

Effect of Sodium Sesquicarbonate, S-Carb[®], and Sodium Bicarbonate on Performance of Growing Broilers and Processing Factors.

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Introduction:

Sodium is an essential mineral for broilers. Historically, salt has been used as the typical sodium source. However, moderate to high salt levels in rations also promotes fecal moisture excretion, which is objectionable in broiler production. Sodium Sesquicarbonate (furnished to the poultry industry as S-Carb[®]) and Sodium Bicarbonate (for the purpose of this presentation, all termed *Na Bicarb*, unless otherwise stated) provides nutritional sodium sources without providing high chloride. Therefore, providing nutritionists with a means of more closely meeting nutritional requirements. As described by NRC (National Research Council, 1984, Nutrient Requirements of Poultry, 8th rev. ed., National Academy Press, Washington, DC), the following table describes nutritional requirements of various poultry:

Specie/Age	Sodium (%)	Chloride (%)
Broiler chickens 0-3 weeks	0.20	0.20
Broiler chickens 3-6 weeks	0.15	0.15
Broiler chickens >6 weeks	0.12	0.12
Turkey 0-4 weeks	0.17	0.15
Turkey 4-12 weeks	0.15	0.14
Turkey >12 weeks	0.12	0.14
Leghorn layer chicks (variable with production)	0.19 to 0.13	0.16 to 0.13
Breeder layer chicks (variable with production)	150 mg per hen daily	130 mg per hen daily

Literature Review:

Recent research (Hooge et al., 1999a, Hooge et al., 1999b, and Hooge et al., 2000) has shown that sodium bicarbonate can provide sodium without promoting increased fecal moisture, and in fact, improving performance.

Hurst et al. (1974) found that broiler chicks in battery brooders performed better with 0.30% dietary salt (NaCl) than with 0.075 to 0.225% NaCl, and

performed equally well with 0.30% compared to 0.375% NaCl, when monensin was included at 121.3 mg/kg in the feed to four weeks of age. In a more practical study, Nam et al. (1979) conducted litter and battery brooder trials with broiler chicks fed corn-soy diets and found 0.15% sodium adequate with either monensin or lasalocid compared to either 0.10, 0.20, or 0.35% sodium. Higher sodium levels did not give any additional benefits. Gard et al. (1980) found that broilers that received 0.17 to 0.19% sodium had heavier ($P < 0.10$) weights than those fed 0.11% or 0.24 to 0.27% sodium. Increasing monensin from 100 to 121 mg/kg did not appear to increase the requirement for sodium from NaCl. Edwards (1985) found significant improvements in 3-wk body weights and feed efficiencies of broiler chicks with or without monensin with increasing dietary NaCl levels from 0.1125 to 0.225, 0.3375, and 0.45%.

Mongin (1968) stated sodium bicarbonate provides sodium, favorably affects blood pH ("can influence the balance of H⁺ ions"), and supplies beneficial bicarbonate. Damron et al. (1986) concluded that the sodium in *Na Bicarb* was equally bio-available to that in NaCl for broiler chicks. Jensen (1982) reported that 4-wk broiler chick weights were significantly improved by 0.65% dietary *Na Bicarb*, compared to results of the control or 0.45% extra NaCl treatment, when a high level of monensin (160 mg/kg) was fed. With monensin at an approved level of 120 mg/kg or at 0 mg/kg, no significant sodium source effects were found.

The incidence of coccidiosis is a constant problem for the broiler industry. Increased sodium from *Na Bicarb* has also been shown to reduce the adverse effect of coccidiosis and decrease in the severity of coccidiosis (Hooge et al., 1999a). The effect of sodium level and source on performance on birds provided with an intentional coccidiosis challenge on day 14 was also evaluated. In both diet types, *Na Bicarb* sources significantly improved weight uniformity, feed efficiency, mortality, and breast meat yield of market age broilers.

The following study was designed to determine the effect low sodium (0.054% added Na) and high sodium (0.081% added Na) from either S-Carb[®] or sodium bicarbonate on performance of broilers when fed continuously from 0-49 days of age. Weight gain, feed efficiency, feed intake, processing data, litter moisture, and bone ash were evaluated.

Trial Procedures:

Birds were housed in 5'x10' pens separated by wire partitions by replicate. The house was cross ventilated with ceiling fans. Continuous lighting was provided to all birds. All treatments and corresponding feeds were color coded to insure proper identification. Chicks were observed at least two times daily to determine mortality, behavioral, and health changes.

The trial utilized six (6) treatments as shown in table 1. Each treatment contained eight (8) replicates of 70 mixed sex birds, for a total of 560 birds per treatment and 3360 birds on study. Vent sex was used to determine sex with birds being placed in pens to insure a 50:50 ratio. The birds utilized were Cobb x

Cobb. Chicks were replaced for the first 5 days during the course of the trial. Daily observations for signs of unusual behavior, growout patterns or health problems were made. Dead birds were removed daily from pens with weights

Table 1: Treatments

ID	Treatment	Sodium source	Cocci challenge @ day 14
1	Negative Control	Salt	No
2	Positive Control	Salt	Yes
3	Low Sodium 0.054% added Na	Sodium Bicarbonate 0.20 %	Yes
4	High Sodium 0.081% added Na	Sodium Bicarbonate 0.30 %	Yes
5	Low Sodium 0.054% added Na	S-Carb 0.18%	Yes
6	High Sodium 0.081% added Na	S-Carb 0.27%	Yes

Diets are shown in table 2. Starter feed was fed from day 0-21, Grower from day 22 to 37 and finisher from 38 to 49. Dietary composition is shown in table 3. All diets were balanced to meet industry and NRC standards.

Table 1: Diet Composition

Starter (0-21 days)	T1	T2	T3	T4	T5	T6
Corn	56.19	56.19	56.07	56.00	56.12	56.08
SBM 48%	36.46	36.46	36.48	36.49	36.47	36.48
Fat	3.53	3.53	3.58	3.60	3.56	3.58
Salt	0.51	0.51	0.37	0.30	0.37	0.30
S. Bicarb	0	0	0.20	0.30	0	0
S-Carb	0	0	0	0	0.18	0.27
Mineral / Vitamin	3.31	3.31	3.30	3.31	3.30	3.29
SACOX	Y	Y	Y	Y	Y	Y
Grower (22-37 days)	T1	T2	T3	T4	T5	T6
Corn	61.62	61.62	61.49	61.43	61.54	61.50
SBM 48%	31.48	31.48	31.50	31.50	31.49	31.49
Fat	3.43	3.43	3.47	3.50	3.46	3.47
Salt	0.46	0.46	0.32	0.25	0.32	0.24
S. Bicarb	0	0	0.20	0.30	0	0
S-Carb	0	0	0	0	0.18	0.27
Mineral / Vitamin	3.01	3.01	3.02	3.02	3.01	3.03
SACOX	Y	Y	Y	Y	Y	Y
Finisher (38-49 days)	T1	T2	T3	T4	T5	T6
Corn	66.93	66.93	66.81	66.74	66.85	66.82
SBM 48%	26.51	26.51	26.53	26.54	26.52	26.53

Fat	3.36	3.36	3.41	3.43	3.39	3.40
Salt	0.40	0.40	0.26	0.19	0.26	0.19
S. Bicarb	0	0	0.20	0.30	0	0
S-Carb	0	0	0	0	0.18	0.27
Mineral / Vitamin	2.80	2.80	2.79	2.80	2.83	2.79
SACOX	N	N	N	N	N	N

Table 2: Dietary Analysis

Pooled Samples:

Starter	Starter	Grower	Finisher
Energy kcal/lb	1400	1425	1450
Protein %	21.91	20.28	17.46
Calcium %	0.87	0.88	0.84
Total Phosphorus %	0.76	0.66	0.62

Electrolyte Analysis by Treatment:

Starter	T1	T2	T3	T4	T5	T6
Sodium %	0.22	0.21	0.19	0.23	0.22	0.21
Chloride %	0.38	0.34	0.25	0.24	0.29	0.24
Potassium %	0.80	0.94	0.88	0.91	0.87	0.92
Na+K – Cl meq/kg	193	236	237	265	236	259
Grower	T1	T2	T3	T4	T5	T6
Sodium %	0.21	0.17	0.18	0.21	0.20	0.18
Chloride %	0.33	0.30	0.25	0.16	0.22	0.19
Potassium %	0.86	0.84	0.83	0.79	0.82	0.81
Na+K – Cl meq/kg	218	204	220	248	235	232
Finisher	T1	T2	T3	T4	T5	T6
Sodium %	0.18	0.15	0.16	0.17	0.16	0.14
Chloride %	0.30	0.26	0.22	0.14	0.19	0.16
Potassium %	0.78	0.76	0.72	0.75	0.75	0.76
Na + K – Cl meq/kg	193	186	192	226	208	210

A coccidiosis challenge was administered on day 14 to treatments 2, 3, 4, 5, and 6. The birds were taken off feed for 2 hours prior to feeding. Starter feed (50 g/bird) containing *E. maxima* (50,000/bird), *E. acervulina* (100,000/bird) and *E. tenella* (25,000/bird) was fed. This provided enough feed to be consumed in 2-3 hours. Water access was not altered during the challenge. Once all feed was consumed, full feed was again provided.

Feed consumption was determined for 0-21 days, 22-37 days and 38 to 49 days. Feed conversion was determined on days 21 and 49. Litter moisture was determined on days 0, 21, 28, 35, 42 and 49. Lesion scores were performed on 6 birds/treatment (three males and three females) on days 21, 35 and 45 days.

Birds were sacrificed on day 49. Carcass post-chill yield, water uptake and skin tears were recorded for all birds.

Results & Discussion:

Performance data is shown in table 4. As expected, the coccidiosis challenge increased mortality and significantly decreased feed efficiency. When compared to the positive control, which also received the cocci challenge, the addition of sodium bicarbonate or S-Carb improved feed efficiency and weight gain. The addition of higher level of S-Carb resulted in a significantly lower mortality than all other treatments. There was no other treatment effect on mortality.

Table 3: Performance 0-49 days

	Mortality %	Weight (lbs)	F/G corrected
Negative Control	3.125 _{ab}	5.228 _{ab}	1.884 _a
Positive Control	4.567 _{ab}	5.108 _b	1.945 _c
S. Bicarb 0.2%	4.327 _{ab}	5.152 _{ab}	1.923 _{bc}
S. Bicarb 0.30%	4.567 _{ab}	5.228 _{ab}	1.907 _{ab}
S-Carb 0.18%	5.048 _b	5.138 _{ab}	1.920 _{bc}
S-Carb 0.27%	1.683 _a	5.255 _a	1.902 _{ab}

a, b indicate significant difference at $p < 0.05$ as determined by Least Significant Difference.

Six birds from each treatment were sacrificed on days 21, 28 and 35 to be evaluated for lesion scores. The gut was scored from 0 to 4 (no lesions to severe lesions) by a veterinarian. The introduction of a coccidiosis challenge significantly increased the severity of the lesions at day 21 and 28. The treatments with higher sodium, either from sodium bicarbonate or S-Carb showed a linear effect in reducing lesion scores with increasing dietary sodium. This effect was significant at 21 days, and showed similar trends at 28 days. The effect of sodium level and source in the diets on lesion scores was non-significant by 35 days.

Table 4: Lesion Scores (challenge at 14 days)

	21 days	28 days	35 days
Negative Control	0.250 _a	0.250 _a	0.188 _a
Positive Control	1.813 _d	0.833 _b	0.188 _a
S. Bicarb 0.2%	1.625 _{cd}	0.750 _b	0.125 _a
S. Bicarb 0.30%	1.250 _{bc}	0.623 _b	0.167 _a
S-Carb 0.18%	1.667 _{cd}	0.730 _b	0.167 _a
S-Carb 0.27%	1.125 _b	0.604 _b	0.188 _a

a, b indicate significant difference at $p < 0.05$ as determined by Least Significant Difference.

Scored from 0-4 (no lesions to dead)

As birds are grown faster to heavier weights, leg strength becomes more important. The imposition of a coccidiosis challenge reduced performance as well as decreased bone density as reflected by bone ash. The increase of dietary sodium as either sodium bicarbonate or S-Carb showed linear improvements in bone ash.

Table 5: Bone Ash %

	21 days	49 days
Negative Control	40.159 _a	47.451 _a
Positive Control	37.541 _b	44.671 _b
S. Bicarb 0.2%	38.226 _b	45.638 _{ab}
S. Bicarb 0.30%	38.928 _{ab}	45.256 _b
S-Carb 0.18%	38.118 _b	45.580 _{ab}
S-Carb 0.27%	39.109 _{ab}	45.776 _{ab}

a, b indicate significant difference at $p < 0.05$ as determined by Least Significant Difference.

Perhaps the most important criterion in evaluating performance is the carcass data. The carcass data from this trial is shown in table 6. Dry yield percentage was depressed by the coccidiosis challenge. Increasing dietary sodium with either S-Carb or sodium bicarbonate showed a linear response in improving carcass yield and improving water intake of the carcass. The birds in the higher sodium treatments showed yield and water uptake that was not significantly different than the non-challenged birds. No effect on skin tears were observed.

Table 6: Carcass Data

	Dry Yield %	Water uptake %	Skin tears %
Negative Control	67.678 _a	6.821 _{ab}	2.475 _a
Positive Control	64.601 _b	6.745 _b	2.425 _a
S. Bicarb 0.2%	66.823 _{ab}	6.860 _{ab}	2.375 _a
S. Bicarb 0.30%	67.305 _{ab}	7.030 _a	2.413 _a
S-Carb 0.18%	66.305 _{ab}	6.869 _{ab}	2.425 _a
S-Carb 0.27%	67.855 _a	7.001 _a	2.375 _a

a, b indicate significant difference at $p < 0.05$ as determined by Least Significant Difference.

As in previous studies increasing dietary sodium while maintaining or reducing chloride, resulted in drier litter. The effect of the coccidiosis challenge resulted in wetter litter. This effect was significant from day 21 through the end of the study. The addition of sodium to the diet showed a linear effect in drying litter. The highest sodium levels resulted in litter moistures not significantly different from the negative control. There was no difference in sodium sources.

Table 7: Litter moisture

Day	0	21	28	35	42	49
Negative Control	46.81 _a	40.93 _a	42.38 _a	44.72 _a	45.52 _a	50.69 _a
Positive Control	46.44 _a	45.20 _b	48.68 _c	51.91 _b	52.43 _d	56.23 _c
S. Bicarb 0.2%	46.76 _a	45.53 _b	46.14 _{bc}	49.28 _b	49.14 _c	54.44 _{bc}
S. Bicarb 0.30%	46.86 _a	43.12 _{ab}	43.15 _{ab}	45.21 _a	46.17 _{ab}	49.15 _a
S-Carb 0.18%	45.59 _a	44.79 _b	45.16 _{ab}	48.95 _b	48.86 _{bc}	51.11 _{ab}
S-Carb 0.27%	46.19 _a	42.98 _{ab}	42.71 _a	45.03 _a	45.97 _a	49.88 _a

a, b indicate significant difference at $p < 0.05$ as determined by Least Significant Difference.

Conclusions:

This study showed that there was a significant improvement in feed efficiency, carcass yield and reduction of lesion scores when broilers were fed diets that contained higher sodium and dietary electrolyte levels. It appears that the efficacy of the coccidiostat, SACOX, was improved when combined with diets higher in sodium. The mortality was reduced following an induced coccidia challenge and the severity of lesion scores was significantly reduced on higher sodium diets.

There was no interaction on any parameter measured among sources of additional sodium. Both sodium bicarbonate and S-Carb were effective when fed at equal sodium levels. Balancing diets with higher than conventional sodium levels, and lower chloride levels with *Na Bicarb* (either sodium bicarbonate and S-Carb) resulted in significant improvements in broiler performance, bone ash slightly (especially with higher levels), reduced litter moisture, carcass yield and carcass moisture uptake.

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