The Methanol, Ethanol and Fusel Oil contents of some Zambian Alcoholic Drinks

CONOR REILLY, Ph. D., Reader in Biochemistry, University of Zambia,
MERCY NWEGBU, Presently Principle Lecturer in Food Science,
Oxford Polytechnic, Oxford, England,
and
BENNET OKAFOR, Student Assistant, University of Zambia

INTRODUCTION

There is considerable evidence that certain Zambian home-produced beers and spirits contain toxic contaminants. Apart from known additives such as methylated spirits and plant juices, high levels of iron, copper and zinc have been recorded (Reilly and McGlashan 1969; Reilly 1973 a and b). These metals normally result from the use of galvanized iron containers during fermentation. The toxic effect of high iron levels in beer has been noted by Lowenthal et al (1967). A potent carcinogen of the nitrosamine group has also been detected in certain Zambian drinks (McGlashan, Walters and McLean 1968).

As a further step in such investigations of locally produced drinks, we looked at levels of methanol and fusel oils, as well as ethanol, in both commercially available and home-produced samples of traditional Zambian beers and spirits. Methanol, or wood spirit, is a common contaminant of alcoholic drinks. It is a highly toxic substance and can, depending on the quantity consumed, lead to blindness, insanity and even death. Methanol is not produced by yeast fermentation but results from the breakdown of pectin in plant material by the enzyme pectinase. Fusel oil is the collective name given to a mixture of such higher alcohols as isoamyl, active amyl and isobutyl alcohol. It is produced by the action of enzymes on amino acids present in the fermentation medium. The oils are highly toxic and have been shown to cause cancer in experimental animals (Gibel, Wildner and Lohs 1968, Purchase 1969). They also account for the aroma and taste of drinks and are responsible for the severe headache and thirst associated with a hangover.

MATERIALS AND METHODS

Samples for analysis included opaque beers (chibuku) obtained from village brewers and from Lusaka City Council brewery. They were all made by fermentation of maize. Samples of laboratory-made maize beer were also examined, as well as a home made ginger beer made from sugar, yeast and ground ginger root.

Distilled spirits were obtained from the Western Province (Kachibembe, distilled maize beer) and the Northwestern Province (two types of kachasu, distilled from maize beer and cassava beer). A laboratory sample was also prepared by distilling laboratory-made maize beer.

Ethanol was estimated by the Conway micro-diffusion technique (Conway 1957). This is based on the principle of the oxidation of ethanol to acetic acid by dichromate and subsequent back titration of the remaining dichromate with sodium thiosulphate.

Methanol was estimated by a colorimetric method using naphthalene-2-sulphonic acid (AOAC 1965 a).

Fusel oils were also estimated by the official AOAC method (1965 b). This used p-dimethylamino-benzaldehyde to develop a colour which was read at 530 nm on a Spectronic-20 spectrophotometer. Standard fusel oil solutions were prepared using isobutyl, isoamyl and redistilled ethyl alcohol.

RESULTS AND DISCUSSION

The methanol, fusel oil and ethanol contents of several samples of different types of beer are shown in Table 1. It is significant that the commercial chibuku made from maize and added yeast, with a short fermentation time, as well as the laboratory-made beers also produced after a short fermentation using maize or sugar and yeast, contain no detectable methanol and lower levels of fusel oil than the village products. The latter are generally made by allowing natural fermentation, by acid-producing bacilli and naturally occurring yeasts, to proceed for as much as seven days. Contamination is inevitable and moulds such as *Mucor* and *Aspergillus spp.* can frequently be seen on the fermenting mash. These organisms are rich sources of pectinase, the enzyme that breaks down pectin to release methanol (Braverman 1963). The prolonged fermentation also encourages the formation of fusel oils from amino acids in the mash (O'Donovan and Novellie 1966). The ginger beer was also made by a method involving a prolonged fermentation, and this, as well as the added plant material, may account for its methanol and fusel oil contents.

It should be pointed out that the average level of 150 ppm of fusel oil in the village chibuku samples, while somewhat higher than the 100 ppm found in British commercial beers by Hudson and Stevens, as quoted by O'Donovan and Novellie (1966), is nevertheless much lower than the average for South African "kaffir beer" of 227 ppm found by these authors. They also report that South African white wine contained 234 ppm and red wine 292 ppm of Fusel Oil.

Distillation, as might be expected, markedly increases the levels of all three alcohols in the drinks. This fact is illustrated in Table 2. The highest fusel oil content, 411 ppm, is close to the levels we found in a locally blended commercial brandy. All the fusel oil concentrations are in the lower ends of the scales given by O'Donovan and Novellie (1966) for grape brandy (215 – 1350 ppm) and Scotch Whisky (320 – 2760 ppm).

The limited number of samples examined in this investigation precludes us from making more than a tentative conclusion. It is clear that a far wider collection from all parts of Zambia and of all types of alcoholic beverages will be necessary before the complete picture of methanol and fusel oil contamination in home-produced beers and spirits is known. We can at least say that the indications are that such contamination does not pose a serious health hazard at least to the moderate drinker in Zambia. With the introduction of even a little technological refinement an even lower level of contamination could be achieved. Seeding the fermentation mixture with a large yeast inoculation or adding an ammonium salt reduces the production of fusel oil considerably. We found that by such means we could reduce fusel oil levels to less than half that normally found in village chibuku. It has already been shown that simple charcoal filtration and the substitution of plastic or stainless steel vessels for galvanized metal drums can reduce both heavy metal and nitrosamine contamination in beers and spirits (McGlashan, Walters and Reilly 1970).

Legislation to control the production of home-produced alcoholic beverages and introduce such simple refinements in manufacturing techniques is required in Zambia. The present negative laws which entirely forbid distilling and, in some places, brewing are not effective. This is a widespread home industry of considerable social and economic importance. In Nigeria and some other African states the local alcohol industry is beginning to be controlled and depots have been set up where village brews are purchased for purification and redistillation under supervision. The resulting product is of high standard and finds a ready market. There is no reason why Zambia should not produce a Zambian Gin of good quality, comparable to the Waragi of Uganda and Malawi Gin.

ACKNOWLEDGEMENTS

I wish to thank Zambia Breweries Ltd., for making a grant towards the support of the student assistants during the long vacation. My thanks also to the following for supplying samples of beers and spirits: Sister Mary Clemens, Mr. Bill Sparks and Mr. O. Mensa.

REFERENCES

Association of Official Agricultural Chemists, (1965), Official Methods of Analysis, 10th Edition, AOAC, Washington, D.C., (a) 138, (b) 136.

Braverman, J.S.S., (1963), Introduction to the Biochemistry of Foods, Elsevier, Amsterdam, 106.

Conway, E.J., (1957), Microdiffusion Analysis and Volumetric Error, 4th Edition, Crosby Lockwood, London, 249.

Gibel, W., Wildner, F., and Lohs, J., (1968), Carcinogenic and Hepatotoxic Effects of Fusel Oil Zeitschrift fur Gastroenterologie 7, 108.

Lowenthal M.N., Siddorn, J.A., Patel, R.P., and Fine, J., (1967), Haemosiderosis, Osteoporosis and Scurvey, Medical Journal of Zambia, 1, 43.

McGlashan, N.D., Walters, C.L., and McLean, A.E.M., (1968), Nitrosamines in African Alcoholic Spirits and Oesophageal Cancer, The Lacet, ii, 1017.

McGlashan, N.D., Walters, C.L., and Reilly, C., (1970), unpublished observations.

O'Donovan, M.B., and Novellie, L., (1966), Kaffircorn Malting and Brewing Studies XV; the Fusel Oils of Kaffir Beer, Journal of the Science of Food and Agriculture, 17, 362.

Purchase, I.F.H., (1969), Kaffircorn Malting and Brewing Studies XII; the Acute Toxicity of Some Fusel Oils Found in Bantu Beer, South African Medical Journal, 43, 795.

Reilly, C., (1973 a), Heavy Metal Contamination in Home-Produced Beers and Spirits, Ecology of Food and Nutrition, 2, 43.

Reilly, C., (1973b), Cancer and the Consumption of Home-Produced Drinks in Zambia – A Possible Correlation, Paper presented at the First International Conference on Basic Medical Sciences in Africa, Lusaka, March 1973.

Reilly, C., and McGlashan, N.D., (1969), Zinc and Copper Contamination in Zambian Alcoholic Drinks, South African Journal of Medical Sciences, 34, 43.