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# African traditional brews: how safe are they?

**Donnati Mosha, Joachim Wangabo & Gaspar Mhinzi**

*Department of Chemistry, University of Dar es Salaam, P.O. Box 35061, Dar es Salaam, Tanzania*

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Several African traditional brews have been analysed for their alcohol and sugar content, acidity, fermentation by-products, heavy metals and other contaminants. Alcohol levels are variable and the highest was found in moonshine (21–44% v/v). Parameters such as methanol, fusel oils, aldehydes, esters and heavy metals have often been found to be above permitted WHO standards for drinking water. High contaminant levels occur in moonshine: methanol (18–152 ppm), butanol (200–800 ppm), propanol (39–75 ppm), esters (1.3–8.6 ppm) and copper (up to 31.2 ppm). Acidities of up to 80.2 mmol/litre are attained in some brands. The apparent high ester levels in banana brew are due to iso-amyl acetate in banana aroma. Sugar levels have been found to diminish, whereas acidity increases on ageing. For some brands, it is shown that the end of useful fermentation is approximately 17 h at 30°C and, beyond this, quality deterioration predominates. This is therefore recommended as a maximum safe shelf-life for human consumption. Metal uptake from surfaces is enhanced by high acidity, long shelf-life and high temperature. Higher alcohol content enhances copper uptake, whilst zinc, iron and copper uptake diminish with increasing sugar and alcohol contents. Handling in iron or galvanized ironware is shown to deplete copper by almost 100% of initial levels and this has potential in health risk reduction applications. Copyright © 1996 Elsevier Science Ltd

## INTRODUCTION

Traditional brews have long been restricted to a social and ceremonial role in African culture. However, with the advent of commercialization and liberalization of consumer goods, the trade has been transformed into a major consumption industry. For example, in Tanzania these brews account for over 89% of the national alcohol consumption (Kilonzo, 1989). They also command an expenditure exceeding the per capita income in some Tanzanian localities. Taste and appearance are the basic forms of quality control and this has serious safety implications for human health. Thus, untreated yeast-friendly water may introduce pathogenic microbes, particularly in the mild alcohol brands, whereas some fermentation inputs may be an added risk from, for example, carcinogenic aflatoxins, residual preservatives, etc. Side products of uncontrolled fermentation may include methanol, fusel oils, aldehydes, esters and acids.

Various additives, ranging from methylated spirit to drugs and herbs, are occasionally added to improve potency. These have often resulted in quality unpredictability in the final product. In order to be in a position to evaluate the commercial potential of the available local brews, an assessment of the risks, if any, from possible contaminants is essential. This paper presents the constituents, shelf-life deterioration trends and factors influencing the uptake of metals from metalware surfaces for various popular traditional African brews. Electrodeposition of toxic metals is also examined as a removal technique.

## MATERIALS AND METHODS

At least five samples of each brand of market-ready traditional brews were collected in plastic containers from outlets in Dar es Salaam followed by prompt laboratory examination. Commencement of laboratory experiments was the starting point of the shelf-life scale. Alcohol was determined as ethyl alcohol ($C_2H_5OH$) by the literature method (Indian Standards Institution, 1967), whereas sugar was determined by refractometry. Acids and esters were assayed by titrimetry. Fusel oils, methanol and acetaldehyde were quantified by gas chromatography. Metallic contaminants were determined at ppm sensitivity by the flame mode of atomic absorption spectrophotometry. Total dissolved solids (TDS), total suspended solids (TSS) and pH were determined by established methods (Greenberg *et al.*, 1985). A metal sheet, 330 cm$^2$ total surface area, folded in multiple to accommodate the entire surface under liquid was employed in the metal uptake experiments.

**Table 1. Selected quality parameters for some African traditional brews and industrial alcoholic beverages**

| | Alcohol (% v/v) | Sugar (% w/v) | Acidity (mmol/litre) | pH[1] | pH[2] | TSS (g/litre) | TDS (g/litre) |
|---|---|---|---|---|---|---|---|
| Coconut palm wine | 6.1–7.8 | 5.6–8.0 | 60.5–79.0 | 3.91 | 3.62 | 5.8 | 23.7 |
| Bamboo wine | 5.5 | 8.5 | 76.8 | 4.00 | 3.80 | 5.2 | 25.8 |
| Komoni | 4.5–7.9 | 4.5–8.5 | 32.0–59.0 | 4.57 | 4.23 | 37.8 | 34.4 |
| Wanzuki | 7.5–8.3 | 4.8–6.5 | 65.0–80.8 | 3.51 | 3.33 | 2.9 | 9.6 |
| Banana wine | 2.0–3.5 | 6.2–9.5 | 28.0–55.4 | 4.52 | 4.21 | 37.3 | 21.5 |
| Moonshine | 21.0–44.0 | b.d. | 1.7–19.3 | 4.41 | — | ⩽2.2 | b.d. |
| 'Safari' lager[3] | 5.0 | 6.5 | 25.2 | 4.30 | — | 0.3 | 27.8 |
| 'Kibuku'[3] | 4.0 | 4.2 | 63.6 | 3.45 | — | 21.2 | 9.8 |
| 'Konyagi' gin[3] | 34.0 | b.d. | b.d. | 8.20 | — | b.d. | b.d. |

[1]Fresh market-ready sample; [2]after 24 h; [3]licensed commercial products.TDS, total dissolved solids; TSS, total suspended solids; b.d., below detection.

**Table 2. Harmful constituents in some African traditional brews**

| | Coconut palm wine | Bamboo wine | Komoni | Wanzuki | Banana brew | Moonshine | WHO[1] standards (ppm) |
|---|---|---|---|---|---|---|---|
| Methanol (ppm) | b.d. | b.d. | b.d. | b.d. | b.d. | 80.0–152 | — |
| Butanol (ppm) | 0.5–16.0 | 8.0–9.0 | 0–5.0 | 10.4–100 | b.d. | 200–800 | — |
| Propanol (ppm) | 0–69.0 | 0.4–0.9 | 5.0–25.0 | 25.0–60.0 | b.d. | 39.0–75.0 | — |
| Acetaldehyde (ppm) | b.d. | b.d. | 1.6–18.0 | 35.0–122 | 1.7–9.0 | 2.0–30.0 | — |
| Esters (mmol/litre) | 0.2–0.4 | 0.2 | 0.2–0.4 | 0.4–0.7 | 2.9–3.8 | 1.3–8.6 | — |
| Lead (ppm) | 0–0.3 | 0.82 | 0–0.4 | <0.05 | <0.03 | <0.03 | 0.10 |
| Cadmium (ppm) | 0–0.6 | 0.08 | 0–0.1 | <0.001 | 0–0.03 | 0.03–0.1 | 0.05 |
| Copper (ppm) | 0.3–1.2 | 0.4 | 0.3–0.5 | 0.04–0.2 | 0.5–0.8 | 0.1–31.2 | 1.5 |
| Zinc (ppm) | 2.5–5.8 | 1.03 | 3.5–14.2 | 0.4–1.4 | 1.7–3.2 | 0–0.3 | 15 |
| Iron (ppm) | 1.1–114.9 | 2.3 | 22.0–52.0 | 1.7–3.0 | 7.2–50.0 | 0.2 | 1.0 |
| Aluminium (ppm) | 0.5–3.1 | 0.4 | 0.3–6.0 | 3.3–6.3 | 2.9–5.0 | <0.03 | [2] |

[1]Maximum limits (WHO, 1971).
[2]Unspecified.

## RESULTS AND DISCUSSION

Tables 1 and 2 summarize the results obtained for the brands studied. Safari lager, Konyagi (gin) and Kibuku (a brand from maize and sorghum) are industrially produced under government licence and supervision. The alcohol content in all the traditional brands examined (except bamboo wine and banana wine) are both variable and exceed the value in the licensed lager 'Safari' (alcohol = 5%). The low alcohol and high sugar (2.0–3.5 and 6.2–9.5%) contents in banana wine have been linked, for example, to amoebic infections, especially when untreated water is used. The tree bark from *Raovolfia inebrians* which is added to banana wine (Kilonzo & Pitkanen, 1992) is known to contain the toxic alkaloid rauvolfine. Moonshine exceeds all the others in alcohol content (21–44%). However, its high levels of methanol (80–152 ppm), butanol (200 ppm), propanol (39–75 ppm), acetaldehyde (2–30 ppm) and esters (1.3–8.6 mmol/litre) rates it as the worst in terms of human health risk. While fusel oils and esters mainly affect the sensory motor system, liver and kidney (Birch & Lindley, 1985; Goodman & Gilman, 1980), excess acids may result in stomach ulcers. Initially methanol elicits acute headache, fatigue, blindness and nausea, but this is often followed by convulsions, acidosis, circulatory/respiratory collapse and death. Fatalities have been recorded from 30 ml methanol (Goodman & Gilman, 1980). While amyl alcohol has been associated with gastritis and severe vomiting, butanol has been linked to irritation of mucous membranes, contact dermatitis, headache, dizziness and drowsiness (Stecher *et al.*, 1976). Acetaldehyde is generally narcotic and large doses may cause death by respiratory paralysis, whereas propanol may be mildly irritating to mucous membranes and has a depressant action similar to ethanol. Adulteration of brews with methylated spirit (or methyl alcohol) has led to recurring tragic poisoning incidents in Africa and India (Kilonzo & Pitkanen, 1992). Although prohibited in Tanzania, the illicit moonshine trade nonetheless thrives and, therefore, efforts to promote a safer product should be examined.

As traditional brews changed from a socio-cultural role to thc modern mass-consumption industry, metalware was introduced into the local brew trade replacing safer traditional woodware, earthenware, leatherware, etc. As a consequence, metals such as aluminium, copper, iron, lead and cadmium are introduced into the brews through the often high processing temperatures, high acidities and long shelf-lives. Thus, for example, up to 31.2 ppm copper contamination occurs in moonshine presumably derived from copper fittings in the crude distillation equipment used. We have found that, in general, increased acidity tends to favour dissolution of copper (see Fig. 1). Traces of copper are known to be essential in metabolism; however, higher doses may cause Wilson's disease (Devergie, 1840). The results in Table 2 show that all the brands conform to the maximum limits for zinc demanded by WHO (1971). However, the levels of iron in all the brands except moonshine are above the permitted WHO limits. Wanzuki has been found to possess the highest level of aluminium. Zinc and iron are essential for metabolism but are harmful in excess (Berman, 1980), while aluminium is rated as unspecified in the WHO standards for drinking water (Table 2). The use of iron cookware has been proposed as a supplement source of dietary iron in Botswana (Kershaw & Paula, 1990). Table 2 also shows higher than WHO permitted levels of lead in coconut palm wine (mnazi), bamboo wine (ulanzi) and komoni. The toxicity of lead and cadmium is through the biochemical immobilization of sulphydryl (–SH) groups in amino acids (Doull *et al.*, 1980). The lack of a filtration step (essential in brewing technology) to remove yeast and related particulates also contributes to undesired constituents in the final product. This can be readily deduced from the TSS results (Table 1). Plant sap-derived brands, i.e. coconut (mnazi) and bamboo (ulanzi) wines, have higher metallic contamination than their cereal counterparts. Now, since these are usually collected directly from the plants using plastic containers, the metal ions must originate from absorption through the soil.

The results in Figs 2 and 3 indicate that acidity increases whilst sugar content decreases on ageing. The peak in the alcohol shelf-life graph at approximately 17 h (Fig. 4) identifies a recommended maximum safe intake time beyond which the recipe would pose a health risk to the consumer.

Typical trends showing the dependence of metal uptake on various factors are shown in Figs 5–10. High alcohol content suppresses surface leaching for iron and

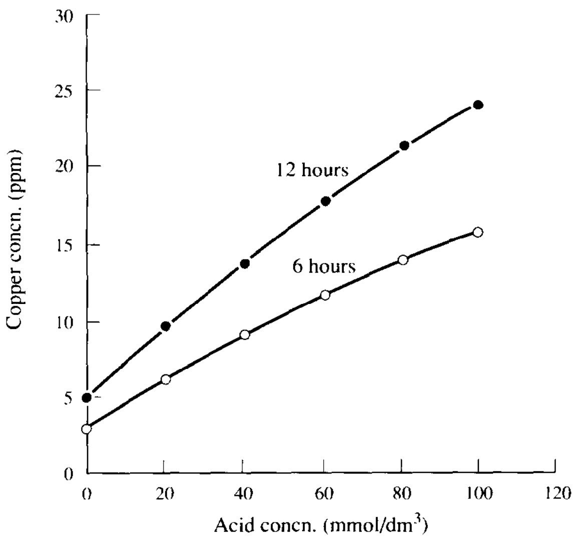


**Fig. 1.** Dependence of copper uptake from metalware surfaces on acidity.

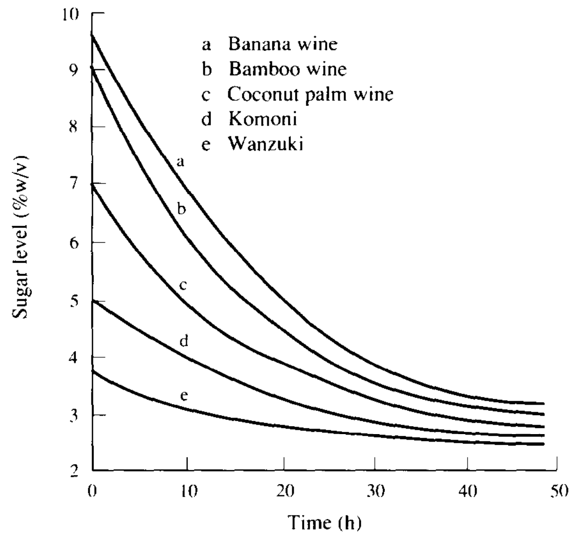


**Fig. 3.** Effect of shelf-life on sugar concentration.

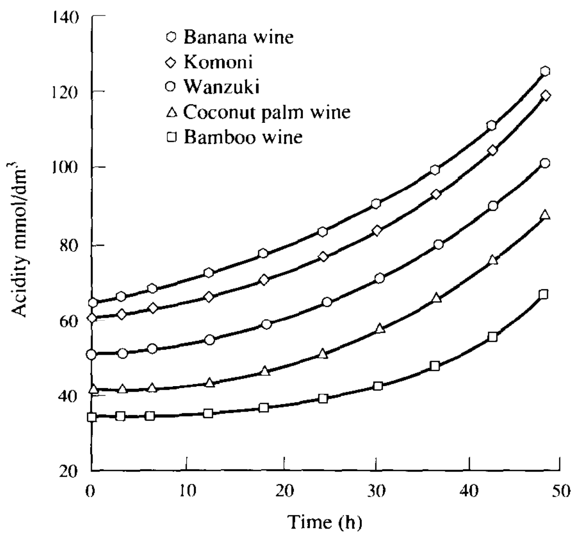


**Fig. 2.** Effect of shelf-life on acidity.

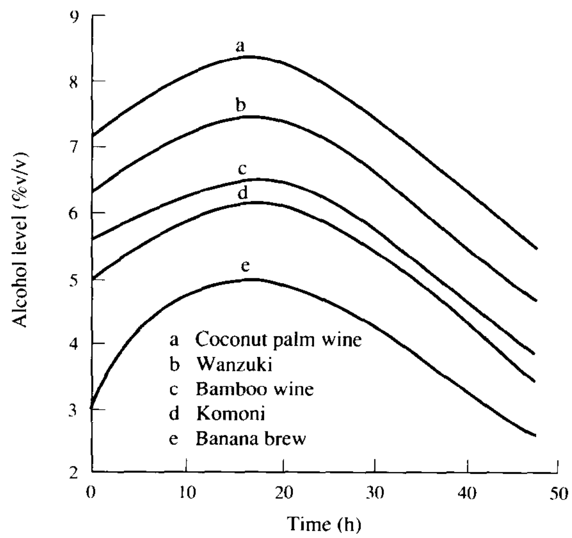


**Fig. 4.** Effect of shelf-life on alcohol levels.

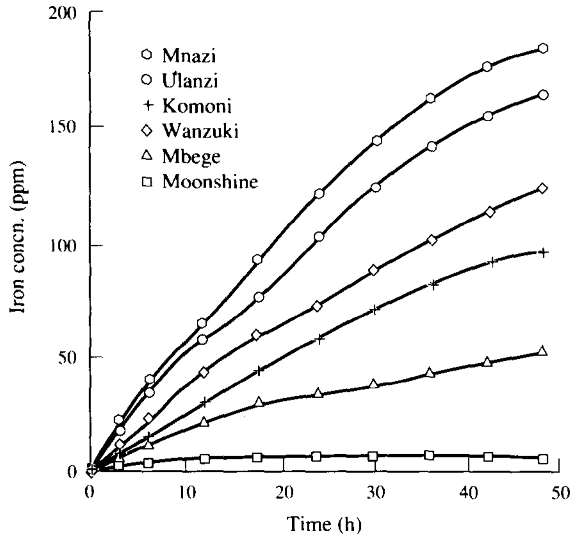


**Fig. 5.** Dependence of iron uptake from metalware surfaces on shelf-life.

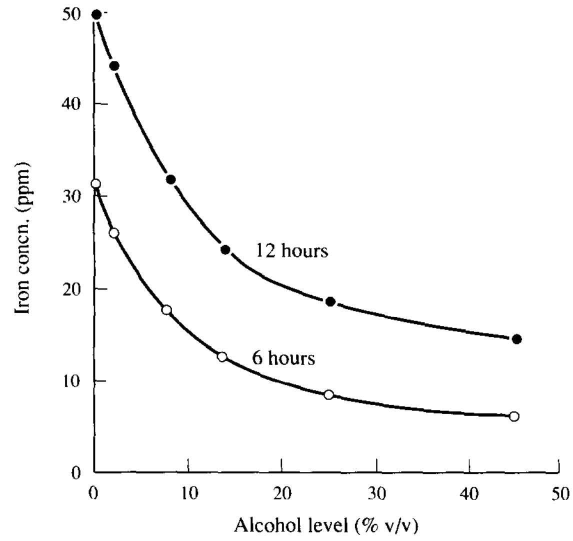


**Fig. 8.** Dependence of iron uptake from metalware surfaces on alcohol level.

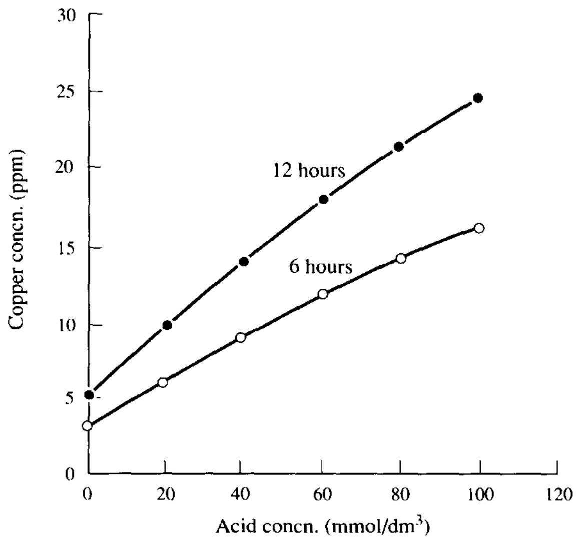


**Fig. 6.** Dependence of copper uptake from metalware surfaces on acidity.

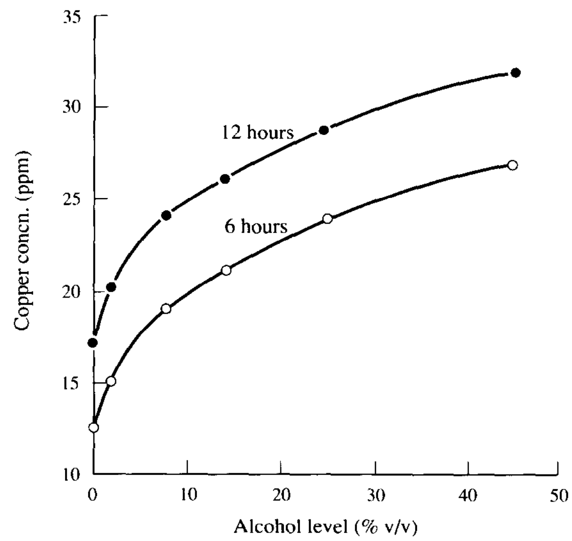


**Fig. 9.** Dependence of copper uptake from metalware surfaces on alcohol level.

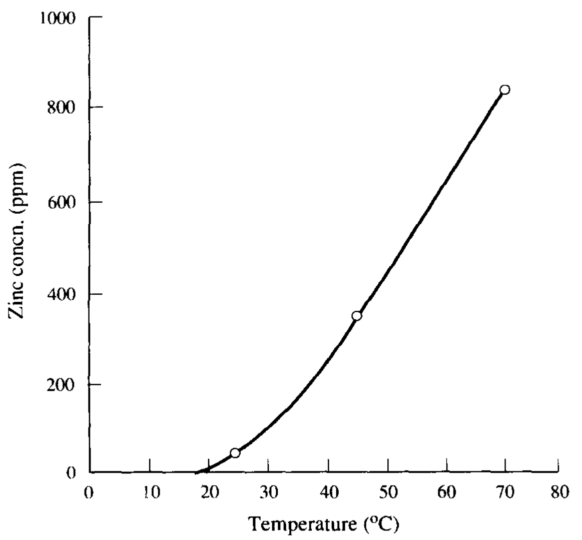


**Fig. 7.** Dependence of zinc uptake from metalware surfaces on temperature.

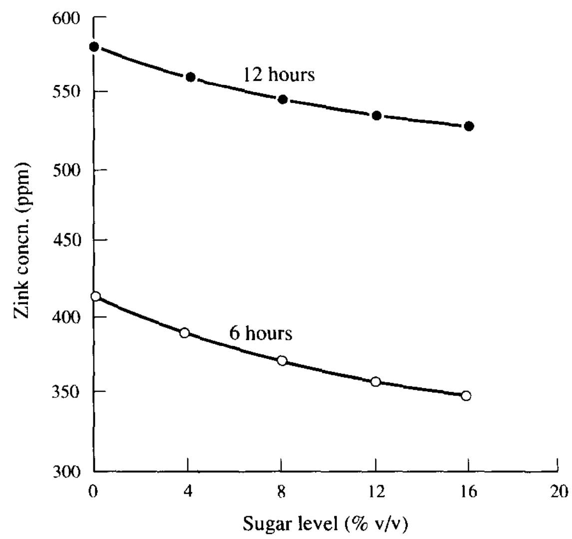


**Fig. 10.** Dependence of zinc uptake from metalware surfaces on sugar concentration.

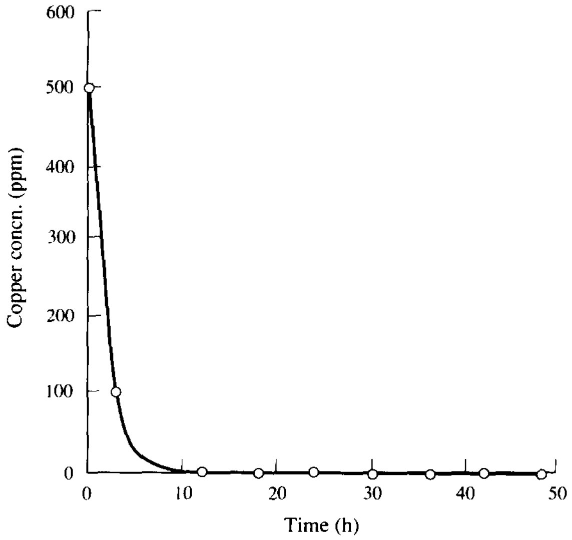


**Fig. 11.** Depletion of copper from galvanised iron by electrode position.

zinc (illustrated for iron, Fig. 8), while a reverse trend is observed for copper (Fig. 9). This explains the unusual copper levels in the strong alcohol brand, moonshine. Zinc, iron and copper uptake from the respective metal surfaces is shown to be suppressed by increased sugar content (illustrated in Fig. 10 for zinc). This work has also shown that copper can be removed from a copper-laden brew by electrodeposition on a galvanized iron surface (Fig. 11). An almost 100% depletion is achieved after 10 h. This technique has potential remedial application in lowering the contamination risk, whereby a toxic metal may be selectively removed and an essential metal introduced.

In conclusion, the lack of standardized specifications and absence of any routine quality control means that traditional brews must be variable in composition. The results presented in this paper have shown that some improvement in all the traditional brews cannot be more timely. Banana wine (mbege) appears to have only two contaminants (high levels of esters and excess iron), whilst moonshine is the most contaminated local brew.


## ACKNOWLEDGEMENTS

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## REFERENCES


Berman, E. (ed.) (1980). *Toxic Metals and Their Analysis.* Heyden and Sons, London.

Birch, G. G. & Lindley, M. G. (1985). *Alcoholic Beverages.* Elsevier Applied Science, London.

Devergie, A. (1840). *Ann. Hyg. Publ.*, **24**, 136. (In Cummings, J. W. (1959). *Heavy Metals and the Brain.* Charles C. Charles, Springfield, IL.)

Doull, J., Klaasen, C. D. & Amdur, M. O. (1980). *Toxicology.* Macmillan, New York.

Goodman, L. S. & Gilman, A. G. (1980). *The Pharmacological Basis of Therapeutics*, 15th edn. Macmillan, New York.

Greenberg, A. E., Trussel, R. R. & Clesseri, L. S. (1985). *Standard Methods for Water and Waste Water*, 16th edn. ALPA Publishing Co., Washington, DC.

Indian Standards Institution. (1967). *Methods of Test for Alcohol Drinks.* IS 3762, New Delhi, India.

Kershaw, K. & Paula, F. (1990). *Symposium Proceedings on Environmental Pollution and its Management in Eastern Africa.* University of Dar es Salaam, pp. 232–235.

Kilonzo, G. P. (1989). Tanzania. In *State Monopolies and Alcoholic Prevention*, ed. T. Kortteinen. Report No. 181. The Social Research Institute of Alcohol Studies, Helsinki.

Kilonzo, G. P. & Pitkanen, Y. T. (eds) (1992). *'Pombe'—Report of Alcohol Research Project in Tanzania.* Report B 24/92. Institute of Development Studies, University of Helsinki.

Stecher, P. G., Windholz, M. & Leahy, D. S. (eds) (1976). *The Merck Index*, 9th edn. Merck and Co., USA.

WHO (1971). *International Standards for Drinking Water*, 3rd edn. World Health Organization, Geneva.