Afr. J. Med. med. Sci. (1976) 5, 191–194.

Cancer and the consumption of home-produced alcoholic drinks in Zambia: a possible correlation*

C. REILLY

Department of Biochemistry, University of Zambia, Lusaka, Zambia

Summary

Evidence has been obtained which suggests that a significant correlation exists between the drinking of home-produced grain-based alcoholic beverages and the level of incidence of cancer of the oesophagus in parts of Zambia. A similar correlation has been reported from other parts of the continent of Africa. Large numbers of samples of Zambian beers and spirits were screened to discover what might be the causative agent of the disease. Two major contaminants were found: (i) high levels of zinc, iron and sometimes of copper; (ii) nitrosamine-like compounds. The former results from the use of old metal drums during production of the drinks, but their carcinogenic effects are doubtful. The latter are highly potent carcinogens whose presence has been shown in a wide range of foodstuffs in recent years. At this stage it is impossible because of analytical problems to assert with absolute certainty which of the nitroso compounds are present. The investigation is continuing and it is hoped that a reliable and relatively easy analytical procedure will soon be available.

Résumé

Il a été mis en évidence un certain rapport entre le taux de consommation des boissons alcooliques de préparation locale et celui du cancer de l'oesophage, dans quelques régions de la Zambie. Des recherches faites dans d'autres pays du continent africain ont abouti aux résultats analogues. On a examiné un grand nombre d'échantillons de bière et d'alcool fabriqués en Zambia, afin de découvrir l'origine de cette maladie. Deux facteurs principaux ont été mis en cause: (i) le taux élevé du zinc, du fer, et parfois du cuivre; (ii) la présence des dérivés de nitrosomation pareils à ceux des mines.

Le premier facteur est dû à l'usage des vieux récipients métalliques pendant la fabrication de la boisson, mais les effets pouvant causer le cancer sont douteux.

Le deuxième facteur provient des éléments très puissants, qui favorisent le cancer et dont la présence a été signalée dans de nombreux produits alimentaires pendants ces dernières années. A ce point il est impossible, en raison des problèmes analytiques, de discerner, d'une façon absolue, quels sont les composés nitreux en présence. Comme les recherches se poursuivent, il faut espérer qu'il y aura bientôt une méthode d'analyse plus sure et relativement plus facile.

Correspondence: Dr C. Reilly, Principal lecturer in Food science and nutrition, Oxford Polytechnic, Oxford OX3 0BP.

* Paper presented at First International Conference on Basic Medical Sciences in Africa. Lusaka, 1973.

Introduction

The finding that a region has a higher level of incidence than elsewhere of a certain disease is of considerable significance in that it facilitates a concentrated and often successful search for a local causative agent of the disease. The linking of lead poisoning in children living in slum areas of cities of the eastern United States of America with the presence of lead oxide paints in old buildings is an example of such a correlation. In Africa particular opportunities for relating disease to the environment are not uncommon. A striking example of this is Burkitt's lymphoma, and attempts have been made to account for the marked differences in incidence of the tumor over relatively short distances in certain areas.

Cancer of the oesophagus occurs in unusually high levels of incidence in some parts of Africa while it is

practically unknown in others. Ahmed (1968) noted that it was the most frequently recorded cancer in some hospitals in the Nyanza region of Kenya, while in Rwanda and Burundi it is apparently unknown (Kisia & Burkitt, 1968). In South Africa similar patterns of high and low incidence have been reported. Oettlé (1963) suggested that consumption of locally-made alcoholic drinks might be related to oesophageal cancer in the Transkei, while du Plessis (du Plessis, Nunn & Roach, 1969) sought a correlation between the eating of a local fruit of the *Strychnos* species and the incidence of the cancer in the same region. Burrell, as noted by du Plessis *et al.* (1969), suggested that there might be a relation between molybdenum deficiency in soils, and consequently in food plants, and the disease. Similar studies of other forms of cancer have been carried out in Kenya (Robinson & Clifford, 1968).

Cancer of the oesophagus in Zambia

In Zambia a study of the distribution of various diseases carried out by McGlashan (1967) showed that this country also has regions of high incidence of cancer of the oesophagus. The results of his study also suggested that there was a causative link between the drinking of locally distilled grain-based spirits and the cancer. Large numbers of samples of beers and spirits from various parts of the country were collected and screened for the possible presence of carcinogenic compounds. The drinks were of many kinds, based on millet, maize, cassava, honey, sugar and various fruits. They had been made in a wide variety of fermentation and distillation apparatus, generally crudely fashioned. Clay pots, gourds, old petrol and tar drums, cans, buckets, enamel bowls and similar types of containers were used.

Analyses of Zambian beers and spirits

Preliminary results revealed two important, possibly carcinogenic contaminants. The drinks that had been made in metal containers generally were contaminated with heavy metals. The results for copper, zinc, iron and lead, which were obtained by atomic absorption spectrophotometry performed on the samples as received from the field, are given in Table 1. Indications of the presence of trace amounts of nickel, cadmium and chromium were obtained by colourimetric analytical techniques in less than 10% of samples analysed. These three heavy metals are highly toxic, but at such a low level of contamination their presence is of minor importance. However this is not the case with zinc, iron or copper. There is some evidence that when zinc is consumed in sufficient quantities it can be carcinogenic (Stocks & Davies, 1964; Rosner & Gorfien, 1968). Iron is not generally believed to be a carcinogen, though it may have other effects on health. Lowenthal *et al.* (1967) traced a connection between hemosiderosis and the consumption of large volumes of iron-contaminated beer by a Zambian male. Similarly Solomon (1972) has suggested that there is an association between iron-overload osteoporosis and the drinking of iron-contaminated beer in South Africa. Copper, while certainly toxic even at low levels of concentration, has not been suggested as a causative agent for cancer. Similarly lead, especially as it is an infrequent contaminant, is not likely to be involved in cancer.

TABLE 1. Heavy metal contamination in Zambian beers and spirits

Metal	Number of samples analysed	Percentage contaminated	Range of metal content (p.p.m.)
Cu	120	61	0·1–58
Zn	120	78	0·025–65
Fe	20	75	1·0–245
Pb	25	4	0·5
Sn	25	8	trace*
Cd	25	8	trace*
Ni	25	8	trace*

* Sn, Cd, and Ni were detected only quantitatively by paper chromatography. Trace indicates that in two of the twenty-five samples examined the presence of the three heavy metals was detected in very small amounts.

The second type of major contaminant detected in these local beers and spirits seems a much more likely cause of cancer. This was a group of compounds related to dimethylnitrosamine. Nitrosamines are potent carcinogens (Magee & Swann, 1969) and their presence has been reported in a wide range of foodstuffs (Sen *et al.*, 1969). However accurate detection of the compounds, especially at the nanogram levels which are sufficient to cause cancer, is extremely difficult (Williams *et al.*, 1971). Our first results were obtained using an infrared spectrophotometric method and were checked by a t.l.c. procedure (Upadhyay, unpublished results, 1968). They indicated the presence of DMN-like substances at level of approximately 1 p.p.m. However the methods used in the analyses are open to criticism

and with the help of Dr C. Walters of the British Food Manufacturing Industries Research Association, further samples of Zambian spirits were examined, first by a polarographic method and later by a combined g.l.c.-Mass spectrophotometric method. Strong evidence was obtained that many of the samples did contain nitrosamine-like compounds at levels of 1–3 p.p.m. (McGlashan, Walters & McClean, 1968). These analytical results have not been unequivocally acceptable to all who have studied them and at the present time only a high probability for the presence of these potent carcinogens in Zambian alcoholic drinks can be claimed. The investigations are continuing and we are hoping that an absolutely reliable procedure for nitrosamine analysis will be developed before long (Reilly, 1972 a, b).

Analyses for other organic contaminants have also been carried out. Histamine has been detected by the method of Marquardt & Werringloer (1965) which involves extraction on an ion exchange column followed by t.l.c. Quantitative results are not yet available for Zambian beers, but the two authors mentioned above found histamine at levels of 5–22 μg/ml in North African wines. They suggest that the histamine does not come from normal yeast fermentation but is formed by lactobacilli and coliform bacilli which contaminate the fermenting grapes. We have shown the presence of both types of bacilli in Zambian village beers.

We have also performed preliminary investigations on fusel oils in Zambian alcoholic drinks. Using the method of O'Donovan & Novellie (1968), a high temperature distillation followed by colour development with p-dimethylaminobenzaldehyde, and comparing the resulting absorption at 538–543 nm with that of standards made according to the Association of Official Agricultural Chemists (AOAC) method, we found levels of fusel oils ranging from 102–420 p.p.m. These were considerably higher than the levels of fusel oil found in commercial beers by O'Donovan & Novellie (1968).

While the above investigations are continuing and we hope to analyse larger numbers of samples of Zambian alcoholic drinks for the latter two contaminants, as well as for ethyl acetate whose presence has also been shown and is due to the activity of *Candida solani*, a wild yeast found in many Zambian beers, there is little evidence that histamine or ethylacetate are carcinogenic or have any other effect than that of contributing to 'hang over'. Fusel oils have, however, been shown to give rise to various forms of cancer, including cancer of the oesophagus in rats (Purchase, 1969).

The results of our investigations to date indicate that there is a strong probability that the drinking of certain home-produced beers and spirits in parts of Zambia is connected with a high level of incidence of cancer of the oesophagus. The drinks certainly contain a high level of zinc (upwards of 100 p.p.m. at times) and iron (often more than 200 p.p.m.), both of which may be a health hazard.

The presence of nitrosamines is less certain, but since the compounds are such potent carcinogens, even the indications of their possible presence should be sufficient to cause serious concern. There is good evidence that such compounds may arise from bacterial action in foodstuffs and even by purely chemical action (Devik, 1967). All the necessary ingredients for the synthesis of nitrosamines are present in Zambian beers and suitable micro-organisms are also abundant. Clearly a health hazard exists and legislation is recommended for the control of local fermentation and distillation techniques and to check products for toxic contamination. The toxic affects of the high levels of fusel oils present in home-produced beers should also be noted. A further possibility which we hope soon to examine is that the use of grain stored under poor conditions, as is often the case in home brewing, may introduce aflatoxins into the product. These are also very dangerous carcinogens which have been reported in groundnuts and grain that had been infected with *Aspergillus* moulds.

Acknowledgments

I wish to thank Dr N. D. McGlashan whose original research initiated this study, Dr C. E. Walters for performing many of the nitrosamine analyses and the University of Zambia for financial support.

References

Ahmed, N. (1966) Geographical incidence of oesophageal cancer in West Kenya. *E. Afr. med. J.* **43**, 235–248.

Association of Official Agricultural Chemists (AOAC) (1967) *Official Methods of Analysis*, 10th edn, p. 136, Washington D.C.

Devik, O.G. (1967) Formation of N-nitrosamines by the Maillard reaction. *Acta chem. Scand.* **21**, 2302–2303.

Du Plessis, L.S., Nunn, F.R. & Roach, W.A. (1969) Carcinogens in a Transkeian food additive. *Nature (Lond.)*, **222**, 1198–1199.

KISIA, I.A. & BURKITT, D.P. (1968) Cancer patterns at Kaimosi Hospital in Western Kenya. *E. Afr. med. J.* **45**, 706–712.

LOWENTHAL, M.N., SIDDORN, J.A., PATEL, R.P. & FINE, J. (1967) Haemosiderosis, osteoporosis and scurvy. *Med. J. Zambia*, **1**, 43–45.

MAGEE, P.N. & SWANN, P.F. (1969) Nitroso compounds. *Brit. med. Bull.* **25**, 240–244.

MARQUARDT, P. & WERRINGLOER, H.W.J. (1965) Toxicity of Wine. *Food cosmet. Toxicol.* **3**, 803–810.

MCGLASHAN, N.D. (1967) Zinc and oesophageal cancer. *Lancet*, **i**, 578.

MCGLASHAN, N.D., WALTERS, C.L. & MCLEAN, A.E.M. (1968) Nitrosamines in African alcoholic drinks and oesophageal cancer. *Lancet*, **ii**, 1017.

O'DONOVAN, M.B. & NOVELLIE, L. (1968) Kaffircorn malting and brewing studies XV. *J. Sci. Food Agric.* **17**, 362–365.

OETTLÉ, A.G. (1963) Regional variations in the frequency of oesophageal cancer cases admitted to hospitals in South Africa. *S. Afr. med. J.* **37**, 434–439.

PURCHASE, I.F.H. (1969) Studies in Kaffircorn brewing and malting xxii: acute toxicity of some fusel oils found in bantu beer. *S. Afr. med. J.* **43**, 795–798.

REILLY, C. (1972) Zinc, iron and copper contamination in home-produced alcoholic drinks. *J. Sci. Food Agric.* **23**, 1143–1144.

REILLY, C. (1972) Heavy metal contamination in home-produced beers and spirits. *Ecol. Food. Nutr.* **2**, 43–47.

ROBINSON, J.B.D. & CLIFFORD, P. (1968) Trace metal levels and carcinoma of the nasopharynx in Kenya. *E. Afr. med. J.* **45**, 694–700.

ROSNER, F. & GORFIEN, P.C. (1968) Erythrocyte and plasma zinc and magnesium levels in health and disease. *J. Lab. clin. Med.* **72**, 213–219.

SEN, N.P., SMITH, D.C., SCHWINGHAMER, L. & MARLEAU, J.J. (1969) Dimethylnitrosamine and other N-nitrosamines in foods. *J. Ass. Off. analyt. Chem.* **52**, 47–52.

SOLOMON, J. (1972) South African Conference on rheumatism, arthritis and allied diseases, Johannesburg. Report in: *Med. Tribune*, Dec., 1972.

STOCKS, P. & DAVIES, R.I. (1964) Zinc and copper contents of soils associated with the incidence of cancer. *Brit. J. Cancer*, **18**, 14–24.

WILLIAMS, A.A., TIMBERLAKE, C.F., TUCKNOTT, O.G. & PATTERSON, R.L.S. (1967) Observations on the detection of dimethyl- and diethyl-nitrosamines in foods with particular reference to alcoholic beverages. *J. Sci. Food Agric.* **23**, 431–434.

(*Received* 6 *April* 1975)