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Zinc dipping can help reduce wool yellowing

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ABSTRACT

On one farm dipping sheep once or twice with zinc sulphate had no effect on the yellowness of wool at shearing. When data from this farm were combined with data reported earlier, the reduction in yellowness was linearly related to the yellowness of the control group (P = 0.091, 0.032 for dipped once or twice, respectively). On another farm, groups of 20 rising two-tooth New Zealand Halfbred ewes were treated in February by either dipping with zinc sulphate solution (2.45 g Zn/l) or dosing with a zinc bolus. Both treatments reduced the yellowness of belly wool at crutching (May) (Y-Z = 4.31, 2.13 and 1.87 for control, bolus and dipped sheep, respectively, P<0.01), but had no effect on the yellowness of the flank wool (Y-Z = -0.16, -0.27, -0.06). Zinc concentrations in clean wool (initial concentration = 78.5 mg/kg) were increased in all three groups at crutching but the differences were significant for the dipped group only (zinc concentrations = 160, 211, 340 mg/kg for control, bolus and dip, respectively, P<0.001). Thus, in some cases, increasing the concentrations of zinc in wool can reduce yellow discolorations at shearing. The effect will be greatest where wool from untreated sheep is yellowest. This could prove to be a useful method to improve wool quality on some farms.

Keywords: Zinc sulphate; zinc oxide; wool; yellowing; Crossbred; New Zealand Halfbred.

INTRODUCTION

Because yellow discoloration of wool makes it difficult to dye and restricts the shades which can be used, such wool is discounted at sale. In an earlier paper (Reid & Urquhart, 2003) we showed that the practice of dipping sheep with zinc solution could reduce yellow discoloration of wool under some circumstances. This paper describes more results from the original trial, including data from a fifth farm, and preliminary results from a further trial examining the effect of zinc supplementation of sheep on the yellowness of their wool.

MATERIALS AND METHODS

Trial 1.

This trial, on one farm, used the same design as that used on four farms described in the earlier paper (Reid & Urquhart, 2003). Briefly the treatments applied were:

Group 1. Control – no treatment.
Group 2. Dipped once with 20 g/l zinc sulphate solution in late spring/early summer.
Group 3. Dipped twice with 20 g/l zinc sulphate solution, once in late spring/early summer and again in mid-summer.

Six hundred mixed age Romney cross Texel and Romney cross Finn ewes were allocated at random among the three treatment groups. The aim was to have sufficient ewes in each group to provide two bales of wool in the main fleece line. The location of the farm, breed of sheep used and timing of treatments are given in Table 1.

After shearing, the bales of wool from the main fleece lines, a second yellow fleece line (comprising 15.6%, 9.6% and 16.5% of the wool from the control, dipped once and dipped twice groups, respectively) and the oddments line (16-19% of the wool from the three lines) were core sampled. Base yellowness (NZS8707:1984) was determined on four sub-samples from the main fleece line and two sub-samples from each of the other two lines. Propensity to yellow (Aliaga *et al.*, 1996) was determined on sub-samples of these core samples as before (Reid & Urquhart, 2003) using either water or zinc sulphate solution (50 g/l) to spray the wool.

TABLE 1: Details of farm location, sheep breed and timing of shearing and dipping on the farms used in Trials 1 and 2.

Trial	Location	Breeds	Pre dip Shearing	Zinc dipping First	Zinc dipping Second	Crutching	Post dip Shearing
1.	Takaka (Nelson)	Romney x (Texel or Finn)	October 2001	13/02/02	28/05/02		28/10/02
2.	Lees Valley (Canterbury)	NZ Half-bred	October 2002	3/2/03		13/5/03	

Staple length and zinc concentrations of the greasy wool were determined as before (Reid & Urquhart, 2003) on mid-side samples collected from 20 sheep from each group before each treatment and again before shearing.

Trial 2.

Three groups of 20 two-tooth New Zealand Halfbred ewes, earlier shorn as hoggets in October 2002, were selected at random before dipping for fly control in early February 2003 (Table 1). Treatments applied were:

1. Control.
2. Dosed with a zinc bolus (The Time Capsule, Agri-Feeds Ltd) at dipping and again at crutching.
3. Dipped with a solution containing zinc sulphate (2.45 g Zn/l).

Wool samples were collected at dipping in February (mid-side) and again at crutching in mid-May (two sites - side and belly).

Mid-side samples from the initial sampling and belly and side samples collected at crutching from six animals from each group were analysed for a range of elements to examine the effect of zinc dosing on other minerals in the wool.

Mineral concentrations

Wool samples were cleaned by the system used to clean wool for colour measurement (NZS8707:1984) using distilled water. After conditioning, these wool samples were digested in concentrated nitric acid, evaporated to dryness and the residue dissolved in 2M hydrochloric acid. The mineral content of the digest was determined by inductively coupled argon emission spectrometry.

The trial protocols were approved by the Lincoln AgResearch Animal Ethics Committee (Trial 1: Application 01/09) and Lincoln University Animal Ethics Committee (Trial 2: Protocol ID WO02/02).

RESULTS

Trial 1.

On-farm results

Zinc concentrations in the initial mid-side wool samples and in the sample from the control group on the second sampling occasion were similar to those observed earlier on four other farms (Reid & Urquhart, 2003). There was a small increase in the concentrations of zinc in the wool of the control group between the second sampling and shearing. Dipping with a zinc sulphate solution resulted in marked increases in the zinc concentrations in the wool between when the first and second treatments were applied (Table 2). Zinc concentrations in the wool from the group dipped once decreased in the 5 months between the second sampling and shearing.

TABLE 2: Effect of dipping sheep with solutions containing zinc sulphate on zinc concentrations (mg/kg) in wool (Trial 1).

Occasion	Control	Dipped		Staple length
		Once	Twice	(mm)
Before first dip	86	83	82	58.1
Before second dip	89	901	877	100.2
Shearing	101	296	975	156.1

Added zinc sulphate had no significant effect on the yellowness of the any of the lines of wool (Table 3).

***In vitro* results**

As there were no interactions between zinc sulphate dipping and the solution used to spray the wool before incubation, only the main effects of zinc sulphate dipping and spraying solution are given. Dipping once with a solution containing zinc sulphate increased both tristimulus Y and Z after incubation significantly, but had no significant effect on tristimulus (Y-Z) - yellowness - after incubation (Table 4). For wool from sheep dipped twice with zinc sulphate solution, none of the tristimulus values were significantly different from those of wool from the control group. Increases in tristimulus Y, Z and decreases in tristimulus (Y-Z) from spraying the wool with zinc sulphate solution before the incubation challenge were all highly significant (Table 5).

TABLE 3: Effect of dipping sheep with zinc sulphate on tristimulus (Y-Z) (base yellow) of wool (Trial 1).

	Control	Dipped		LSD	Significance
		Once	Twice		
Main fleece line	2.9	3.1	3.3	0.85	NS
Yellow fleece line	5.5	4.2	5.7	1.50	NS
Oddments	7.8	8.2	7.2	2.64	NS
Combined*	4.8	4.6	4.9	0.72	NS

* Data from the two fleece lines and oddments line analysed together, removing differences between lines as a block.

TABLE 4: Effect of dipping sheep with zinc sulphate on the colour of wool (tristimulus values) from the main fleece line in Trial 1 after incubating at 40ºC and 100% RH for 6 days.

Tristimulus variate	Control	Dipped		LSD	Significance
		Once	Twice		
Y	53.4	54.8	53.0	0.94	**
Z	44.7	46.0	43.8	1.43	*
Y-Z	8.8	8.8	9.2	0.77	NS

TABLE 5: Effect of spraying wool from the main fleece line in Trial 1 with either water or zinc sulphate on the colour of wool (tristimulus values) after incubating at 40ºC and 100% RH for 6 days.

Tristimulus variate	Water	Zinc sulphate	LSD	Significance
Y	51.8	55.7	0.76	**
Z	41.4	48.2	1.17	**
Y-Z	10.4	7.4	0.63	***

Trial 2.

Mineral content

At crutching, the belly wool was higher in zinc, potassium, magnesium, calcium and phosphorus and lower in copper and sulphur than the wool from the side of the sheep.

Dipping the sheep with a solution containing zinc sulphate significantly increased the zinc concentration of the wool (Table 6). It also increased the copper concentration of the side wool. Supplementing the sheep with zinc using a zinc oxide bolus had no effect on the copper concentration in wool from either the side or the belly. Neither dipping with zinc sulphate solution nor the use of the zinc oxide bolus had any effect on the potassium concentration in the wool from the side, but both reduced the potassium concentration of the wool from the belly, where the potassium concentrations in the wool from the control group was highest. This high potassium concentration of belly wool may have resulted from urine contamination.

TABLE 6: Effect of dipping and supplementing sheep with zinc on mineral concentrations in wool. Concentrations expressed in mg/kg conditioned wool (g/kg for sulphur) (Trial 2).

		Zn	Cu	K	Mg	Ca	P	S
a. Initial samples								
Mean		78.5	8.28	61	37.2	341	127.6	26.7
SEM		1.3	0.21	7.9	2.0	14.1	2.6	0.25
b. Crutching								
Treatment								
	Control	160[a]	6.14	151.2[b]	50.6	397	129.0	25.2[a]
	Bolus	211[a]	6.27	79.2[a]	53.6	371	138.3	25.1[a]
	Dip	340[b]	7.31	69.8[a]	42.1	344	136.0	26.6[b]
	LSD	90.1	1.07	47.8	10.4	91.9	15.3	1.2
	Significance	***	ns	**	ns	ns	ns	*
Site								
	Mid-side	167	7.23	64.8	33.7	278	125.4	26.2
	Belly	306	5.92	135.2	63.9	464	143.4	25.0
	LSD	73.5	0.88	39.0	8.5	75.1	12.5	1.0
	Significance	***	**	***	***	***	**	*
Site*treatment interaction								
Mid-side	Control	202	6.72[a]	71.2[ab]	28.5[a]	250	123.5	26.2
	Bolus	287	6.20[a]	43.3[a]	37.4[ab]	297	127.3	25.3
	Dip	430	8.77[b]	80.0[ab]	35.0[ab]	286	125.5	27.1
Belly	Control	118	5.57[a]	231.2[c]	72.7[c]	544	134.5	24.2
	Bolus	135	6.33[a]	114.7[b]	69.9[c]	445	149.3	24.8
	Dip	249	5.85[a]	59.7[ab]	49.2[b]	402	146.5	26.0
LSD		127.4	1.52	67.6	14.7	130.0	21.6	1.7
Significance		ns	*	**	*	ns	ns	ns

Effects on colour

As a result of a bias inadvertently introduced at the time of initial randomisation of the sheep to their treatment groups, there was a significant difference between the three groups in base yellow. All three tristimulus values X, Y and Z, were higher in the group dipped with zinc sulphate than in the other two groups ($P<0.05$) and the difference in Y-Z (Dip<Control<Bolus) approached significance ($P = 0.059$). For analysis of all subsequent colour measurements, the relevant colour measurements of the initial wool samples have been used as covariates.

Not surprisingly, belly wool was highly significantly lower in tristimulus Y and Z and higher in tristimulus Y-Z than side wool. Dipping or dosing with zinc significantly increased tristimulus Z and decreased tristimulus Y-Z of belly wool, but had no effect on the colour of side wool (Table 7). The effect of dipping on all tristimulus values was greater than the use of the bolus, although these differences were not significant.

TABLE 7: Interaction between treatment and site on colour of wool (tristimulus values) at crutching in May 2003. Colour of wool before treatment used as a covariate (Trial 2).

		Tristimulus		
Treatment		Y	Z	Y-Z
Control		52.9	50.8^{a}	2.07^{b}
Bolus		53.5	52.5^{b}	0.93^{a}
Dip		53.6	52.7^{b}	0.91^{a}
LSD		0.7	1.4	0.75
Significance		ns	**	**
Site				
Side		54.2	54.3	-0.16
Belly		52.4	49.7	2.77
LSD		0.5	1.0	0.59
Significance		***	***	***
Interaction				
Side	Control	54.2^{c}	54.3^{c}	-0.16^{a}
	Bolus	54.3^{c}	54.6^{c}	-0.27^{a}
	Dip	54.0^{bc}	54.1^{c}	-0.06^{a}
Belly	Control	51.6^{a}	47.2^{a}	4.31^{c}
	Bolus	52.6^{b}	50.5^{b}	2.13^{b}
	Dip	53.1^{b}	51.2^{b}	1.87^{b}
LSD		1.0	1.8	1.04
Significance		*	*	***

DISCUSSION

Earlier trials have shown close positive relationships between the yellowness of wool from the control group and the effect of zinc dipping. In the first trial described in this paper, the effects of zinc dipping were not significant, even where the yellowness of the control wool was greatest (highest tristimulus Y-Z), as in the yellow fleece line or oddments. In an earlier trial, using a similar design on four farms, the effect of dipping with zinc sulphate was significant on one farm (Reid & Urquhart, 2003). The yellowness of the main line wool from the control group in that farm was higher than on the other three farms or the one farm reported here (Trial 1).

In the second trial, the effect of dipping or dosing with zinc on the colour of the belly wool was considerably larger than on the side wool which was less yellow. The effects observed in this second trial were larger than those observed in fleece or oddment wool of similar colour in either the earlier trial (Reid & Urquhart, 2003) or the first trial described here. The reason for these differences is not known at this stage. The trials used sheep of different breeds with different mean fibre diameters. The New Zealand Halfbred contains 50% Merino blood.

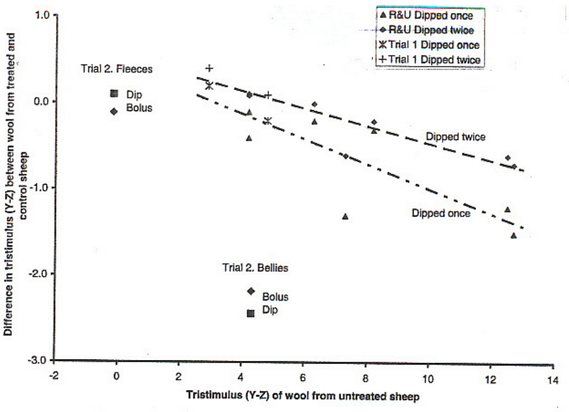
The concentrations of zinc in the wool resulting from either dipping or dosing with zinc were within the range observed in both the earlier study (Reid & Urquhart, 2003) and Trial 1 in this paper. The zinc bolus treatment was included in this trial to examine the effectiveness of an alternative method for supplementing with zinc. Although its effect on zinc concentration in wool was less than that of dipping and not significantly different from the control, its effects on wool yellowness and potassium concentration were not significantly different from those of the dipping treatment. Grace and Lee (1992) also observed an increase in wool zinc concentrations and a decrease in wool potassium concentrations when sheep were dosed weekly with zinc oxide at a similar rate to that used in Trial 2. They did not observe any effect on wool colour (tristimulus X, Y, Z or Y-Z). The yellowness of wool from their control group was less than that from the one farm where a significant reduction in yellowness was observed in the earlier trial (Reid & Urquhart, 2003), but similar to the yellowness of the control wool from Trial 1 and belly wool from the control group in Trial 2 in this paper.

In Trial 2 the bolus had a lesser effect on wool mineral content or colour than dipping with a solution containing zinc sulphate.

Because the yellowness (tristimulus Y-Z) of the fleece wool in the control group in Trial 2 was very low, the effect of zinc dosing or dipping would be expected to be small. The size of the effect of zinc on yellowness was similar to that observed in either Trial 1 or the earlier trial (Reid & Urquhart, 2003) with slightly yellower wool. However, when the data from Trial 1 were combined with those from the other four farms described earlier, the size of that effect for the main lines depended on the yellowness of the control group (Figure 1). The effects of zinc in Trial 2 were greater than would be expected from these relationships.

No significant relationship was found on any of the farms described in the earlier paper (Reid & Urquhart, 2003) or in the farm used for Trial 1 in this paper, between the effect of dipping with zinc sulphate on yellowness of wool and the previous shearing time, time of either first or second treatments, time from the previous shearing and initial treatment, time between treatments nor time between the first or second dipping and the next shearing. It would thus appear that the effect of zinc on wool yellowness is not related to shearing or dipping times.

FIGURE 1: Comparison of the effects of dipping or dosing sheep with zinc on the yellowness (tristimulus (Y-Z)) of wool at shearing, combining data from Reid & Urquhart (2003) (R&U) and Trial 1 from this paper. Data from Trial 2 are included for comparison.



In view of the known inhibiting effect of zinc on copper absorption and metabolism (Lee *et al.*, 1999), it is reassuring to note that the use of zinc boluses in Trial 2 and zinc oxide dosing (Grace & Lee, 1992) had no overall effect on the copper concentration of wool.

Zinc applied in a dip solution to the wool had a greater effect on the zinc concentration of clean wool than did zinc administered through a rumen bolus. The zinc ion from the dip must have been absorbed by the wool fibre and become tightly bound to it, as it was not removed by the washing process.

Potassium concentrations in suint are highly correlated with propensity to yellow and wools resistant to yellowing have been shown to be lower in potassium concentration than susceptible wools (Aitken *et al.*, 1994; Sumner *et al.*, 2004). Those authors showed that suint potassium concentrations are more highly correlated with propensity to yellow than is the potassium concentration in the clean wool. The finding of lowered potassium concentrations in belly wool from sheep either dipped with zinc sulphate solution or supplemented with a zinc oxide bolus may provide a mechanism for the effects of zinc described in this and an earlier paper (Reid & Urquhart, 2003). The mechanism for this reduction in potassium concentration in belly wool is not known, but may have resulted from an inhibition of potassium excretion, either in the urine or in the suint on the belly. It is not known whether this is the only effect zinc dosing or dipping has on the processes involved in wool yellowing. Given that the bacterial content of the fleece has been implicated in the yellowing process (Winder *et al.*, 1998), one effect of zinc may be to reduce the population of one or more species of bacteria involved.

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