EFFICIENCY OF THE HUMAN MOUTH AS AN EXTRACTOR OF SUCROSE FROM CANE — A Biological Study

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Abstract

Part of a recent study,[1] upon reasons for the absence of dental and paradontal disease in cane cutters,[2] was devoted to a consideration of the amount of sucrose ingested per worker per day through the chewing of cane. Using the Sugar Industry's Central Board's Direct-sampling of Cane Apparatus,[3] assessment of extraction efficiency of the human mouth showed figures between 79 and 83% — a surprisingly efficient extraction. Application of these extraction rates to weights of cane chewed by individual workers suggest that the minimum total annual ingestion of sucrose via the chewing of cane in the Natal sugar belt by field workers alone (excluding families, and people who walk past cane fields) is in the region of 9 225 tons.

Introduction

All cane cutters chew cane daily. Of the cane varieties in Natal, NCo 310 is the best for chewing — the "connoisseur's" cane — the other common varieties, NCo 376 and N 55/805 not being nearly as popular, though in certain hilly parts of the lower North Coast, some "vintage" 805 is now preferred.

If a trashed cane stalk is divided into 3 parts — upper, middle and lower — the top third has the least sucrose and is difficult to chew. This is invariably cut off and discarded. Whether the middle or lower thirds of the stalk has the wider internodes depends upon the month in which the cane was planted. In the present study, the middle thirds had the widest internodes, but slightly less sucrose. Thus though more easily chewed, it was less sweet. The lower third had the highest sucrose but shorter internodes. When the top third has been cut off and discarded, the cutter then proceeds to peel, and to chew downwards from the top of the middle third. Most workers chew a minimum of 2 such prepared stalks per 8 hour shift or per "task" (see below). This information has been checked recently and found to be correct. Due to the large amount of fibre in the cane stalk, this chewing has a markedly abrasive effect upon the gums and the teeth.

Methods and materials

Five separate tests were done each upon (*a*) the middle thirds, and (*b*) the lower thirds of trashed stalks of NCo 310, prepared as set out above. The stalks were peeled and including the fibrous nodes, the sections were cut into 2,5 cm lengths. The control sections of the cane stalk were simply analysed by the Sugar Industry Central Board's direct cane sampling procedure.[3] The other or "test" sections were then chewed, and the parts usually spat out were carefully preserved in an inert container; these fibrous remnants were also assayed by the direct cane sampling procedure. A comparison of sucrose contents in the control and the "spat-out" sections of cane enables an accurate assessment of extractions efficiency of the human mouth to be made.

Inversion effects as a possible source of error

It took 20 minutes for the 5 volunteers to chew the cane sections, and 20 minutes for the digester to handle the discarded fibrous material. Thus in regard to the chewed cane, there was a 40 minute period of study. Bearing in mind that the pH of the first expressed juice (FEJ) of most sugar mills is 5,1, and that hydrogen ion-catalysis and time, and enzyme effects, are all factors in regard to inversion, it appeared important to rule out inversion effects either in the digester or in the mouth.

The human mouth

All mouths tested had pH's between 6-7. Absence of inversion effects were easily established by retaining a teaspoonful of sucrose in the mouth for 20 minutes, and then the surface of the tongue was tested by one of the standard glucose oxidase strips — freshly procured, where no reaction was seen. The experiment was controlled by then retaining glucose in the mouth for a short period, and by using the very next portion of the strip which at once showed a reaction.

The digester

The pH of FEJ (first expressed juice) is 5,1. Careful control studies have been shown at this acid pH level (or rather hydrogen ion pH level, as inversion is catalysed by H^+ ions and not necessarily *acid*) show that no inversion has occurred in the digester in the 20 minutes that the cane is being digested. This is simply done by alkalinising the slurry with sodium bicarbonate and noting no improvement in sucrose extraction rates. It would appear highly unlikely that inversion is an accuracy-limiting factor in this study.

Results of studying efficiency of the human mouth as a sugar mill

Actual extraction rates of the 5 control and test portions varied between the lower and middle thirds of the stalk. The cane from the lowest section averaged out at 19,0% sucrose and the spat out residue contained 4,2%, giving an extraction rate of 77,9%. Extraction was slightly higher for the less sweet middle section. Here, control sections averaged out at 18,2% whereas the residue contained 3,1%, giving an extraction rate of 83,2%. These rates are not bad when compared with a well run mill (95-96%) or a very badly run mill (91-92%). These comparisons are not exactly equivalent, because (*a*) the peel of the cane did not enter into the chewing study, and (*b*) there must be few first mills with extraction rates of over 70%. Ideally, one would need to time how long the cane was chewed, and how long cane is actually being crushed by the first mill.

Mechanics of cane chewing and proportions of peel to total growth

The weight of a trashed stalk of cane variety NCo 310 plant cane at 18 months varies according to a number of factors (soil, rainfall, fertilization). Generally it averages out at 1,5 kg.

Five trashed stalks were prepared as generally prepared for chewing. Total weight was 7 254 g less 5 g evaporation in the sectioning, giving an effective total weight of 7 249 g and an average stalk weight of 1 449 g. The stalks were then cut in the usual manner with a cane knife in the same manner a cutter prepares the stalks for chewing. The top "third" was removed and the remaining part was cut into middle and lower "thirds". The total weight of the top "thirds" which are usually discarded was 3 040 g (41,9% of total weight), giving an

average of 608 g per stalk. That of the middle third was 2 179 g (30,1% of total), giving an average of 436 g per stalk — that was 2 179 g (30,1% of total), giving an average of 436 g per stalk — that of the lowest "thirds" was 2 030 g giving an average of 406 g per stalk. Each of the two lower ends was peeled to assess percentage represented by peel and core.

Application of sucrose contents and extraction rates to portions chewed

Average weights chewed for middle and lowest sections of stalk were 306 g and 293 g. Sucrose contents for these differing sections and their differing extraction rates were then applied to assess the average amount of sucrose obtained in chewing a prepared trashed stalk of variety NCo 310, as it is generally prepared in the fields for chewing.

MIDDLE SECTION (of 5 stalks)	Total weight. . .		2 179 g
	Peel . .	630 g	
	Core . .	1 530 g	(portion chewed— average per stalk = 306 g)
	Evaporation	19 g	
		2 179 g	% peel/total growth: 29,2
LOWEST SECTION (of 5 stalks)	Total weight . .		2 030 g
	Peel . .	543 g	
	Core . .	1 454 g	(portion chewed — average per stalk = 283 g)
	Evaporation	23 g	
		2 030 g	% peel/total growth: 27,05

It would seem reasonable to consider the amount of evaporation in chewing as equivalent to that which occurred in the experiment. This evaporation was also excluded when assessing percentage of total growth constituted by peel.

TABLE 1

Variety NCo 310 — Trashed Stalks
Chewed Fractions — Core and Nodes
Application of Sucrose content and extraction rates

Stalk Section	Chewed Fraction (Core & Nodes)	Derived Sucrose Content	Extraction Rate	Sucrose Equivalent
Upper	Nil	Nil	N / A	Nil
Middle	306 g	At 18,2% sucrose 55,69 g	83,0%	46,22 g
Lower	293 g	At 19,0% sucrose 55,67 g	77,9%	43,36 g
		Total sucrose ingested per stalk of cane chewed		89,58 g

As a *minimum* of two stalks is chewed daily per task, this gives a minimum sucrose daily intake via cane chewing of 179,16 g.

Economic aspects of cane chewing in Natal

It is interesting to attempt to gauge how much sucrose is ingested in NATAL BY THE TOTAL FIELD LABOUR FORCE OF 00 000 WORKERS.* Most cutters chew between 3 and 5 kg of cane daily. If 4 kg is taken as an average, and 30% of the cane stalk is taken away (the discarded part), approximately 3 kg is left. Thus in a working contract of approximately 300 days a worker's estimated minimum total consumption will be 900 kg or 0,9 tons. With a total labour force in the fields this is equivalent to a consumption of 73 800 tons. At 12,5% sucrose content, the sucrose equivalent is 9 225 tons. At the inflated LDP of £500 per ton, this amounts to a minimum cost equivalent of £4,5 million. It should be borne in mind these are estimates of *minimum intakes of field workers*, and do not take into account the larger intakes of many workers, or the intake of their families or other people that have access to sugar cane fields.

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References

1. Campbell, G. D. (1974). "Virtual Absence of Dental Caries in One Context of High Sucrose Intake". Paper Congr. Intern. Sugar Res Foundn., Durban, 1974.
2. Campbell, G. D. (1974). In *Lipid Metabolism, Obesity and Diabetes Mellitus. Impact upon Atherosclerosis.* (Greten, Levine, Pfeiffer and Reynold) Georg Thieme Publ. Stuttgart. "Epidemiology of Diabetes in Mammals, with special reference to the Tongaat Sugar Company Survey", 131.
3. Sugar Industry Central Board (1974). Manual of Cane Sampling and Analysis for South African Sugar Factories (revised edition), 23.