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The Use of Electrolyzed Water for Sanitation Control of Eggshells and GP Center

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The use of electrolyzed water for washing and sanitizing eggshells and an egg washer was evaluated for its effectiveness at a Grade & Packing Center adjacent to a poultry farm for a period of nine months. The test results indicate improvement in sanitation control. Dissolving yolks of broken eggs with electrolyzed alkaline water followed by sanitizing with electrolyzed acidic water produced favorable effects. Also, the use of electrolyzed water has an advantage in that it simplifies the conventional washing and sanitizing process and motivates operators to employ the process more frequently. This sense developed in operators may be a significant factor in the improvement of sanitation control.

Keywords: electrolyzed water, eggshells, egg washer, GP(Grade & Packing) center

Since the 1996 outbreak of foodborne illness cases caused by pathogenic *Escherichia coli O-157: H7*, both food providers and consumers have become highly conscious of food sanitation (Foodborne Illness outbreaks, 2002). Still, the number of cases has shown no significant sign of improvement. Among the pathogens causing these illnesses, *Salmonella* has been responsible for the most remarkable increase in number. To cope with this situation, the Ministry of Health, Labor and Welfare (formerly the Ministry of Health and Welfare) provided sanitation guidelines on liquid eggs in 1993 (Sanitation assurance related to liquid egg production, 1993) and also on whole eggs in 1998 by partial amendments to the Food Sanitation Law Enforcement Regulations (Amendments to the food sanitation law and food additives standards, 1998). But none of these has brought satisfactory results. With whole eggs, *Salmonella* contamination is found more on eggshells than inside (Komura, 1997), and its entry from eggshells into the inner part of the egg has also been observed (Komura, 1998). At the GP Center (Grade & Packing Center) and egg stores, this means the most important factor in sanitation control is to thoroughly wash and sanitize eggshells before the packing process.

Electrolyzed water produced by electrolysis of salt water has been used for the purpose of sanitation control and recognized widely in the medical field (Iwasawa & Nakamura, 1999) as well as in the food service industry (Koseki & Ito, 2000; Sato *et al*., 2000). In 2002 electrolyzed water was recognized as a food additive and allowed to be used directly on foods, which raises expectation of effective prevention against foodborne illness (Ministry of Health, Labor and Welfare, 2002a; b). It is reported that the most effective use of electrolyzed water is washing with alkaline water to remove protein and other organisms followed by sanitizing with acidic water (Sato *et al*., 2000). This paper reports the results of a nine-month experiment at the GP Center to evaluate the efficacy of the alkaline and acidic water combination in washing and sanitizing eggshells.

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Materials and Methods

A comparative bacterial count was made before and after introduction of a water electrolyzer used with an egg washer and in the GP Center.

GP Center The experiment was made in cooperation with the Hanai Poultry Farm (production capacity: 30,000 eggs/day) equipped with an inline GP Center, located in Obu, Aichi. Producing eggs of various brands to be sold mainly through their direct sales system, they are extremely cautious about sanitation control.

Electrolyzed water Electrolyzed water refers to acidic water and alkaline water produced by electrolyzing dilute salt water through a membrane. The water electrolyzer ROX-20TA by Hoshizaki Electric Co., Ltd. was used to generate electrolyzed alkaline water and acidic water. Electrolyzed acidic water with a pH level under 2.7 contains 20–60 mg/kg of available chlorine and is recognized as a food additive, while electrolyzed alkaline water with a pH level upper 11.3 contains a small amount of sodium hydroxide (NaOH).

The electrolyzed water produced was checked for pH level with a pH meter (TOA, HM-10P), for available chlorine concentration with *o*-Tolidine (Yoneyama Yakuhin Kogyo Co., Ltd., for quantitative analysis of residual chlorine) as a reagent and with an absorptiometer (Shimadzu Corporation, UV-160A). The electrolyzed alkaline water with pH 11.3–11.6 was heated to 50°C before use. The electrolyzed acidic water with pH 2.5–2.7 and available chlorine concentration of 20–30 mg/kg was used at room temperature.

Bacterial growth simulation test in yolk and white Bacterial growth was observed on the assumption that an egg had broken inside the egg washer and was left unwashed for one night. To prepare the initial bacterial solution, a sterile cotton swab dampened with physiological saline was used to wipe the eggshell and soaked in the saline to wash off the collected bacteria. The bacterial solution was then dripped into a 90 mm DIA sterile petri dish containing a culture medium prepared with yolk (approx. 20 g) and white (approx. 40 g) of one egg and incubated at 25°C (summertime condition at the poultry farm) for 24 h. A sterile cotton swab dampened with physiological saline was used to wipe the surface of the incubated culture medium (approx. surface area 60 cm^2) and soaked in the saline to wash off the collected bacteria. The saline was then mixed and diluted with a standard agar medium (Nissui Pharmaceutical Co., Ltd.) for total viable bacterial count and incubated at 37°C for 48 h before the colonies were counted.

Piping connections to egg washer and facilities Piping of the water electrolyzer was connected to the AOYAMA egg washer SOP-100III (capacity 10,000 eggs/h) and was modified for programmed operation. Table 1 shows the operation process. The operation conducted during the experiment was automated so that no extra burden was placed on the operator.

In addition, a shower head was installed for floor cleaning and a sink faucet for hand washing.

Bacterial count in poultry farm Figure 1 and Table 2 show the sampling points, areas and materials. The bacterial count was made once a month before daily operation began,

Table 1. Egg washer operation process.

	Before	After
Egg wash cycle		
Pre-wash	50°C hot water shower for 3 s	50°C electrolyzed alkaline water shower for 3 s
Wash Sanitize	50°C, 200 ppm sodium hypochlorite shower+brushing for 10 s	Electrolyzed acidic water shower+brushing for 10 s
Pre-dry	50°C hot water shower for 3 s	50°C electrolyzed alkaline water shower for 3 s
Dry	Air blow+brushing for 10 s	Air blow+brushing for 10 s
Cleaning cycle		
Clean		50°C electrolyzed alkaline water shower for 3 min
Sanitize	Operator brushes with tap water shower every day (10 min)	Electrolyzed acidic water shower for 3 min
Rinse		Tap water shower for 3 min
Dry	Air blow for 5 min	Air blow for 5 min

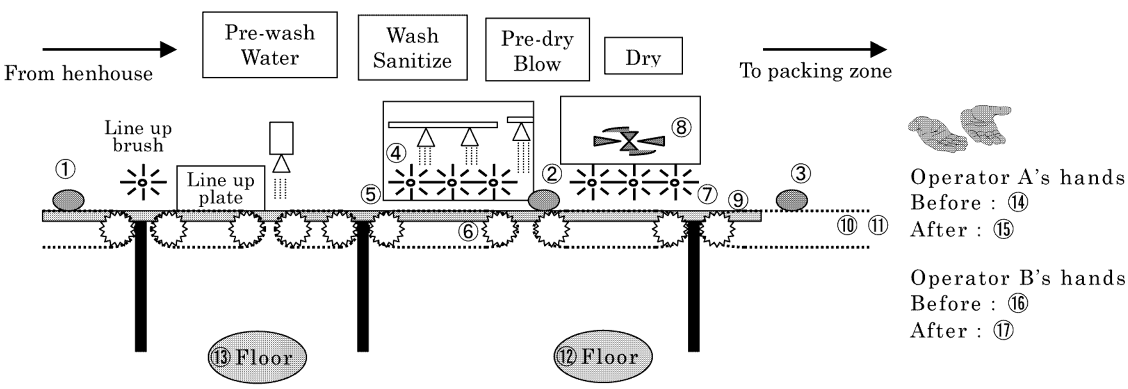

Fig. 1. Sampling points.

Table 2. Sampling points & measured areas.

No.	Measured point	Measured area	Material
	Eggshell		
①	Unwashed eggshell (average of 5)	Entire surface	—
②	Washed/sanitized eggshell (〃)	Entire surface	—
③	Dried eggshell (〃)	Entire surface	—
	Egg Washer		
④	Washing brush	10 bunches	Acrylic resin
⑤	Guide plate before washing brushes	30 mm×30 mm	Stainless steel
⑥	Washing/drying area conveyor roller	15 mm DIA, 500 mm	Polypropylene
⑦	Drying brush	10 bunches	Polyvinyl chloride
⑧	Drying fan interior wall	30 mm×30 mm	Galvanized (painted)
⑨	Drying/packing area dividing plate	30 mm×30 mm	Stainless steel
⑩	Packing conveyor roller 1	10 mm DIA, 400 mm	Acrylic resin
⑪	Packing conveyor roller 2	〃	〃
	Floor		
⑫	Floor 1	10 cm^2	Concrete
⑬	Floor 2	〃	〃
	Hand		
⑭	Packing operator A (during operation)	One palm	—
⑮	Packing operator A (after hand washing)	One palm	—
⑯	Packing operator B (during operation)	One palm	—
⑰	Packing operator B (after hand washing)	One palm	—

when the maximum count is expected excluding eggshells and the hands of operators. The eggshells to be measured were sampled from the eggs on the line. The operators' hands were wiped dry with a towel and then sampled both before and after washing with electrolyzed water. A sterile cotton swab dampened with physiological saline was used to wipe the specified area of each sampling point and then soaked in the saline to wash off the collected bacteria. The saline was then mixed and diluted with a standard agar medium (Nissui Pharmaceutical Co., Ltd.) for total viable bacterial count and incubated at 37°C for 48 h before the colonies were counted.

Results and Discussion

Bacterial growth in yolk and white The culture medium of yolk and white was incubated at 25°C for 24 h. Table 3 shows a significant bacterial growth on the surface of the yolk medium. This suggests that if some yolk is left by accidental egg breakage inside the egg washer and the washing/sanitizing process is inadequate, bacteria will grow in only one night, causing a risk of bacterial contamination if there is contact with eggshells the following day.

Bacterial count in poultry farm Table 4 shows the results of bacterial count. Before the introduction of the water electrolyzer, bacterial count increased from immediately after the washing/sanitizing process (No. ②) to after the drying process (No. ③). Inspection showed that an egg had broken during the drying process, and its yolk and white had stuck to the conveyor rollers and drying brushes where bacteria grew to recontaminate the washed/sanitized eggshells. With the conventional method, when an egg breaks in the drying section, its yolk and white will solidify easily in a short time and be hard to flush away with tap water after the day's operation, resulting in bacterial growth as found in the above experiment. Also, there are many problems with the conventional cleaning method, such as the egg washer construction, removability of the brush, and the danger of cleaning with the egg washer in operation.

To solve these problems, controls were added to clean the egg washer itself without imposing any burden on the operator. Table 1 shows the cleaning method in detail. The cleaning cycle was fully automated with the piping connected not only to the parts directly in contact with eggshells but also to the other parts of the drying section to wash off splashes, if any. To take full advantage of the effects of electrolyzed water, a 50°C alkaline water shower was used for dissolving and removing the solidified yolk and white, then acidic water for sanitizing, and finally tap water for rinsing. As a result, most of the bacterial growth was prevented immediately after the washing/sanitizing process (No. ②) and after the drying process (No. ③) [The result in 12/2001 was probably due to sampling error.] The bacterial counts inside the egg washer also show the effectiveness of the washing/sanitizing process using electrolyzed water. In this experiment, both electrolyzed water shower and brushing were used to wash/sanitize the measured points No. ④ to No. ⑦, while only the shower was used for points No. ⑧ to No. ⑪ whose construction did not allow installation of the brushes and drying fans. As the results suggest that brushing increases the washing/sanitizing efficacy, use of brushing in combination with the electrolyzed water shower should be extended as far as the packing conveyor rollers.

The nearly 10% reduction in the eggshell bacterial count immediately after the washing/sanitizing process (No. ②) is believed to be caused by improvement of the shower location as well as the washing efficacy of electrolyzed alkaline water. The

Table 3. Bacterial growth in yolk & white (25°C).

	Yolk	White
Initial count	2.11**	2.11
After 12 h	4.08**	2.25
After 24 h	6.01**	2.12

Log CFU/cm^2, n=5 average, **Significant at p=0.01 level.

Table 4. Bacterial count.

No.	Measured point	Measurement date									
		Before	After								
		'00 8/29	'01 5/18	6/19	7/17	8/21	9/11	10/15	11/14	12/11	'02 1/15
	Eggshell										
①	Unwashed eggshell (average of 5)	4.72	3.42	4.33	4.66	3.79	3.62	3.37	4.01	2.61	3.90
②	Washed/sanitized eggshell (〃)	2.55	<1.00	1.95	1.07	<1.00	1.66	1.27	1.30	1.16	<1.00
③	Dried eggshell (〃)	3.17	<1.00	1.71	1.73	1.30	1.16	1.46	<1.00	3.14	1.31
	Egg Washer										
④	Washing brush	3.70	1.88	<1.00	<1.00	1.04	<1.00	<1.00	<1.00	<1.00	<1.00
⑤	Guide plate before washing brushes	3.00	<1.00	<1.00	<1.00	2.65	<1.00	<1.00	<1.00	1.88	<1.00
⑥	Washing/drying area conveyor roller	1.78	<1.00	<1.00	3.40	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
⑦	Drying brush	3.66	<1.00	<1.00	2.03	<1.00	1.26	<1.00	<1.00	<1.00	<1.00
⑧	Drying fan interior wall	5.64	<1.00	<1.00	1.20	1.00	1.90	<1.00	2.56	<1.00	3.91
⑨	Drying/packing area dividing plate	4.05	<1.00	2.20	2.06	1.23	2.03	3.26	1.98	<1.00	1.62
⑩	Packing conveyor roller 1	2.30	<1.00	1.62	2.96	1.20	1.68	2.27	1.81	1.18	<1.00
⑪	Packing conveyor roller 2	3.00	<1.00	1.78	2.20	1.40	<1.00	2.41	<1.00	2.08	1.72
	Floor										
⑫	Floor 1	>8.00	4.65	5.68	3.92	5.73	4.28	2.48	3.54	4.26	4.36
⑬	Floor 2	>8.00	4.70	5.70	5.96	5.93	4.95	4.47	4.08	3.72	4.11
	Hand										
⑭	Packing operator A (during operation)	—	4.30	3.08	2.90	3.04	2.70	2.48	3.69	2.48	2.48
⑮	Packing operator A (after hand washing)	—	<1.00	2.08	2.22	2.18	1.75	1.04	2.32	1.60	1.77
⑯	Packing operator B (during operation)	—	2.78	2.85	2.48	3.08	2.60	2.48	2.30	2.48	2.48
⑰	Packing operator B (after hand washing)	—	1.60	2.08	2.93	2.66	1.88	2.18	1.28	<1.00	<1.00

Log CFU/measured area, <1: not detected, −: not tested, n=3 average.

shower location was moved forward by 50 cm to allow enough time for infiltration of the alkaline water into impurities and blood on the eggshells, making the next shower brushing process more effective. No precise data is available, but this improvement reduced the number of soiled eggs roughly from 1000 to 400. The consequent upgrading of soiled eggs from low-priced grade to normal grade not only contributed to the egg sales price, but also reduced the labor cost for sorting, providing a great advantage for the farm manager.

Floor and hand washing/sanitizing Before the introduction of electrolyzed water, the floors (No. ⑫, ⑬) were contaminated with 10^8CFU/100 cm^2 or more bacteria, probably because the yolk and white of broken eggs stuck to the floors. As mentioned above, solidified yolk and white were hard to remove, and the floors were not adequately cleaned. But the use of electrolyzed alkaline and acidic water made the floors easily cleanable and kept them sanitary. It also helped to reduce the smell of rotten eggs that had been noticeable inside the facilities before the introduction of electrolyzed water.

The hand washing/sanitizing procedure also controlled bacterial growth stably. As stated in the report on the efficacy of hand washing with electrolyzed water (Otoguro *et al*., 1996), use of this water caused no harm to the skin. The operators wash their hands more frequently than before during their routines.

Conclusion

This experiment in egg washing facilities for a nine-month period proved that the use of electrolyzed water improves the sanitation control of eggshells, egg washer and egg washing facilities. The egg washing and egg washer cleaning procedures are fully automated and only need periodic maintenance to maintain stable washing and sanitizing effects. In contrast, the floor and hand washing procedures are dependent on the operators' sense of sanitation control. The washing and sanitizing procedure with electrolyzed water is less burdensome and troublesome to the operators than the conventional procedure and motivates them to use it more frequently. This sense developed in the operators should lead to significant progress in sanitation control.

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