INFLUENCE OF HATCHING EGG SANITISATION TREATMENTS ON EGG WEIGHT LOSS DURING INCUBATION AND EGGSHELL SURFACE APPEARANCE

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ABSTRACT

The influence of wet sanitisation treatments on egg weight loss during incubation and eggshell surface appearance was evaluated. Broiler hatching eggs were placed into an incubator (operating at 37.5°C and 55% relative humidity) and egg weight was recorded at 2 day intervals for calculation of 21-day percentage egg weight loss. Duplicate groups of 44 eggs were either spray sanitised using a MST Mini-Master-4000(r) egg sanitising machine with water, Chlor-Wash(r) (4 g/L), or bleach (7000 ppm sodium hypochlorite), or additional groups of eggs were immersed for 5 minutes in the same solutions at 44°C. Following sanitisation eggs were held for 6 hours at room temperature, returned to the incubator and weighed at 2 day intervals over a 12 day period. After the final egg weighing, a cuticle stain was applied to half of the eggs and ten remaining eggshells per treatment were processed to produce scanning electron micrographs.

Egg weights from setting (61.39 g) to the final weighing (55.25 g) did not differ significantly ($P > 0.0586$) among treatment groups. Before sanitisation, calculated 21-day percentage egg weight loss did not significantly differ among groups, 12.49% with a range from 12.18 to 12.79%. However, after application of sanitisation treatments, 21-day egg weight loss did not significantly change for only the untreated control eggs (-0.02 to 12.52%). Eggs sprayed with water had an increase in 21-day weight loss by 0.47 to 12.97%. Comparison of other treatments to values for the water spray group resulted in further increases in 21-day weight loss of 0.50 to 13.44% for water immersion, 0.07 to 13.07% and 0.35 to 13.40% for eggs sprayed with Chlor-wash, and 0.53 to 13.37% for eggs immersed in Chlor-wash. Eggs sprayed with the bleach solution increased 0.38 to 13.04% and eggs immersed in the bleach solution had the highest increase of 0.54 to 13.80%.

Visible intensity of cuticle staining revealed minimal differences, compared to untreated control eggs, for eggs treated with water or eggs sprayed with Chlor-wash. Eggs immersed in Chlor-wash were less darkly stained, eggs sprayed with the bleach solution were lightly stained, and it was not possible to detect the cuticle by staining for eggs immersed in the bleach solution. Electron micrographs confirmed cuticle stain observations for eggs treated with the bleach solution. Eggs sprayed with the bleach solution displayed uneven erosion of the cuticle while those immersed in the bleach solution had no apparent cuticle layer.

KEY WORDS: Eggshell cuticle, Egg weight loss, Sanitisation, Cuticle stain, Broiler hatching eggs

INTRODUCTION

Hatching eggs are sanitised on the farm or in the hatchery to reduce the shell borne microbial load carried from farm into the incubator (Cox et al., 1994; Berrang et al., 1997). Egg sanitising products can be applied as a liquid spray, foam, or gas. All sanitisation chemicals effectively kill microorganisms upon contact but some may alter eggshell porosity by removal of the cuticle (increase in porosity, Peebles and Brake, 1986; Brake and Sheldon, 1990; Sheldon and Brake 1991) or deposition of chemical residues that may occlude pores (decrease in porosity, Scott, et al., 1993). Changes in eggshell porosity will affect egg weight loss during incubation and extreme changes may alter hatchability or chick quality (Lundy 1969; Tullett and Deeming 1982; Christensen and McCorkle, 1982, Vick and Brake, 1986; Bagley and Christensen, 1991). Egg weight loss during incubation for birds has been conserved through evolution and is generally near 16 to 18% of initial egg weight (Drent 1970; Rahn and Ar, 1974). Egg weight loss values for body weight selected commercial broilers have been reported to range from 12 to 14 % (from setting to transfer; Lundy, 1969; Rahn, 1981; Tullett, 1981). Incubation egg weight loss changes over the production period for a flock, as hens age there is an increase in egg size and a corresponding thinning of the eggshell. Therefore alteration of eggshell porosity may be beneficial when eggs from several flocks of diverse age are placed into a single incubator.

The objectives of this study were to evaluate egg weight loss before and after sanitisation treatments, to determine if reported increases in weight loss are solely due to cuticle removal and a change in eggshell porosity, or are partially due to loss of the weight gained during wet sanitisation.

MATERIALS and METHODS

Egg Handling and Incubation Conditions

Broiler hatching eggs were collected from hens 33 weeks of age and stored at 14.4°C (58°F) for less than 5 days. Eggs were segregated into 16 groups of 44 eggs each, individually numbered and weighed prior to setting into a single incubator (NMC 2000, NatureForm Hatchery Systems, Jacksonville, FL 32218) operating at 37.5°C (99.5°F) and 55% relative humidity, and eggs were automatically turned every hour. Throughout the experiment each individual egg rack was returned to the same location in the setting buggy within the incubator after each weighing.

To obtain an initial egg weight, after eggs had attained incubation temperature, eggs were weighed the following morning after 14 hours incubation, and again after 2 and 4 days. From the percentage egg weight loss for the 48 hour periods, projected 21-day percentage egg weight loss was calculated. After the 4-day weighing, eggs were removed from the incubator (remaining within racks) and placed in a 5°C refrigerator overnight to kill any developing embryos. This procedure was undertaken in order to prevent embryo heat production in fertile eggs during the subsequent 12 days of incubation. Embryonic heat production would elevate the internal egg temperature (relative to the temperature of the incubator) and therefore elevate saturation vapour pressure, resulting in greater egg weight loss than in eggs that did not contain developing embryos (Booth and Rahn, 1990).

Eggshell Sanitisation Treatments

Eggs were removed from the cold room and permitted to warm to room temperature for 6 hours prior to initiation of sanitisation treatments. The three sanitisation solutions were water, Chlor-wash(r) (90 g per 22.7 L of water), and bleach (7000 ppm sodium hypochlorite in water). Solutions were applied either by spray (approximately 10 seconds) or immersion dipping for 5 minutes. Eggs were spray sanitised using the first tank of a MS Technologies Inc. Mini-Master/4000(r) egg sanitising machine (MS Technologies, Inc. Chattanooga TN, 37421). Solution temperature was automatically controlled at 44°C (111°F) with thermostatic heaters and recirculating pumps. Eggs remained within their setting racks during either spray or immersion sanitisation. After solutions were applied as a spray, the solutions were transferred into a plastic tank for the immersion dip treatment. For the second replication fresh solutions were prepared and the egg processing procedure repeated as stated. Control eggs were not treated but remained within the room where the sanitisation procedures occurred. Eggs were returned to the setting room and held for 6 hours at 24°C before weighing and returned to their same location in the setting buggy within the incubator. Eggs were again weighed after 2, 4, 6, 8, and 12 days following sanitisation. From the recorded egg weights, projected 21-day percentage egg weight loss was calculated.

Cuticle Staining and Scanning Electron Micrographs

Half of the eggs from each group (from both replications for a total of 40 per treatment group) were cuticle stained by submersion in Cuticle Blue as directed by the manufacturer (1 minute at room temperature, MS Technologies, Inc., Chattanooga TN, 37406). Eggs were allowed to air dry for 2 weeks and were photographed blunt-end up (Photographs 1 to 8). Ten of the remaining eggs had their contents removed through the pointed end, were rinsed with water and air dried for 2 days before placing them into individual desiccators (by group) for a 2 week period. Dry pieces from the blunt-end of the eggshell were mounted on stubs, sputter coated, and the exterior surface viewed with a scanning electron microscope (JSM-6400V, JEOL USA Inc., Peabody, MA, 01961) at magnification of X 2,000. Photomicrographs from five eggs per group were taken and representative samples are shown in Photographs 9 to 16.

Statistical Analysis

Eggs weights were summarised and analysed using the General Linear Models procedure SAS(r), and the means separated using the Tukey's Studentised Range (HSD) Test (SAS Institute, 1996). For all analysis, significance was determined at $P < 0.05$. There were no significant differences between the replicates for egg weight or calculated 21-day percentage egg weight loss, therefore data were combined. After initial calculation of 21-day percentage egg weight loss before application of sanitisation treatments, any eggs with values that were < 8% or > 16% were removed and excluded from the data (15 eggs) and mean egg weight and 21-day egg weight loss values recalculated.

RESULTS AND DISCUSSION

Egg weight on each day of sampling did not differ among groups from the time of initial setting (61.39 g) through the end of the experiment (55.25 g) after a total of 16.6 days of incubation ($P = 0.0586$, Table 1). After the first 14 hours of incubation, eggs had lost 0.11% resulting in an egg weight of 61.34 g. This small sample time period and the fact that eggs were not continuously at incubation temperature resulted in extreme underestimation of 21-day egg weight loss (4.1%). Over the next 4 days the average 21-day percentage egg weight loss was 12.49 % and did not differ significantly ($P = 0.4657$) among groups before application of the sanitisation treatments, Table 2.

Following sanitisation, drying for 6 hours, and incubation for 2 days calculated 21-day egg weight loss increased for all groups from 0.31 to 0.95 percentage points, Table 2. The 2-day weighing period following sanitisation did not result in any detectable difference in calculated 21-day percentage egg weight loss. However, thereafter differences among treatment groups were significant. The untreated control eggs had significantly lower 21-day percentage egg weight loss values than only those immersed in the bleach solution at 4 and 6 days after treatment. After 8 and 12 days, eggs immersed in water, sprayed 3-times, immersed in Chlor-wash, or the bleach solution all had significantly greater 21-day percentage egg weight loss than control eggs. Over the 12 days of incubation after application of the sanitisation treatments, 21-day percentage egg weight loss was significantly higher for eggs immersed in water, Chlor-wash, the bleach solution, or sprayed 3 times with Chlor-wash compared to control eggs.

The calculated changes in 21-day percentage egg weight loss (from before to after application of sanitisation treatments) were all greater for treated eggs compared to control eggs. Egg weight loss did not significantly change for control eggs (-0.02 to 12.52%) throughout the 12 day sample period. Eggs sprayed with water had an increased in 21-day weight loss by 0.48 to 12.97%. Comparison of other treatments to values for the water spray treatment group resulted in further increases in 21-day weight loss of 0.50 to 13.44% for water immersion, 0.07 to 13.07% and 0.35 to 13.4% for eggs sprayed with Chlor-wash, and 0.53 to 13.37% for eggs immersed in Chlor-wash. Eggs sprayed with the bleach solution increased 0.38 to 13.04% and eggs immersed in the bleach solution had the highest increase in 21-day egg weight loss, 0.54 to 13.8%. These results indicate that about half of the increase in egg weight loss following wet sanitisation is due to application of sanitisation solutions (immersion greater than spray) and the subsequent release of water from the egg upon return to incubation.

The intensity of cuticle staining revealed minimal differences, compared to control eggs, for eggs treated with water or eggs sprayed with Chlor-wash (Photographs 1, 2, 3, 4, 5, 6). Eggs immersed in Chlor-wash were less darkly stained (Photograph 7), eggs sprayed with the bleach solution (Photograph 8) were lightly stained, and it was not possible to detect the cuticle by staining for eggs immersed in the bleach solution (Photograph 8). Electron micrographs confirmed the loss of cuticle for eggs treated with the bleach solution. Eggs sprayed with the bleach solution displayed uneven erosion of the cuticle (Photograph 15) while those immersed in the bleach solution had no apparent cuticle layer (Photograph 16). Eggs in all other treatment groups were indistinguishable when viewed under the electron microscope.

Table 1. Egg weights during incubation before and after application of sanitisation treatments

Treatments	Before sanitisation (days)				After sanitisation (days)					
	0 (g)	0.6 (g)	2 (g)	4 (g)	0 (g)	2 (g)	4 (g)	6 (g)	8 (g)	12 (g)
Untreated Control	61.87	61.82	61.07	60.33	60.19	59.43	58.70	57.96	57.22	55.75
Water										
Spray	61.90	61.84	61.10	60.36	60.20	59.44	58.69	57.96	57.21	55.74
Immersion	61.84	61.77	61.03	60.29	60.12	59.35	58.60	57.86	57.11	55.64
Chlor-wash										
Spray	61.13	61.07	60.33	59.61	59.43	58.66	57.90	57.14	56.37	54.87
Spray, 3 times	61.01	60.94	60.20	59.47	59.30	58.55	57.82	57.09	56.36	54.91
Immersion	61.78	61.70	60.97	60.24	60.08	59.32	58.58	57.85	57.11	55.64
Bleach										
Spray	61.38	61.31	60.59	59.88	59.72	58.99	58.27	57.55	56.83	55.41
Immersion	60.24	60.18	59.44	58.71	58.55	57.79	57.05	56.31	55.56	54.08
Average	61.39	61.32	60.59	59.86	59.70	58.94	58.20	57.46	56.72	55.25
PSEM	0.61	0.61	0.61	0.60	0.60	0.60	0.60	0.59	0.59	0.59
P value	0.0836	0.0866	0.0841	0.0827	0.0796	0.0769	0.0709	0.0687	0.0646	0.0586

Means within a column did not differ significantly ($P < 0.05$)

Table 2. Calculated 21-day percentage egg weight loss before and after application of sanitisation treatments

Treatments	Before sanitisation (days)			After sanitisation (days)					
	2 (%)	4 (%)	Average days 2 to 4 (%)	2 (%)	4 (%)	6 (%)	8 (%)	12 (%)	Average days 4 to 12 (%)	Change (%)
Untreated Control	12.73	12.35	12.54	12.83	12.55b	12.51b	12.52c	12.52c	12.52c	0.02d
Water										
Spray	12.69	12.35	12.50	13.07	12.91ab	12.88ab	13.09bc	13.02bc	12.97abc	0.48c
Immersion	12.51	12.41	12.46	13.38	13.24ab	13.30ab	13.63ab	13.60ab	13.44ab	0.98ab
Chlor-wash										
Spray	12.66	12.38	12.52	13.39	13.12ab	12.99ab	13.19abc	12.98bc	13.07abc	0.55c
Spray, 3 times	12.69	12.45	12.56	13.32	13.16ab	13.30ab	13.57ab	13.56ab	13.40ab	0.83ab
Immersion	12.44	12.28	12.36	13.31	13.12ab	13.25ab	13.52ab	13.60ab	13.37ab	1.01ab
Bleach										
Spray	12.32	12.04	12.18	12.97	12.87ab	12.96ab	13.12abc	13.22abc	13.04abc	0.86ab
Immersion	12.92	12.65	12.79	13.66	13.59a	13.65a	13.95a	14.03a	13.80a	1.02a
Average	12.62	12.36	12.49	13.24	13.07	13.12	13.33	13.32	13.21	0.72
PSEM	0.25	0.25	0.25	0.26	0.27	0.27	0.27	0.28	0.28	0.08
P value	0.3720	0.5189	0.4657	0.0558	0.0132	0.0023	0.0001	0.0001	0.0003	0.0001

abc Means within a column with no common letter differ significantly ($P < 0.05$)

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CONCLUSIONS

Nonsignificant differences in egg weight after application of sanitisation treatments indicates that egg weight alone is not an accurate predictor of cuticle removal.

Cuticle staining and scanning electron micrographs confirmed cuticle loss for eggs sprayed or immersed in the bleach solution.

After adjustment for wetting (by spray or immersion) the increases in calculated 21-day percentage egg weight loss for eggs treated with the bleach solution was 0.38 for spray and 0.04 immersion.

These results suggest that application of wet sanitising solutions (by spray and immersion) may confound the 1% increase in 21-day egg weight loss associated with cuticle stripping.