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Iodine as an alleviator of bromine toxicity in thyroid, liver and kidney of broiler chickens

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ABSTRACT

The study pursued the hypothesis that bromine (Br) in drinking water at levels > 0.01 mg Br/L may have detrimental effects on the liver, kidneys and thyroid and the thyroid hormones T_3 and T_4 and that iodine (I) may alleviate the potential hazardous effect of Br. The research was done with mixed Ross broiler chickens over a 42-day post-hatch growth period. The trial design was six treatments, T1: 0 mg Br/L and 0 mg I/L; T2: 1 mg Br/L and 0 mg I/L; T3: 3 mg Br/L and 0 mg I/L; T4: 0 mg Br/L and 0.7 mg I/L; T5: 1 mg Br/L and 0.7 mg I/L; and T6: 3 mg Br/L and 0.7 mg I/L delivered via drinking water and three replicates per treatment with 30 birds per replicate. The effect of Br on T_3 and T_4 levels overall was non-significant, but T_3 and T_4 levels decreased between Weeks 4 and 6 with a significant effect at Week 6 on T_3. Br had an overall effect on the thyroid gland ($P = 0.0457$), liver ($P = 0.0025$) and kidney ($P = 0.0032$), and had accumulated in these three organs. Histopathological assessment showed explicit damage to the livers that received the Br treatments. Iodine (0.07 mg/L) ameliorated the negative effects of high Br (3 mg/L Br) concentration and ingestion.

1. Introduction

Groundwater in South Africa contains a high range of natural bromide (Br) with recorded values from 0 to 18.4 mg/L (Casey and Meyer, 2001, 2006). At 18.4 mg/L Br the concentration is eight times the level of 2.3 mg/L recommended by The Safe Drinking Water Committee (1988) for a 70 kg person drinking 2 L/day and 92 times the 0.2 mg/L noted as a maximum Br level in drinking water (El'piner et al., 1972). The current South African Water Quality Guidelines (Second Edition), 1996, set 0.01 mg/L Br as the reference value for livestock (Casey and Meyer, 1996). A concentration of a water quality constituent (WQC) that exceeds the reference value is considered to be a potentially hazardous chemical constituent (PHCC). In the instances where Br exceeds 0.01 mg/L, Br is considered to be a PHCC.

The potential toxicity of Br is well documented. Vaiseman et al. (1986) reported that 96% of ingested Br can accumulate in the human body as in livestock, especially within the thyroid gland, liver and kidneys (Jolles, 1966). The accumulated concentrations of Br in livestock can lead to excessive intakes of the mineral by humans through consumable products from livestock as via milk noted by Vreman et al. (1985). Mamabolo et al. (2009) found that broilers over a 42-day growth period exposed to 0.1 mg/L Br as NaBr with Total Dissolved Solid (TDS) < 500 mg/L, accumulated 14.89 mg/kg DM (dry matter) in the liver, 12.22 mg/kg DM in the kidney, 20.52 mg/kg DM in heart muscle, 13.96 mg/kg DM in thigh muscle and 7.70 mg/kg DM in breast muscle. The Br accumulation was significantly higher than arsenic (As administered as As_2O_3) or lead (Pb administered as $Pb(NO_3)_2$) in the same tissues under the same conditions. Mamabolo et al. (2009) further reported that TDS of 1500 mg/L increased water intake, but had a positive ameliorating effect on the accumulation of the elements in the tissues. Br concentrations were still greater than the As or Pb.

The risk of exposure to Br levels > 0.01 mg/L on livestock was reaffirmed (Du Toit and Casey, 2010). Broilers were exposed to balanced combinations of 1 and 3 mg Br/L and 0.0 and 0.7 iodine (I) mg/L through drinking water (Days

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Table 1
Average T_4 hormone levels (pmol/L) (means and SD) of broilers with the different bromine (Br), iodine (I) levels (mg/L) in treatments T1 to T6 compared within weeks 4 and 6.

Week	Treatments						Means	P-value
	T1 0 Br + 0 I	T2 1 Br + 0 I	T3 3 Br + 0 I	T4 0 Br + 0 .7 I	T5 1 Br + 0.7 I	T6 3 Br + 0.7 I		
4	6.27	6.38	5.42	5.52	5.77	6.50	5.98	0.7412
	(0.89)	(1.54)	(0.28)	(0.40)	(0.73)	(0.60)	(0.91)	
6	6.00	5.59	5.29	5.89	5.80	5.10	5.61	0.5360
	(1.09)	(0.62)	(0.33)	(0.75)	(0.24)	(0.00)	(0.63)	

Differences determined at $P<0.05$ according to the Fischer's Test.

1–42). Treatments administered at 1 and 3 mg Br/L or at ingestion rates of 1.59 and 4.44 mg Br/day affected production parameters significantly. I had an effective ameliorating effect on Br. The negative effect on production parameters may reflect sub-clinical pathological conditions.

Physiological manifestations may occur following the ingestion of Br over different time periods. The biggest influence is on the production of thyroid gland hormones; the thyroid glands of rats that received high dietary Br increased significantly (Rauws and Van Logten, 1975). The goitrogenic effect of Br is further supported by Velický et al. (2004) who recorded marked changes in the morphology of the thyroid gland and reduced iodide accumulation in the thyroid gland, as well as the skin in rats fed a diet containing a high concentration of Br.

Hellerstein et al. (1960) reported that species differences of Br concentrations in tissues were small and that Br does not accumulate in a particular organ or tissue. Cole and Patrick (1958) and Jolles (1966) on the other hand did report relative proportions of Br in various organs 2 h after intraperitoneal administration of 50 microcuries (μc) ^{82}Br as KBr. The relative proportions were 1.000; 0.536; 0.320; 0.394; 0.131; and 0.602 for the thyroid gland; kidney; adrenals; liver; brain and blood (Jolles, 1966). Langley (1958) reported that the biological half-life of Br could be decreased by the administration of surplus I ions.

The study pursued the hypothesis that Br in drinking water at concentrations exceeding the guideline value (0.01 mg Br/L) may have a detrimental effect on the liver, kidneys and thyroid and the thyroid hormones T_3 and T_4 in broilers over a 42-day growth period, and that I in the drinking water may alleviate the potential hazardous effect of Br.

2. Materials and methods

2.1. Ethics approval

Procedures for this trial were approved by the University of Pretoria Animal Use and Care Committee (Reference EC080805-032).

2.2. Trial design

The statistical design was a 3×2 factorial design with three levels of Br (0, 1 and 3 mg/L) and two levels of iodine (I) (0 and 0.7 mg/L) with three replicates per treatment and thirty Ross broilers of mixed sex per replicate. The duration was 42 days post-hatch. Water intake (WI), weight gain and feed intake (FI) were recorded weekly for each replicate. The treatments were designated

T1: 0 mg Br/L and 0 mg I/L; T2: 1 mg Br/L and 0 mg I/L; T3: 3 mg Br/L and 0 mg I/L; T4: 0 mg Br/L and 0.7 mg I/L; T5: 1 mg Br/L and 0.7 mg I/L; and T6: 3 mg Br/L and 0.7 mg I/L.

2.3. Animal husbandry

The housing, management and nutrient composition of the starter (ME/kg DM 11.2), finisher (ME/kg DM 11.4) and post-finisher (11.6 ME/kg DM) broiler diets were as described by du Toit and Casey (2010). Water was delivered from graduated cylinders via bell drinkers for accurate measuring of water intake. The trace element premix contributed 0.001 g/kg I to the diets, and 0.0 g/kg Br.

2.4. Treatments

Selection of 1 and 3 mg Br/L was by considering these concentrations of PHCC against the recommended level 0.01 mg/L (Casey and Meyer, 1996). Since in many rural settings people use the same water source as the livestock the corollary to the opinion of McKee and Wolf (1963) that water safe for human consumption may presumably be used safely by livestock should be considered. The physiological responses of livestock to PHCC may be indicators of the risk to people.

The administration of 0, 1 and 3 mg Br/L was to verify the recommended levels of Br at 2.3 mg/L (The Safe Drinking Water Committee, 1988), 0.2 mg/L noted as a maximum Br

Table 2
Average T_3 hormone levels (pmol/L) (means and SD) of broilers with the different bromine (Br) and iodine (I) levels (mg/L) in treatments T1 to T6 compared within weeks 4 and 6.

Week	Treatments						Mean	P-value
	T1 0 Br + 0 I	T2 1 Br + 0 I	T3 3 Br + 0 I	T4 0 Br + 0.7 I	T5 1 Br + 0.7 I	T6 3 Br + 0.7 I		
4	3.33	3.55	4.60	3.27	4.10	3.37	3.70	0.2503
	(0.94)	(0.74)	(1.53)	(0.32)	(0.30)	(1.46)	(0.89)	
6	2.20^{b}	2.78^{a}	2.17^{b}	2.07^{b}	2.55^{a}	2.53^{a}	2.38	0.0010
	(0.30)	(0.50)	(0.16)	(0.35)	(0.28)	(0.33)	(0.18)	

^{ab} Row means with different superscripts within weeks differ ($P<0.05$) according to the Fischer's Test.