

REVELATION

Effects of soaking hay on its nutritional quality

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INTRODUCTION

The association between mouldy hay and equine respiratory disease is well-established (McPherson *et al.* 1979; Clarke 1986; Cuddeford 1989). Most hay samples are significantly contaminated with mould spores (Clarke and Madelin 1987) and in order to reduce the respiratory challenge presented to stabled horses it is common practice to soak hay in water before feeding, often for up to 12 h. The beneficial effects on aerobiology conferred by soaking for as little as 5 mins have been demonstrated (Clarke 1987) but whether there is any nutritional disadvantage is unknown.

Grass dry matter contains a significant but variable content (15–30%) of water-soluble carbohydrates (Thomas 1977). This fraction can be significantly reduced by leaching when grass is dried in the field under unfavourable weather conditions (McDonald *et al.* 1988). Water-soluble carbohydrates and nitrogenous compounds are lost from fresh grass when it is ensiled resulting in a liquid effluent with a high biological oxygen demand (BOD). BOD is a measure (in mg/litre) of the amount of oxygen required by micro-organisms to oxidise the organic content of a liquid and figures of 12,000–80,000 are typical of silage effluent (Roberts 1988), making it a dangerous environmental pollutant. Soaking hay for 12 h produces a dark-brown liquor which ferments in warm conditions (Clarke 1987) and which has a detectable BOD (Simpson 1991).

The conventional laboratory analysis of forage for water-soluble carbohydrate is based on a 1-h aqueous extraction (after Deriaz 1961). Prolonged soaking of hay

might therefore be expected to lead to losses of water-soluble carbohydrate and possibly of crude protein. If these losses are significant, then the resultant soak liquor may present a potential hazard to the environment.

This study aimed to provide information on the changes in nutritional quality associated with the hay soaking process and on the time scale involved. A series of laboratory analyses for water-soluble carbohydrate and crude protein were performed on hay before and after soaking for times ranging from 5 mins to 12 h and on the resultant liquor samples produced. The BOD values of soak liquors were determined to confirm nutrient loss and to estimate potential pollution hazard.

MATERIALS AND METHODS

Samples of hay were obtained from the College Horse Unit on 3 occasions (Hays A, B and C) and analysed during the experiments (Table 1).

Sub-samples (250 g) of hay were immersed in 5 litres tap water in 10-litre plastic vessels (based on normal practice at the Equine Studies Unit). After soaking for the designated time, the hay was drained on plastic trays before being oven-dried for 2 h at 102°C for the determination of water-soluble carbohydrate (WSC) in duplicate by the anthrone method and further dried for 18 h for the determination of crude protein (CP) and residual moisture in triplicate by the Kjeldahl digestion and Markham distillation procedures, respectively.

Samples of liquor were retained and analysed immediately for WSC and CP by the above methods. BOD determinations were performed by the Winkler method on 3 different dilutions of liquor samples.

Initial experiments (Ia, b and c) investigated a 12-h soaking on triplicate hay samples. Later experiments (IIa, b and c) investigated shorter soak times on single samples of hay. In Exp. III the additional environment hazard imposed by the liquor when hay was repeatedly soaked in the same water was investigated.

The experimental design is summarised in Table 2. Statistical comparisons between results for each experiment were made by analysis of variance.

TABLE 1: The composition of the 3 hay samples

Analysis	Hay A		Hay B		Hay C
	Sample a	Sample b	Sample a	Sample b	
Dry matter (%)	87.2	91.0	87.3	87.8	84.5
Crude protein (g/100 g)	11.7	11.0	8.5	8.4	8.6
WSC (g/kg)	99.7	102.7	73.7	74.0	83.6

TABLE 2: Experimental details

Exp.	Hay sample	Determination of:			Soak time (mins)
		WSC	Crude protein	BOD	
la	A	+	+	+	720
b	A	+	+	+	720
c	C	+	-	+	720
IIa	B	+	+	+	5, 30, 120
b	B	+	+	+	10, 30, 120,
c	C	+	-	+	10, 30, 120, 480, 720
III	A	-	-	+	720 (same water used once, twice and three times)

RESULTS

EXPERIMENT I

Mean results for the 3 experiments involving a 12-h soak period are presented in Table 3. Analytical results for WSC and CP in the soak liquors are expressed on the basis of hay dry matter so that direct comparisons may be made. The results consistently demonstrate a loss of WSC and CP fractions during the soaking process. The BOD values of soak liquors (Table 3) confirmed the leaching of nutrients from the hay samples.

EXPERIMENT II

The results in Table 4 show that shorter soak periods reduced the degree of nutrient loss, particularly the WSC values. There was a corresponding increase in BOD values with increased soaking times.

EXPERIMENT III

When 2 samples (a, b) of Hay A were soaked once, the mean BOD value was 5,000 (3,900 and 6,100) mg/litre. After 2 and 3 soakings in the same water, the mean values were 5,800 (4,900 and 6,700) mg/litre and 6,100 (5,800 and 6,400) mg/litre, respectively. Repeated soaking therefore led to a cumulative build-up of nutrients in the liquor but the initial soaking in fresh water made the major contribution to the final BOD value.

DISCUSSION

Soaking hay for a 12-h period has a significant impact on its content of water-soluble carbohydrates and nitrogenous compounds: the magnitude of dry matter loss was in the region of 2.0–4.0% for water-soluble carbohydrate and 1.5–2.0% for crude protein (Table 3). These nutrients comprise part of the digestible fraction of hay dry matter. Given estimates of digestibility to horses in the region of 50%^a for average quality hays (Frape 1986; Wise 1987), these figures represent a sizeable nutrient loss to the horse. Soaking times of 30 mins or less led to smaller losses in water-soluble carbohydrate and an insignificant loss of crude protein.

Clarke (1987) demonstrated that the duration of soaking is not as important as thorough wetting in terms of reducing respirable challenge. He reduced the number of respirable particles per mg source by ~96% after a 5-min soak compared with 99% after a 24-h soak. The present study indicates that to minimise nutrient loss whilst significantly reducing respiratory challenge, a 5- or 10-min soak is the most desirable strategy. This will have the added advantage of producing a soak liquor representing only a small potential hazard to the environment.

Results for the 12-h soaking trial indicate that the resultant liquor represents a pollutant which is 10 times as strong as raw sewage and one-tenth the strength of

TABLE 3: Nutrient losses associated with a 12-h soak period (Exp. I)

Exp.	Sample	WSC (g/kg hay)		CP (g/100 g hay)		BOD (mg/litre)	
		Pre-soak	Post-soak	Pre-soak	Post-soak	Pre-soak	Post-soak
la	Hay A	99.1	— ^a	11.7	9.3 ^{***}		
	Liquor	0	39.0	0	3.1	0	3800
1b	Hay A	102.7	71.4	11.0	9.8		
	Liquor	0	24.3	0	1.9	0	5000
1c	Hay C	83.6	46.0 ^{**}	— ^a	— ^a		
	Liquor	0	32.2	— ^a	— ^a	0	3550

^a Missing value.

^{**}P<0.01, ^{***}P<0.001 compared with pre-soak value.

TABLE 4: Nutrient losses associated with soak periods of <12 h (Exp. II)

Exp.	Hay	Soak time (mins)	WSC (g/kg hay)		CP (g/100 g hay)		BOD (mg/litre) Liquor
			Hay	Liquor	Hay	Liquor	
IIa	B	0	73.7	0	8.5	0	0
		5	— ^a	4.4	8.5	1.0	500
		30	— ^a	13.7	8.3	1.3	880
		120	— ^a	25.2	7.9	2.0	5600
IIb	B	0	74.0	0	8.4	0	0
		10	75.8	6.8	8.6	1.8	770
		30	61.6	12.5	7.9	1.7	780
		120	47.0	21.6	8.0	2.3	1100
		480	36.3	34.2	7.4	3.0	— ^a
		720	38.5	41.6	7.6	2.0	— ^a
IIc	C	0	83.6	0			0
		10	75.7	4.7			650
		30	57.4	9.9			750
		120	62.1	11.8			1040
		480	27.8	37.7			3100
		720	46.0	30.0			3570

^a Missing value.

dangerous pollutants such as pig slurry or silage effluent (Roberts 1988). Although most stable yards will only dispose of small quantities of soak liquor at any one time, there may be serious implications for commercial establishments soaking hay for a large number of animals.

Although it was not possible to predict the exact nutritive value of soaked hay for rationing purposes, the consistency of results obtained, together with the good agreement between nutrient disappearance from hay and appearance in soak liquor, justify the general recommendations that a soak period of minimum duration should be used to maximise the nutritional quality of the resultant forage fed to the stabled horse.

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