CARBONATED DRINKING WATER FOR IMPROVEMENT OF EGGSHELL QUALITY OF LAYING HENS DURING SUMMERTIME MONTHS

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Primary Audience: Egg Producers, Laying Flock Supervisors, Nutritionists

SUMMARY

A carbonated drinking water system was installed in a cage layer facility and its effects on performance of 46- and 86-wk old commercial laying hens was evaluated during a 12-wk period in the summer. The water system effectively acidified the drinking water (pH 4.73 for carbonated water versus 7.67 for normal tap water). Overall, egg specific gravity (Weeks 1-12) of eggs laid by older hens was improved ($P \leq .06$) by providing a constant source of carbonated drinking water versus those given only tap drinking water (1.0790 versus 1.0776 g/cm^3). Egg production, egg weight, egg mass, feed consumption, and feed efficiency were not different ($P > .05$) for hens provided carbonated versus tap drinking water. Thus, a carbonated drinking water system can be operated efficiently in a commercial cage layer facility and can help improve eggshell quality of flocks experiencing shell quality problems during the summer.

Key words: Carbonated drinking water, laying hens, production performance, egg specific gravity, improved eggshell quality

1992 J. Appl. Poultry Res. 1:194-199

DESCRIPTION OF PROBLEM

Summertime temperatures often cause laying hens to produce thin and soft-shelled eggs. Due to this phenomenon, extreme losses in income from marketable eggs can occur. Current practical means of maintaining comfortable in-house air temperatures during summer months include maintaining adequate ventilation, avoiding crowded cage situations, and the use of evaporative pad cooling (limited to certain areas of the country). Providing optimum ventilation is one of the most common technique used to alleviate the effects of heat stress. Bird [1] described how to provide and maintain a good ventilation system for layers

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during the summer. Although modern cage layer facilities are well insulated and have adequate ventilation systems, heat stress problems in layer flocks still occur periodically.

When in-house air temperatures rise above maximum bird comfort levels (about 85°F), hens respond by increasing their rate of panting in order to cool themselves and maintain stable body temperatures. As panting continues, the physiological state of the blood changes due to the loss of carbon dioxide. This produces a condition known as respiratory alkalosis which causes a disruption of essential minerals needed for birds to maintain normal egg laying functions. The effects of high environmental temperatures have been described by Odom [2].

In addition to the negative effects of high temperatures on egg production and egg size, thinning of the eggshell occurs [2]. Early efforts [3] to correct this problem by adding sodium bicarbonate to the diet or by enriching the air with carbon dioxide led to inconsistent results with regard to maintaining optimum eggshell quality. A later report [4] documented beneficial effects of providing carbonated drinking water to laying hens exposed to high environmental temperatures. The positive effects of carbonated drinking water on eggshell quality and egg production have not been tested under field conditions.

The objectives of the present study were to evaluate the operation of a water carbonation unit in a commercial layer facility and to examine the effects of carbonated versus tap drinking water on eggshell quality and production performance of laying hens during summertime conditions.

MATERIALS AND METHODS

A 12-wk experiment was conducted to test the practicality of using a carbonated drinking water system for laying hens maintained in a commercial-type cage layer facility during warm summertime months. The water carbonation equipment [5] was developed by AIRCO Industrial Gases, an operating division of The BOC Group, Inc. [6], and installed in a cage layer facility at the University of Illinois Poultry Research Farm. During the study, the water carbonation device provided the hens with a constant source of carbonated drinking water through a trigger-type cup watering system.

A total of 288 Single Comb White Leghorn hens of the H&N strain were housed in a cage layer house of commercial design with water and feed provided *ad libitum*. A 16% crude protein standard layer diet containing 3.75% calcium and .45% available phosphorus was provided for the hens on an *ad libitum* basis. A 17-h daily photoperiod was maintained throughout the study. Hens of two different ages were used. One half of the hens (144) were 46 wk of age (young hens), and were assigned randomly to 12 replicate groups of 12 hens each (four adjacent raised wire cages, 12 x 18 in, containing three hens per cage). Six of the groups were arranged on the top level of a double deck cage system with three groups being located randomly in each row of two back-to-back rows. The remaining six groups were assigned to the bottom level (three groups per row of two back-to-back rows). The other half of the hens (144) were 86 wk of age (old hens), and were allocated to 12 replicate groups of 12 hens each as described for the young hens. These hens had been molted previously at 65 wk of age. Within each age group, one half of the hens (6 groups) received a continuous supply of carbonated water and the other half (6 groups) received tap water through a trigger-type cup watering system.

The experimental period began on July 2 and ended on September 24 (12 weeks). Daily records of high and low in-house air temperatures were maintained and summarized weekly. The pH of the carbonated and tap

TABLE 1. Weekly in-house air temperature (°F)

RANGE	WEEK												AVG.
	1	2	3	4	5	6	7	8	9	10	11	12	
Low	75	76	75	73	72	68	73	74	73	75	70	64	72
High	93	87	91	89	87	83	88	87	89	90	84	77	87
Mean[A]	84	82	83	81	80	76	81	81	81	83	77	71	80

[A]Mean temperatures represent the average of the low and high daily readings for each week.

water was measured during Weeks 1 and 12 of the experiment. Egg production and deaths were recorded daily. Livability (days alive/total possible days alive) was calculated from mortality. Egg weight and egg specific gravity was measured each week on all eggs produced on two consecutive days. Specific gravity was determined using the flotation method with NaCl solutions varying in specific gravity from 1.056 to 1.096 in .004 increments. Egg mass (grams of egg per hen per day) was calculated each week using hen-day egg production and average egg weight. Feed consumption and feed efficiency (grams of egg:gram of feed) was also measured weekly.

Certain data were transformed [7] prior to statistical analysis [8].

Results and Discussion

Weekly in-house temperatures are presented in Table 1. The highest mean daily temperature of 84°F occurred during the first week. The daily high temperature imposed heat stress during most weeks (with exception of Weeks 6, 11, and 12) as evidenced by increased panting by hens during late afternoon.

WATER pH

The pH of the tap and carbonated water was measured at the beginning and end of the experiment with a portable pH meter. Measurements were taken at points near the carbonator and at the end of the 74 cage rows. The pH of the tap water averaged 7.67, while pH of the carbonated water averaged 4.73. We consider this to indicate that the carbonation unit acidified the water effectively. These pH values were similar to those reported previously by Odom *et al.* [4], in which the tap water had a pH of 7.79 and the carbonated water had a pH of 5.17.

In previous laboratory tests conducted by The BOC Group, Inc. [9], the loss of carbon dioxide from a sample of carbonated water was 16, 23, and 24%, after exposure to the atmosphere for 1, 2, and 3 hours, respectively. Because water consumption occurred at a fairly rapid rate during the present study, hens that drank carbonated water probably received a substantial amount of carbon dioxide at all times.

TABLE 2. Effect of carbonated versus tap drinking water on livability, hen-day, and hen-housed egg production[A]

PARAMETER	TREATMENT	YOUNG HENS	OLD HENS	MEAN	SEM[B]
Livability (%)[C]	Carbonated	98.2	93.4	95.8^b	
	Tap	100.0	100.0	100.0^a	
	Mean	99.1^a	96.7^a		
					1.5
Hen-day egg production (%)	Carbonated	83.1	76.8	79.9^a	
	Tap	82.8	77.7	80.2^a	
	Mean	83.0^a	77.2^b		
					0.9
Hen-housed egg production (%)	Carbonated	81.6	71.6	76.8^a	
	Tap	82.8	77.7	80.2^a	
	Mean	82.2^a	74.6^b		
					1.4

[A]Means of six replicate groups of 12 hens each per treatment.

[B]Pooled SEM for water treatment and age of hen means; 12 groups of 12 hens per mean.

[C]Livability values were transformed using a square root algorithm prior to analysis of variance.

[a,b]Main effect age means within a row and within a parameter having no common superscripts are significantly different, while main effect water treatment means within a column and within a parameter having no common superscripts are significantly different (P≤.05).

TABLE 3. Effect of carbonated versus tap drinking water on feed consumption and feed efficiency[A]

PARAMETER	TREATMENT	YOUNG HENS	OLD HENS	MEAN	SEM[B]
Feed consumption (g/hen/day)	Carbonated	104.5	102.2	103.3[a]	
	Tap	103.9	103.6	103.8[a]	
	Mean	104.2[a]	102.9[a]		
					1.00
Feed efficiency (g egg:g feed)	Carbonated	.482	.481	.482[a]	
	Tap	.480	.475	.478[a]	
	Mean	.481[a]	.478[a]		
					.006

[A]Means of six replicate groups of 12 hens each per treatment.

[B]Pooled SEM for water treatment and age of hen means; 12 groups of 12 hens per mean.

[a]Main effect age means within a row and within a parameter having common superscripts are not significantly different, while main effect water treatment means within a column and within a parameter having common superscripts are not significantly different ($P>.05$).

LIVABILITY AND EGG PRODUCTION

The individual and main treatment means for livability, hen-day, and hen-housed egg production are shown in Table 2. Livability was significantly lower ($P\leq.05$) for hens that were provided carbonated water versus those that received tap water throughout the 12-week experiment. However, the livability figures represent only 6 old hens and 2 young hens which died in the carbonated water treatment. We believe this represents a chance occurrence, not an effect due to water carbonation.

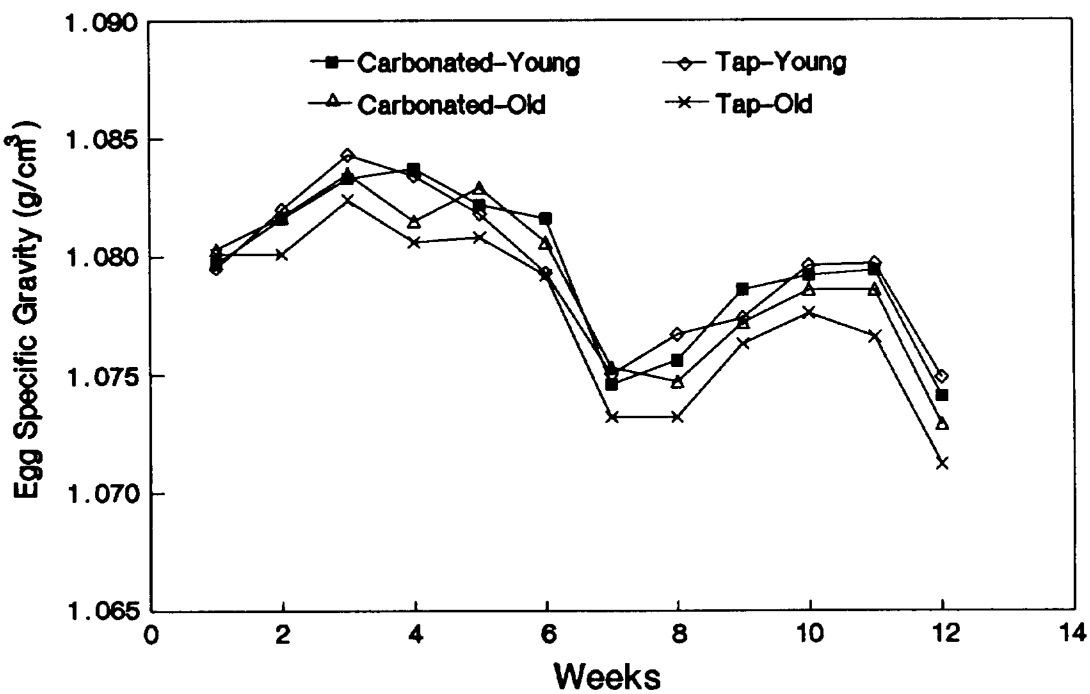

FIGURE 1. Effect of water treatment and age of hen on weekly egg specific gravity. Values are the mean of six replicate groups of 12 hens each.

No significant differences (P>.05) were found between water treatment main effect for hen-day or hen-housed egg production (Weeks 1 to 12). However, egg production (hen-day and hen-housed) was better (P≤.05) for younger versus older hens. In a previous report [4], egg production was not different for hens exposed to a 95°F environment for 1-wk and given either tap or carbonated water. The present results agree with that study, and demonstrate that egg production is not affected adversely by providing hens with carbonated drinking water.

FEED CONSUMPTION AND FEED EFFICIENCY

The influence of carbonated versus tap drinking water and age of hen on feed consumption and feed efficiency are shown in Table 3. There were no significant effects (P > .05) of water treatment or age of hen on either feed consumption or feed efficiency.

EGG WEIGHT AND EGG MASS

In analyzing the effects of water treatment and age of hen on egg weight and egg mass, egg weight was affected significantly by age (Table 4). As expected, older hens produced larger (P≤.05) eggs than younger hens. Egg mass was not affected by the age of the hens.

EGG SPECIFIC GRAVITY

A primary negative effect of heat stress is reduction of eggshell quality [1]. A general decline in egg specific gravity occurred for all treatments as the duration of the experiment increased (Figure 1). Egg specific gravity was numerically greater during all weeks for old hens that were given carbonated drinking water versus those provided with tap water. This effect was not observed for the young hens. A general decrease in egg specific gravity was noted from Week 6 to Week 7 for all treatments. Comparison of the 12-wk individual treatment means (Table 4) showed that old hens that received carbonated water produced eggs with higher (P≤.06) specific gravity than old hens that received tap water.

The positive effects of carbonated drinking water on egg specific gravity in the present study are in agreement with those reported earlier [4]. In the earlier report however, egg

TABLE 4. Effect of carbonated versus tap drinking water on egg weight, mass, and specific gravity[A]

PARAMETER	TREATMENT	YOUNG HENS	OLD HENS	MEAN	SEM[B]
Egg weight (g/egg)	Carbonated	60.4	63.6	62.0[a]	
	Tap	60.1	63.1	61.6[a]	
	Mean	60.2[b]	63.4[a]		
					.30
Egg mass (g egg/hen/day)	Carbonated	50.1	48.9	49.5[a]	
	Tap	49.8	49.0	49.4[a]	
	Mean	50.0[a]	49.0[a]		
					.60
Egg specific gravity (g/cm^3)	Carbonated	1.0795[x]	1.0790[x]	1.0792[a]	
	Tap	1.0795[x]	1.0776[y]	1.0785[a]	
	Mean	1.0795[a]	1.0783[b]		
					.0003

[A]Means of six replicate groups of 12 hens each per treatment.

[B]Pooled SEM for water treatment and age of hen means; 12 groups of 12 hens per mean.

[a,b]Main effect age means within a row and within a parameter having no common superscripts are significantly different, while main effect water treatment means within a column and within a parameter having no common superscripts are significantly different (P≤.05).

[x,y]Individual water treatment means for egg specific gravity having no common superscripts are significantly different (P≤.06).

specific gravity was improved by providing young hens (30 wk of age) with carbonated drinking water, and the surrounding environmental temperature was higher (95°F).

Strong [10] examined the relationship between eggshell quality and the percentage of cracked eggs in a commercial egg processing plant. Sixty eggs were collected per wk for 3 consecutive wk from flocks of the same strain at 22, 30, 56, or 86 wk of age. It was found that eggshell quality measurements of specific gravity and percent shell were significantly correlated ($P < .01$) with the percent cracks (-.88 and -.85, respectively). This indicates that egg specific gravity measurements should be considered a reliable indicator of the severity of egg breakage. The observation that carbonated drinking water improves egg specific gravity of eggs from older hens in the present study indicates that this treatment may reduce the incidence of egg breakage in commercial poultry operations.

CONCLUSIONS AND APPLICATIONS

1. A water carbonation unit was installed successfully and operated efficiently in a commercial cage layer facility.
2. Drinking water was acidified adequately (Tap, pH = 7.67; Carbonated, pH = 4.73), and the unit provided a constant source of carbonated drinking water.
3. Carbonated drinking water did not produce deleterious effects on performance.
4. Egg production, egg weight, and egg specific gravity were better for young versus old hens.
5. Egg specific gravity (i.e., eggshell quality) was improved for older hens by providing them with carbonated versus tap drinking water during summertime conditions.
6. This carbonated drinking water system could merit application to commercial layer flocks; it may improve eggshell quality of flocks which are experiencing increased egg breakage during the summer.
7. Because the carbonated water unit is actually producing a mild form of carbonic acid, watering systems which utilize only plastic or stainless steel parts should be used to avoid possible metal corrosion problems.

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5. The BOC Water Carbonation Unit, General Description: Water for the system is carbonated by cascading incoming water through a packed column containing carbon dioxide. On demand from the watering system, water flows out of the bottom of the unit through a pressure reducing valve which provides a constant source of carbonated water at a pressure of 3 to 4 pounds per square inch. A more detailed description of the unit can be obtained from George McCain at The BOC Group, Inc.

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7. All data were analyzed by analysis of variance procedures. Livability data were transformed using a square root algorithm [7]. These transformations were then subjected to analysis of variance. Percent livability was reported as originally calculated before transformation. Significant differences between treatment means were determined by using Fisher's least significant difference test. Significance implies $P \leq .05$ unless otherwise indicated.

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11. The authors wish to thank AIRCO Industrial Gases (Murray Hill, NJ), an operating division of the BOC Group, Inc., for financial support of this project. We also want to thank George McCain, Project Engineer, of the BOC Group Technical Center, for designing, assembling, and installing the unit. The technical assistance of Robert Leeper, Irvin Nordling, Chet Utterback, and Ann Ciganek is gratefully acknowledged.