/mL in the pipe and 1,44 Log CFU/mL in the nipple). *Salmonella* and *Shigella* were found in the nipple samples without WPS, at 1,60 Log CFU/mL and 1,84 Log CFU/mL, respectively, while being undetected in all WPS samples.

By Day 15, there was a noticeable reduction in the bacterial levels in the water samples. Coliform bacteria were reduced to 9,2 MPN /mL in the pipe without WPS, while all other samples, including those with WPS, tested negative. *E. coli* was still absent except for a slight detection of 0,70 Log CFU/mL in the nipple without WPS. *Enterobacter* levels dropped to undetectable levels across all samples, indicating effective control or natural decline of the bacteria. Both *Salmonella* and *Shigella* were negative in all samples, suggesting a significant improvement in microbial quality.

On Day 30, the water quality continued to improve. Coliform bacteria were detected at a minimal level of 3,6 MPN /mL in both pipe and nipple without WPS, while they remained undetectable in all WPS samples. *E. coli*, *Enterobacter*, *Salmonella*, and *Shigella* were all absent across all samples, indicating that the water was free from these pathogens by the end of the study period.

The study results indicate that using the Panasonic WPS in broiler chicken farms effectively reduces harmful bacteria in drinking water over time. By Day 30, most pathogens, including Coliforms, *Enterobacter*, *Salmonella*, and *Shigella*, were undetectable in the WPS-treated samples, demonstrating the system's efficiency in maintaining water quality. The consistent absence of *E. coli* throughout the study further emphasizes the purification system's effectiveness. Overall, the use of WPS significantly enhances the microbial safety of drinking water in broiler farms, contributing to healthier conditions for the chickens.

Broiler Farm Production Performance

The number of day-old chicks (DOC) in this study was 7.700. Of these, 3.000 chicks were provided with water treated through filtration (WPS), while 4.700 chicks were given water without filtration (No WPS). Different strains of chickens were used for the study: the WPS treatment used the BBMS strain, while the No WPS treatment used the NewHope BM strain. The observations on the average performance of the broiler chickens from the beginning of rearing until harvest (average harvest age of 26 days) are presented in the following table:

Table 6. Average performance of broiler chicken (average harvest age of 26 days)

Variables	No WPS	WPS
Feed consumption (kg/bird)	1,51	1,59
Harvest weight (kg/bird)	1,09	1,05
FCR	1,38	1,51
Mortality (%)	6,30[a]	3,67[b]
Performance Index	279	250

Different letters in the same row indicate statistically significant differences as determined by the t-test.

From the table above, it is evident that the average feed consumption, average body weight, FCR, and performance index of broiler chickens provided with water through filtration (WPS) and without filtration (No WPS) were not statistically significant. However, the WPS treatment significantly reduced the mortality rate. The mortality rate from the start of rearing to harvest was 3.67% for the WPS treatment and 6.30% for the No WPS treatment. Most of the deaths occurred after 14 days of age. In the water from the nipple drinkers in the No WPS treatment, *Salmonella sp.* was found with a concentration of 1.60 Log CFU/mL. This bacterium is highly pathogenic. Additionally, *E. coli* and *Shigella* were also detected in the water for the No WPS treatment.

RT-PCR sampling results from both untreated and treated coops revealed that Avian Influenza (AI) was not detected in any of the samples (Figure 2). This finding indicates that the presence of AI was absent in both conditions.

Figure 2. RT-PCR results on Avian Influenza

No. contoh	Jenis pengujian	Hasil pengujian
24/148 Swab Orofaringeal B 1 B 2 B 3 B 4	**RT – PCR Konvensional untuk Deteksi Virus Avian Influenza Tipe A**	Berdasarkan hasil pengujian pada 4 (Empat) contoh yang diuji menggunakan metode Reverse Transcriptase (RT) – PCR AI Konvensional dengan primer matriks A, diperoleh hasil " B 1. **NEGATIF** " *Avian Influenza* Tipe A B 2. **NEGATIF** " *Avian Influenza* Tipe A B 3. **NEGATIF** " *Avian Influenza* Tipe A B 4. **NEGATIF** " *Avian Influenza* Tipe A

Carcass Nutritional Quality

The results of the proximate analysis regarding the nutritional content of broiler chicken meat and the Cl residue levels are presented in the table below:

Table 7. Results of proximate analysis and chloride content analysis of eggs

Variable	No WPS	WPS
Water (%)	74,47	74,85
Ash (%)	1,37	1,39
Fat (%)	0,49	0,51
Protein (%)	23,64	23,69
Chloride (mg/100g)	44,05	28,03

The proximate analysis of broiler chicken meat at harvest (average age of 26 days) revealed that the levels of moisture, ash, fat, and protein from the water filtration (WPS) treatment and the no filtration (No WPS) treatment were not statistically different. The nutritional content of the chicken meat is influenced not only by the genetic quality of the livestock but also significantly by the nutritional content of the feed. This aligns with Ensminger et al. (2004), who stated that broiler productivity up to 6 weeks of age is affected by genetic factors (45%) and non-genetic factors (55%), including the quality of feed nutrition.

Samsuar et al. (2017) stated that the regulation in Indonesia allows a maximum dose of chlorine, either from sodium hypochlorite or calcium hypochlorite, of 820 mg and 360 mg per 100 g of food, respectively. Broiler chickens provided with water through filtration (WPS) from day one until harvest (average age of 26 days) produced meat with significantly lower chloride residue (28,03 mg/100 g) compared to those without filtration (No WPS), which had a residue of 44,05 mg/100 g. Thus, the use of water filtration with WPS resulted in healthier meat.

Carcass Microbial Quality

Carcass microbial quality measures qualitative coliform, *E. coli, Enterobacter, S. aureus, S. epidermidis*, *Salmonella,* and *Shigella*. The meat samples for analysis were taken from the breast section. The results were presented on Table 8.

Table 8. Chicken meat microbial quality

Parameter	Days	Non-WPS (Log CFU/mL)	WPS (Log CFU/mL)
Coliform	30	5,84	3,97
E. coli	30	0,11 ± 0,14	-0,09 ± 0,14
Enterobacter	30	0,66 ± 0,57	0,23 ± 0,29
S. aureus	30	1,02 ± 0,12	0,82 ± 0,41
S. epidermidis	30	1,98 ± 0,15	1,79 ± 0,09
Salmonella	30	Negative	Negative
Shigella	30	1,19 ± 0,28	0,61 ± 0,13

The microbial quality of chicken breast meat from broiler chickens showed significant differences between samples from those given untreated water (non-WPS) and those given water treated with the Panasonic WPS. Coliform levels were higher in the non-WPS samples at 584 MPN/mL, compared to 397 MPN/mL in the WPS-treated samples, indicating that the purified water helped reduce coliform contamination. *E. coli* levels were slightly detected in non-WPS samples (0,11 ± 0,14 Log CFU/mL), while they were nearly undetectable in the WPS samples (-0,09 ± 0,14 Log CFU/mL), suggesting a better safety profile in the treated group. *Enterobacter* levels were also higher in the non-WPS samples (0,66 ± 0,57 Log CFU/mL) compared to 0,23 ± 0,29 Log CFU/mL in WPS samples, further demonstrating the effectiveness of WPS in reducing microbial contamination. *Staphylococcus aureus* (*S. aureus*) levels were found at 1,02 ± 0,12 Log CFU/mL in the non-WPS samples, whereas they were slightly lower in WPS samples (0,82 ± 0,41 Log CFU/mL). *Staphylococcus epidermidis* (*S. epidermidis*) showed a similar trend, with higher levels in non-WPS samples (1,98 ± 0,15 Log CFU/mL) compared to WPS samples (1,79 ± 0,09 Log CFU/mL). *Salmonella* was undetectable in both groups, reflecting effective control of this pathogen in both treated and untreated water conditions. *Shigella* levels were notably reduced in WPS samples (0,61 ± 0,13 Log CFU/mL) compared to non-WPS samples (1,19 ± 0,28 Log CFU/mL), highlighting the benefits of using purified water. Overall, the use of the Panasonic WPS resulted in a noticeable reduction in various pathogenic bacteria in chicken breast meat.

Table 9. Intestine microbial quality

Parameter	Days	Non-WPS (Log CFU/mL)	WPS (Log CFU/mL)
Coliform	30	Not analyzed	Not analyzed
E. coli	30	1,91 ± 0,14	1,61 ± 0,32
Enterobacter	30	2,27 ± 0,14	2,01 ± 0,13
S. aureus	30	Not analyzed	Not analyzed
S. epidermidis	30	Not analyzed	Not analyzed
Salmonella	30	-0,002 ± 0,100	Negative
Shigella	30	2,43 ± 0,46	2,02 ± 0,15

The microbial quality of the chicken intestine was analyzed to assess the potential impact of pathogenic microbes on the gastrointestinal tract and mortality rates. The result of the microbial analysis of chicken intestines are shown below on Table 9. The results showed that *Salmonella*, a key pathogen linked to higher mortality rates, was slightly present in the intestines of chickens drinking untreated water (non-WPS) at -0,002 ± 0,100 Log CFU/mL, whereas it was completely undetectable in the chickens drinking WPS-treated water. This finding supports the hypothesis that untreated water can increase the risk of *Salmonella* infection, which may contribute to higher mortality rates. In addition, other pathogens such as *E. coli* and *Shigella* were also found at higher levels in the non-WPS group compared to the WPS group, indicating that purified water helps in reducing overall pathogenic load in the intestines. These results suggest that using WPS-treated water can significantly lower the presence of harmful bacteria, potentially reducing infection risks and improving the overall health and survival of chickens.

CONCLUSIONS

For 30 days of drinking water treatment in broiler chicken farm with filtration (WPS) resulted in:

5. Improved water physical quality
6. Significantly enhances the microbial quality of water and carcass (lower overall levels of coliform, *E. coli, Enterobacter, S. aureus, S. epidermidis*, *Salmonella,* and *Shigella)*
7. Improved production performance (mortality rates was by reduced up to 42%)
8. Produce healthier meat (lower chloride residue levels, <360 mg per 100 g of food)

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