

THE EFFECT OF DIFFERENT EXTRACTION PROCESSES ON THE NUTRIENT CONTENT OF FILTERCAKE

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Abstract

Samples of filtercake from all mills in the South African and Swaziland sugar industries were analysed for nutrient composition at regular intervals during 1979. It was found that at those mills using the cane diffusion process average P, Ca, Mg, Zn and Mn percentage contents of filtercake were considerably higher than those from factories where tandem rollers were used to crush cane. This can probably be attributed to the fact that filtercake percent cane from mills with diffusers was on average about half that from factories where mill tandems only were used, the latter producing a filtercake containing a larger amount of extraneous matter, which has a diluting effect on nutrient content. Because a cane producer's allocation of filtercake is based on the amount of cane he delivers to the mill and the average filtercake percent cane for the mill, the amount of nitrogen in filtercake allocated to a cane producer supplying a factory with diffusers was shown to be only half to three quarters of that contained in the allocation from factories with mill tandems. The percentage of N was also substantially reduced by incorporation of fly ash with filtercake.

Introduction

The last comprehensive survey of the nutrient content of filtercake from all factories in the South African sugar industry including Swaziland was conducted in 1971 by Alexander². The average total nitrogen content of filtercake was then 1,93% and only two mills produced filtercake containing less than 1,60% N. Today the N content of filtercake is often much lower, and in several instances has been close to 1,00%.

It was thought that the lower nitrogen content might be associated with the diffusion process which has been introduced in a number of South African mills for extracting sucrose from sugarcane. Figure 1 shows that the amount of filtercake in relation to the amount of cane milled has fallen considerably at those mills which have changed over to the diffusion process. The figures for the Amatikulu and Pongola mills illustrate this reduction particularly clearly. However, where cane is still crushed with mill tandem rollers, the filtercake percent has not declined markedly. Lower nitrogen values may be due in some instances to the addition of flue gas scrubber waste (fly ash) to the filtercake.

When the last survey was made relatively few factories extracted sucrose by the diffusion process or cleaned the boiler furnace flue gases. Therefore it was decided that during the 1979-80 milling season samples of filtercake from all mills would be analysed at regular intervals, with a view to determining what changes, if any, had occurred in nutrient content since the last survey, and to examine the agricultural implications of such changes.

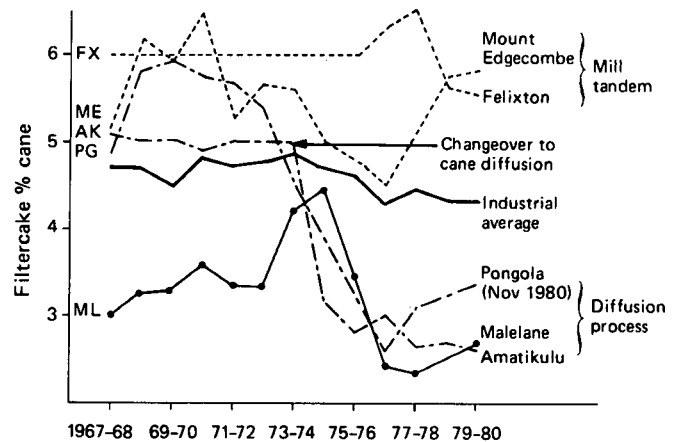


FIGURE 1 The effect of different extraction processes on filtercake percent cane.

Procedure

At each mill composite samples were taken during July, August, October and November 1979 using the following procedures. Over a two-day period whenever a filtercake sample was collected directly from the filters for testing in the mill laboratory, a small portion (100-200 g) was set aside in a container, all portions being placed in the same container. At the conclusion of each 48-hour period the resultant composite sample was oven dried to constant mass at approximately 85°C, and the dried material transferred to a plastic bag. The sample was then forwarded to the Fertilizer Advisory Service laboratory at the Experiment Station for analysis.

Results and Discussion

Table 1 shows the average nutrient composition of the four composite filtercake samples taken from each factory between July and November 1979, together with average filtercake percent cane figures for all mills during the 1979-80 milling season. Also shown are the average nutrient values for all mills together with those obtained for the same factories during the 1970 and 1971 filtercake surveys^{1, 2}. Comparisons should be made with reservation because the 1970 average values were based on samples taken off the filters in July and October only, whilst the 1971 average values refer to composite samples collected over a single week during September 1971. Probably the most meaningful comparison that can be made, therefore, is that between the 1970 average values and the mean values for July and October 1979, which are also shown in Table 1.

TABLE 1
Average nutrient composition of filtercake samples taken between July and November 1979
(mean of four samples on an oven-dry basis)

Extraction process 1979	Factory	C %	N %	C/N ratio	P % total	P % avail	K %	Ca %	Mg %	Cu ppm	Zn ppm	Mn ppm	Fe %	S %	FC % cane
CD*	Amatikulu	41,5	1,69	24,7	2,38	2,07	0,22	4,14	0,91	82	205	2 418	0,36	0,13	2,67
MTR†	Darnall	45,2	1,52	29,9	0,85	0,74	0,28	1,64	0,38	42	83	900	0,48	0,13	5,90
BD‡	Empangeni§	37,9	1,16	32,7	0,71	0,62	0,31	1,58	0,32	42	81	1 065	1,36	0,14	3,52
BD‡	Entumeni	39,6	1,49	27,0	0,91	0,79	0,28	2,04	0,43	58	94	1 136	0,76	0,14	3,71
MTR†	Felixton	36,3	1,32	27,6	0,78	0,67	0,39	1,60	0,34	52	110	1 135	1,33	0,14	5,38
MTR + CD	Gledhow	43,0	1,58	27,3	1,00	0,87	0,24	1,86	0,39	34	90	1 162	0,64	0,13	3,65
MTR†	Glendale	45,0	2,00	23,3	0,97	0,78	0,36	2,11	0,54	98	144	1 179	0,75	0,15	6,00
MTR†	Illovo	41,9	1,84	23,1	0,85	0,71	0,20	1,88	0,33	54	98	934	1,06	0,16	4,36
CD*	Malelane§	34,7	1,04	33,6	2,52	2,21	0,25	4,22	0,76	92	187	2 290	1,62	0,14	2,71
MTR + CD	Mhluwe¶	37,6	1,30	29,2	1,02	0,92	0,38	2,19	0,71	64	119	770	—	0,12	2,80
MTR†	Mount Edgecombe	38,2	1,46	26,2	0,70	0,58	0,19	1,43	0,28	55	95	813	1,50	0,16	5,94
MTR†	Noodsberg	35,2	1,49	24,0	0,58	0,44	0,25	1,37	0,23	46	90	896	1,62	0,18	4,79
BD‡	Pongola	35,6	1,43	25,1	1,29	1,15	0,40	3,60	0,63	71	125	1 520	1,46	0,14	4,07
MTR + BD	Sezela	41,9	1,59	26,5	0,88	0,77	0,19	2,42	0,47	42	91	1 065	0,66	0,15	4,59
MTR + CD	Tongaat	45,3	1,79	25,5	1,05	0,91	0,29	1,92	0,46	56	91	1 191	0,46	0,17	5,00
MTR†	Ubombo	32,4	1,05	31,4	0,80	0,70	0,47	1,94	0,52	119	117	824	2,53	0,19	4,91
MTR†	Umfolozi	41,0	1,57	26,1	1,18	1,04	0,36	2,26	0,46	84	153	1 006	0,87	0,20	6,15
MTR†	Umzimkulu	41,1	1,64	25,5	0,67	0,54	0,21	1,32	0,29	42	91	705	0,58	0,11	4,53
CD*	Union Co-op	37,6	1,97	19,4	1,28	1,12	0,31	2,90	0,51	75	103	1 620	0,96	0,12	0,94
Average (All Mills)		39,5	1,52	26,7	1,07	0,93	0,29	2,23	0,47	64	114	1 191	1,05	0,15	4,30
Average (all mills) September 1971		36,8	1,89	19,7	0,99	0,90	0,30	1,51	0,41	50	56	683	0,44	—	4,95
Average (all mills) Jul + Oct 1970		—	1,70	—	0,90	0,73	0,27	1,92	0,37	54	68	884	—	0,20	4,99
Average (all mills) Jul + Oct 1979		—	1,60	—	1,12	0,98	0,29	2,42	0,49	55	122	1239	—	0,14	4,32

* CD cane diffuser † MTR mill tandem rollers ‡ BD bagasse diffuser § 3 samples only ¶ 2 samples only

It appears that the average nitrogen content of filtercake has declined slightly whilst phosphorus, calcium, magnesium zinc and manganese contents have risen quite significantly since 1970. Table 2 shows that these changes could be largely attributed to those factories now using the diffusion process for sucrose extraction and in particular cane diffusers. In the table the mean nutrient composition of filtercake from three factories which operate cane diffusers (Amatikulu, Malelane, and Union Co-op) and three factories with bagasse diffusers (Empangeni, Entumeni and Pongola) is compared with that from nine factories where mill tandems only were used in 1979 (Darnall, Felixton, Glendale, Illovo, Mount Edgecombe, Noodsberg, Ubombo, Umfolozi and Umzimkulu). Results from three factories where both diffusers and mill tandem rollers were used (Gledhow, Sezela and Tongaat) have been included together with average filtercake percent cane and moisture percent filtercake values.

Of significance in helping to explain the higher nutrient content of filtercake from factories with diffusers is the average filtercake percent cane value which, as shown in Table 2, was only half that obtained from factories where mill tandems only were used (see also Figure 1).

It would be appropriate at this stage to consider briefly the three processes currently used to extract sucrose in South African sugar mills, namely cane diffusion, bagasse diffusion or mill tandem rollers. The difference between these processes is shown diagrammatically in Figure 2.

Where mill tandem rollers are used to crush cane considerable quantities of soil and other extraneous material are contained in the juice and settle with the precipitates in the clarification process. This results in a comparatively large amount of filtercake with a relatively low nutrient content i.e. the extraneous material has a particularly low nutrient content. In the diffusion process, however, some of the extraneous matter (bagasse diffuser) or most of it (cane diffuser)

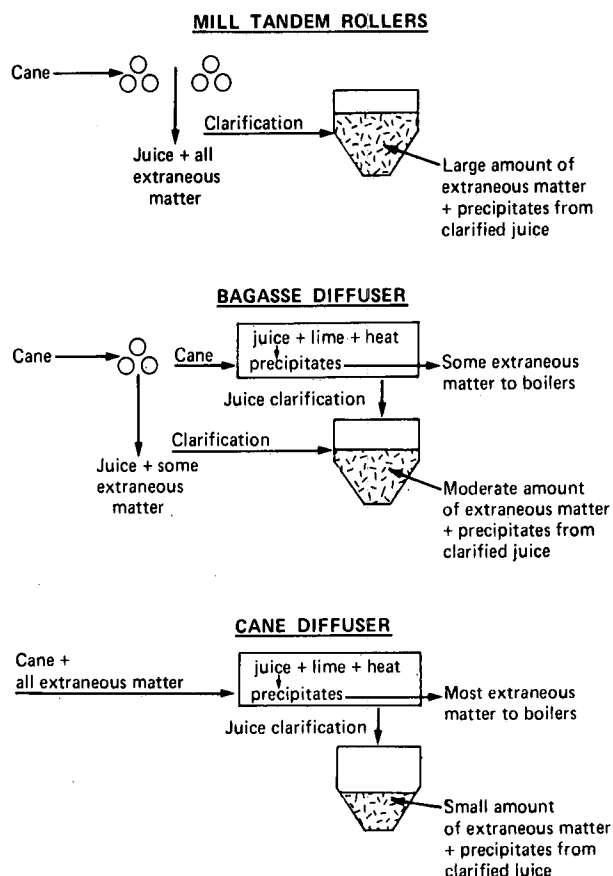


FIGURE 2 The effect of three different extraction processes on filtercake percent cane.

TABLE 2

Nutrient composition of filtercake from the diffusion process compared with that where mill tandem rollers are used for sucrose extraction

Sucrose extracted by	Month sampled 1979	N %	P% total	P% avail.	K %	Ca %	Mg %	S %	Zn ppm	Mn ppm	FC % cane	Moist % FC
Cane diffuser (means of 3 factories)	July	1,58	2,44	2,04	0,21	4,41	0,83	0,14	179	2 265	1,96	74,5
	August ..	1,75	2,17	1,93	0,25	3,62	0,78	0,14	200	2 093	2,06	75,5
	October ..	1,58	1,83	1,66	0,30	3,74	0,65	0,11	149	2 242	2,17	75,4
	November ..	1,34	1,81	1,56	0,28	3,25	0,65	0,12	131	1 837	2,24	75,0
	Average	1,56	2,06	1,80	0,26	3,76	0,73	0,13	165	2 109	2,11	75,1
Bagasse diffuser (means of 3 factories)	July	1,50	1,23	1,05	0,28	3,13	0,66	0,15	105	1 472	3,75	74,8
	August ..	1,37	0,87	0,75	0,36	2,08	0,37	0,14	104	1 362	3,62	73,8
	October ..	1,28	0,83	0,76	0,34	2,31	0,33	0,11	87	1 025	3,86	72,7
	November ..	1,29	0,94	0,84	0,33	2,11	0,47	0,14	87	1 103	3,84	72,3
	Average	1,36	0,97	0,85	0,33	2,41	0,46	0,14	96	1 240	3,77	73,4
Diffuser + mill tandem (means of 3 factories)	July	1,80	1,09	0,94	0,24	2,21	0,50	0,13	100	1 232	4,33	76,5
	August ..	1,59	0,96	0,85	0,22	1,98	0,38	0,16	93	1 253	4,47	76,6
	October ..	1,70	0,91	0,80	0,25	2,04	0,39	0,14	101	1 025	4,43	76,7
	November ..	1,52	0,95	0,81	0,24	2,03	0,48	0,18	69	1 048	4,43	76,5
	Average	1,65	0,98	0,85	0,24	2,07	0,44	0,15	91	1 140	4,42	76,6
Mill tandem (means of 9 factories)	July	1,71	1,00	0,86	0,26	1,93	0,46	0,15	125	1 079	5,21	75,4
	August ..	1,60	0,77	0,64	0,32	1,58	0,35	0,15	110	1 057	5,16	75,6
	October ..	1,53	0,75	0,65	0,32	1,86	0,32	0,16	118	850	5,47	74,7
	November ..	1,33	0,75	0,61	0,29	1,54	0,36	0,18	83	743	5,46	75,3
	Average	1,54	0,82	0,69	0,30	1,73	0,37	0,16	109	932	5,33	75,3

moves with the bagasse to the boilers. This results in a relatively small amount of filtercake with a high nutrient content in respect of most elements. A notable exception is nitrogen. In the diffuser considerable amounts of organic debris and denatured proteins settle onto the bagasse which goes to the boilers and there is, therefore, a significant reduction in the nitrogen content of filtercake from factories with diffusers. The data in Table 2 illustrate that this is likely to be the case, because although the average N percent dry matter in filtercake from diffusion and mill tandem factories was almost the same, factories with diffusers produced on average only half as much filtercake as did factories with mill tandems only. However, the percentages of several other nutrients in dry filtercake from the cane diffusion process were more than double those from factories with mill tandems (See Table 2).

The reduction in N content in filtercake from the cane diffusion process assumes significance when it is remembered that the criteria used for determining allocation of filtercake to the cane producer are the amount of cane he delivers to the mill and the average filtercake percent cane for the mill. Table 3 shows that in terms of kilograms nutrient per 100 tons cane sent to the mill, a grower will receive roughly the same amount of P, K, Ca and Mg from his filtercake allocation whatever process is used to extract sucrose. However, this is not the case with regard to nitrogen. Table 3 shows that

the amount of N a grower would receive in his filtercake allocation from factories with diffusers would only be about half to three quarters of that from factories with mill tandems.

Filtercake and fly ash incorporation

Apart from the effect of the process used to extract sucrose from the cane, the other important factor which undoubtedly influences the nutrient composition of filtercake is the addition of fly ash. The data in Table 4 show how the incorporation of fly ash with a sample of filtercake from the Illovo mill substantially lowered its nutrient value. The nitrogen content in particular was reduced and this probably accounts for the lower N values which have been obtained in some of the samples of filtercake analysed more recently at the Experiment Station. Phosphorus and calcium contents were also lower but the potassium content was considerably enhanced. Analysis of the fly ash showed that apart from a relatively high potassium content, all other nutrient contents were very low and hence the significant dilution effect when it was mixed with filtercake.

In Australia, Maclean³ concluded that no problems should be encountered in transporting and spreading well mixed 1:1 mixtures of fly ash and filtercake provided that the moisture content of each material did not exceed approximately 70

TABLE 3

Kilograms of nutrients in filtercake per 100 tons cane, as affected by different extraction processes

Sucrose extracted by	Average FC % cane	N	P	K	Ca	Mg
Cane diffuser ..	2,11	8,2	10,8	1,4	19,6	3,8
Bagasse diffuser ..	3,77	13,6	9,6	3,3	24,0	4,6
Diffuser + mill tandem ..	4,42	17,3	10,8	2,5	22,8	4,6
Mill tandem ..	5,33	20,3	10,2	3,9	21,6	4,9

TABLE 4

The effect of fly ash incorporation on the nutrient content of filtercake (oven-dry basis)

Material	N%	P% total	P% avail	K%	Ca%	Mg%
Filtercake & flyash (Illovo)	0,94	0,60	0,51	0,50	1,45	0,46
Fly ash only	0,11	0,18	0,11	0,56	0,31	0,34

percent. In order to reduce variability in the nutrient composition of filtercake under South African conditions it would seem important to ensure that a mixture is obtained in which the fly ash has been incorporated as uniformly as possible before it leaves the factory.

Monetary value

Taking the mean, N, P and K values in Table 2, and assuming that the average moisture content of filtercake at time of application is 60 percent, and that only 30 percent of the nitrogen is available to a crop, then the average value of filtercake, prior to any addition of fly ash, from mills using cane diffusers is about R8,40 per ton compared with R4,30 per ton where mill tandems only are used. This difference is due almost entirely to the higher P content of filtercake from the diffusion process. As filtercake is used primarily to supply P, the above comparison is pertinent in practice only if the amount of filtercake applied is related to a particular crop requirement for P.

C/N ratio

Alexander² drew attention to the fact that nitrogen availability in organic residues is dependent on the C/N ratio of the material. It is apparent from Table 1 that the average C/N ratio of fresh filtercake is generally above 25:1 and if applied to the soil in this condition its effect would be to immobilise some of the available nitrogen, the extent varying from type to soil type. Addition to filtercake of fly ash which has a very low N content will give a product with an even

higher C/N ratio, though this will not necessarily increase its immobilising effect in the soil, since most of the carbon in fly ash is present in the elemental form and as such is inert to microbial attack. Moberly and Meyer⁴ and Wood⁵ have shown that N is mineralised rather than immobilised in the soil following the addition of filtercake that has had time to decompose to the extent that its C:N ratio is less than 20:1.

Acknowledgements

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