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Ash from fireplaces at homesteads in rural regions of South Africa as potential source of minerals to goats

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Abstract

In this study the mineral composition of ash from fireplaces at rural homesteads was determined to establish if such ash could be a source of minerals to goats. The mineral composition of ash collected from homesteads in six different communal farming regions of South Africa was determined. The ash samples collected in the three northern regions of the country contained between 180 and 248 g Ca/kg dry ash, while those from the Eastern Cape Province contained low concentrations (8–45 g Ca/kg ash) and high concentrations of Si. It is concluded that wood was probably used as fire making material in the northern regions, while cattle manure was probably used in the Eastern Cape regions, though soil contamination could have contributed to the high Si concentrations. The concentration of the Fe and Zn in ash was high while that of the other elements in ash was relatively low and would probably contribute little to a goat's diet, considering the proportion of ash in a total diet. It is concluded that in some regions of the country goats would be able to ingest a substantial proportion of Ca when scavenging on ash heaps or receiving ash as a dietary supplement, while in other regions this will not be the case.

Keywords: Ash, element sources, maize cobs, cattle manure, wood
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Introduction

In communal farming regions of Africa, goats are frequently scavenging for food and are quite likely to take in ash from household fires. It is well documented that wood ash is rich in Ca and has been used successfully as a fertilizer especially to ameliorate the acidity in soils (Demeyer *et al*., 2001). The product also showed promise as a mineral supplement to livestock in the tropics (Imbeah, 1999) and in the treating of low quality fibres to improve fibre utilization by ruminants (Nolte *et al*., 1987; Raminez *et al*., 1992). This study investigated to what extent ash from fireplaces at rural homesteads could be a source of minerals to goats when taken in inadvertently or be mixed with other feeds to supplement the minerals in the diet of the goat. The mineral composition of ash collected from homesteads in different regions of South Africa was determined. Different materials are used in South Africa to make fires. The mineral composition of ash in wood and bark from trees has been reported previously (Van Ryssen & Ndlovu, 2003). In response to the results on the composition of the homestead ash in this study, two other sources of fire making material, maize cobs and cattle dung, were collected and analysed for mineral element content.

Materials and Methods

Ash from fireplaces at homesteads was collected in six subsistence farming regions of South Africa, *viz*. the bushveld areas of the Limpopo, Mpumalanga and the north-eastern KwaZulu-Natal Provinces, as well as from the northern and southern Transkei and the Ciskei in the Eastern Cape Province. Samples were collected from five homesteads per region. The ash was sifted through a kitchen sieve to remove coarse coal particles. The mineral composition was also determined of the ash in maize cobs collected from three locations in subsistence farming areas and from three commercial farms, and in ash from cattle manure collected in subsistence farming areas in the Eastern Cape. The organic matter content of the ash was determined by combustion in a muffle furnace at 500 ^{o}C, and the remaining ash was analysed for macro- and micro-element concentrations. After dissolving the ash in HCl, the Ca, Mg, Fe, Cu, Mn and Zn concentrations were determined, using atomic absorption spectrophotometry, and Na and K, using flame emission spectrophotometry. The photometric method using molybdovanadate was used to measure the P concentration in the ash (AOAC, 1990). Silica and Al concentrations were measured, using the ICP-AES method. The ash samples within each region were pooled to measure the crystalline forms of the metals in the ash, using the standard Powder x-ray diffraction (XRD) technique on a Siemens D-501 automated diffractometer (Chung, 1974). Means were compared statistically using an ANOVA procedure (SAS, 1994).

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Results and Discussion

Van Ryssen & Ndlovu (2003) found that ash from wood and bark contained on average 280 and 340 g Ca/kg, respectively. In comparison, the Ca concentrations in the homestead ash from the three Northern bushveld regions of South Africa were slightly lower, between 180 and 248 g/kg (Table 1), suggesting that wood was probably the main source of fire making material in these areas. Imbeah (1999) reported that ash from wood fires collected from houses in Papua New Guinea contained 121 g Ca/kg ash, while Campbell (1990) stated that wood ash in general contains between 80 and 330 g Ca/kg. From the XRD test (Table 2) the Ca was mainly in the form of calcite ($CaCO_3$), in accordance with Demeyer *et al*. (2001), and in the same form as feed lime that is used in livestock nutrition (Bredon *et al*., 1987). Cereals such as maize and sorghum grains and their by-products contain low concentrations of Ca (Bredon *et al*., 1987). Ash could be used to supplement the Ca in such products. From an animal nutritional point of view the ash is not a good source of P, the most likely mineral element to be deficient in livestock feeds in the tropics. Also, at a hypothetical level of inclusion of 1-2% ash of the total diet, ash would not be a major source of any of the other elements, with the exception of Fe and Zn, especially if the elements are present in forms with a low bioavailability, such as oxides (Demeyer *et al*., 2001).

Table 1 Average (± s.e.) percentage organic matter (OM) and concentration of macro- and micro-elements in ash from rural homestead fires

Region*	OM	Ca	P	Mg	K	Na	Si	Cu	Mn	Fe	Zn	Al
	%	g/kg dry ash						mg/kg dry ash				
Limpopo	3.1	248	6.8	28.2	50.9	6.8	50	95	191	3850	2124	3582
	±1.4	±50	±2.3	±12.4	±23.2	±3.3	±32	±32	±130	±735	±2427	±1230
Mpu-	4.5	183	8.5	25.4	52.5	6.7	137	89	104	5853	308	5488
malanga	±1.8	±52	±4.2	±9.4	±9.3	±4.2	±67	±58	±60	±3131	±255	±1511
KwaZulu-	6.5	197	12.2	55.9	64.4	13.3	71	193	208	10551	619	6360
Natal	±2.3	±1.1	±0.5	±34.2	±10.1	±3.0	±17	±22	±32	±2947	±241	±1176
Ciskei	6.1	37	12.2	14.7	7.0	4.5	331	135	171	13887	644	7954
	±1.3	±2.8	±1.0	±0.8	±0.7	±0.4	±22	±21	±20	±1374	±243	±259
Southern	5.3	45	16.2	20.4	9.9	5.0	252	141	198	12881	429	7752
Transkei	±1.7	±9.1	±2.2	±2.9	±2.4	±0.9	±142	±14	±30	±7142	±44	±576
Northern	1.7	8.0	8.0	9.98	13.5	2.1	_	41	190	6077	321	_
Transkei	±0.4	±5.1	±3.0	±2.4	±6.7	±0.3		±12	±34	±1203	±60	
LSD	3.15	58.6	4.9	30.2	22.2	4.9	138	60	124	6838	1968	13.8

*Five samples per region; LSD – least significant difference ($P < 0.05$)

Table 2 Crystalline forms of elements in homestead ash, pooled per region, using x-ray diffraction (XRD) analysis (expressed semi-quantitatively as percentages of total*)

Crystalline form	Limpopo %	KwaZulu-Natal %	Mpumalanga %	Eastern Cape		
				Ciskei %	Southern Transkei %	Northern Transkei %
Calcite ($CaCO_3$)	85.9	76.0	70	17	15	2
Quarts (SiO_2)	3.8	5.4	7	60	36	79
Hematite (Fe_2O_3)	0.7	1.7	0	0	0	0
Portlandite ($Ca(OH)$)	1.3	1.8	2	0	0	0
Lime (CaO)	0.7	1.4	0	0	0	0
Siderite ($Fe(CO_3)$)	0.7	1.8	1	0	3	0
Dolomite ($CaMg(CO_3)_2$)	1.4	1.7	0	0	0	0

* Crystalline forms present in low proportions not presented

In the present study the ash from the three regions in the Eastern Cape contained only between 8 and 45 g Ca/kg ash. Considering the high concentrations of Si in the latter samples a possible reason for this could be soil contamination. However, different fire making material with different chemical compositions could have been used in these regions, such as maize cobs and cattle manure. The mineral composition of

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ash in maize cobs from commercial *vs.* communal farms was (g/kg dry ash): 9.9 and 8.2 Ca; 19.8 and 19.8 Mg; 8.3 and 2.5 Na, 586 and 415 Fe; 175* and 403* Zn (*P < 0.01), and in mg/kg dry ash: 246 and 210 Cu; 541and 497 Mn, respectively. According to these analyses more the 50% of the ash in maize cobs consisted of Fe and Zn. It is therefore most unlikely that maize cobs could have been the source of the homestead ash from the Eastern Cape which contained high concentrations of Si in the form of quartz (Table 2).

Although the cattle faeces were not collected at the same localities as the homestead ash, their mineral composition corresponded fairly well with that of the homestead ash from the Eastern Cape (Table 3). This could suggest that cattle manure was probably an important source of fire making material in the Eastern Cape and could explain the differences in composition of homestead ash between the Eastern Cape and the northern provinces of South Africa. Except for the Fe concentration, these mineral concentrations in the cattle faeces from the communal grazing areas in the Eastern Cape Province were less than 50% of that in faeces from steers in feedlots (converted to an ash basis) in the USA, as reported by Fontenot (1991).

Table 3 Average mineral element composition in the ash (dry basis) in cattle faeces collected in communal grazing areas *vs*. the composition of the homestead ash collected in the Eastern Cape

Sources of ash	Ca g/kg	P g/kg	Mg g/kg	K g/kg	Na g/kg	Fe mg/kg	Zn mg/kg	Cu mg/kg
Cattle faeces	45.2	11.6	14.4	21.4[a]	12.2[a]	41371[a]	366	107
E. Cape Homesteads	29.8	12.1	15.0	10.1[b]	3.9[b]	10948[b]	465	106

Values with superscripts a-b signify differences at P < 0.05

Conclusions

The mineral composition of ash from homestead fireplaces can vary tremendously, depending on the fire making material. Therefore, although ash from some homesteads contains high concentrations of Ca which could be of nutritional significance to goats, homestead ash, in general, cannot be recommended as a mineral supplement to goats. If Ca has to be supplemented, it is advisable to burn wood specifically for that purpose rather than to collect ash from fireplaces.

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