ELSEVIER

0308-8146(95)00073-9

Food Chemistry, Vol. 55, No. 2, pp. 115–119, 1996

0308-8146/96 $15.00 + 0.00

The role of ashes and sodium bicarbonate in a simulated meat product from chikanda tuber (*Satyria siva*)

M. T. Kaputo

Food Technology Research Unit, National Council for Scientific Research, P.O. Box 310158, Chelston, Lusaka, Zambia

(Received 23 November 1994; accepted 16 March 1995)

The role of ash water filtrates and sodium bicarbonate in preparing a chikanda product was evaluated. Chikanda is eaten by a majority of Zambians in the form of snacks and as a complementary food to starchy preparations. Banana leaves, bean stalks and leaves, groundnut shells, charcoal and coal briquettes were used in preparing ashes. These were analysed for ash, pH, alkalinity and mineral content using standard references methods. The ash contents of these raw materials ranged from 2.3 to 6.8% except for coal briquettes (18.8%) with much of coal briquette ash being silica (9.1%). The alkalinity and pH values of the ashes for the four raw materials were high, 62.6–95.6% and 11.0–12.0, respectively. The ashes were generally found to be rich in mineral nutrients with groundnut shells having the highest amounts of sodium (88 ppm), potassium (2785 ppm), iron (187 ppm), iodine (8800 ppm) and phosphorus (6.8%). Ash from banana leaves gave high levels of calcium (7296 ppm) and magnesium (2364 ppm). The functions of ash water filtrates and sodium bicarbonate in chikanda simulated meat products are probably to supplement mineral nutrients and to contribute to a soapy taste and firmness.

INTRODUCTION

Chikanda (*Satyria siva*) is a wild orchid tuber growing in wetland areas of Zambia. The tuber is used in preparing a popular simulated meat-like product (Whitby, 1972). The product is used as a complementary dish to maize, sorghum and cassava food preparations. It is also often consumed as a snack especially at wedding ceremonies, with beer and at bus stations. Mainga (1984) reported that chikanda prepared in a traditional way is rich in proteins and is 82.2% water, 8.8% protein, 2.6% fat and 2.6% ash. In preparing the chikanda product, the pounded tuber is cooked with pounded groundnuts, ash water filtrates or sodium bicarbonate and salt with or without spices. The inclusion of ash water filtrates or, in their absence, sodium bicarbonate, is an essential step. Traditionally, most Zambian households add filtrates from ash water mixtures to certain food preparations such as cowpea leaves, okra and chikanda mainly to improve flavour and texture of these foods (Whitby, 1972). Recently, there has been a domestic shift toward using sodium bicarbonate in foods instead of the ash water filtrates. The preference for sodium bicarbonate rather than ash water filtrates has been made possible by the ready availability of this additive in the Zambian market.

There is already abundant information on the chemistry of sodium bicarbonate as a food additive. However, basic scientific data on ashes used in local food preparations is still fragmentary. Therefore, this paper evaluates and discusses various ashes that are commonly used in foods in Zambia. Particular reference is made to the role of ash water filtrates and sodium bicarbonate in a product prepared from chikanda tuber.

MATERIALS AND METHODS

Type and source of raw materials

Raw materials used in preparing ashes were banana leaves, bean stalks and leaves, groundnut shells, charcoal and coal briquettes. Charcoal was purchased from Chelston market in Lusaka. Banana leaves and bean stalks and leaves were obtained from one household garden at the National Council for Scientific Research (NCSR) village, Lusaka. Chikanda, groundnuts and groundnut shells were purchased from Lusaka Soweto Market. Coal briquettes, which are being popularised in Lusaka households as an alternative source of energy, were used in these studies for comparison purposes and

were obtained from the Building and Industrial Minerals Research Unit of the NCSR, coal briquette pilot plant. Synthetic fibrous casings of calibre-90 (Flat width 140 mm) and of calibre-55 (Flat width 80 mm), brown or khaki in colour, were obtained from Columbit (PTY) Limited, Cape Town, South Africa. All other reagents were of AnalaR grade (BDH Chemicals plc, Poole, UK). Smoked beef polony was provided by the Zambia Cold Storage Corporation Limited, Lusaka. Traditional prepared chikanda used for comparative evaluation was provided by a household at NCSR village.

Raw materials evaluation

Banana leaves and bean stalks and leaves were dried in the sun for 2 days prior to chemical analysis and use. All other materials were analysed and used as purchased or procured.

Moisture, ash and acid-insoluble ash were determined according to the procedure of the AOAC (AOAC, 1970); pH values of 1% ash water suspensions and 1% sodium bicarbonate were determined on a Philips pH meter (model PW 9420, Cambridge, UK). Alkalinity was determined on 0.01 g ash samples dissolved in 10 ml HCl (0.5 M) and 10 ml boiling water. The excess acid was titrated with NaOH (0.05 M) using methyl red indicator (Josyln, 1970). Sodium and potassium were determined by flame photometry on a CIBA-Corning 410 photometer (Halstead, Essex, UK). Calcium, iron, copper and magnesium were analysed using an atomic absorption spectrophotometer (model AA5, Varian Techtron, PTY, Melbourne, Australia). Iodine was determined by oxidising with bromine, acidifying and estimating free iodine with sodium thiosulphate (0.05 M) using starch indicator as described by Pearson (1970). Phosphorus was determined by reacting wet digested ash samples with molybdic acid to form a phosphomolybdate complex, followed by reducing the complex with 2-amino-naphthol sulphonic acid to form a blue colour (Ranganna, 1977). The colour was measured at 650 nm on a recording spectrophotometer (UV-240, Shimadzu, Kyoto, Japan).

Preparation and evaluation of simulated meat products from chikanda

Pounded groundnuts (350–380 g) were boiled in water (2000 ml) containing a vegetable spicy mixture (16–18 g) and common salt (NaCl, 30–35 g) for 30–45 min. Sodium bicarbonate (1.5% w/v) was added to the hot groundnut–water mixture followed by the addition of ground dried and partially gelatinised chikanda (160–180 g). The mixture was stirred while hot in a Hobart mixer (Model A120, London, UK) at a slow speed for a minute and then for 2 min at a fast speed. The hot mixture was quickly transferred into synthetic-fibrous casings. The open ends were tied with cotton strings after filling. The casings with contents were then boiled for 3 h in water containing common salt (2% w/v). Salt was added in water to keep an osmotic equilibrium balance between the contents of the casings and heating media. Cooked chikanda was cooled to room temperature (20–23°C). In the preparation of chikanda, sodium bicarbonate was substituted, in the first case with charcoal ash water filtrate (2% v/v), and, in the second, with groundnut shells ash water filtrate (2% v/v). The filtrates had been prepared by placing (100 g) ash on perforated tin and adding water (100 ml). The ash water filtrate was collected in a receiving bowl. This was used in the substitution for sodium bicarbonate.

Moisture, ash and minerals were determined on chikanda using standard procedures as described before. Texture was evaluated by measuring the resistance of chikanda pieces (42 mm thick, 80 mm in diameter) to plunger penetration in millimeters using a laboratory penetrometer (Engineering Laboratory Equipment Limited, Hemel Hempstead, UK).

RESULTS AND DISCUSSION

Moisture and ash contents of raw materials

The moisture contents of banana leaves, bean stalks and leaves, groundnuts shells, charcoal and coal briquettes

Table 1. Ash, alkalinity and pH values of raw materials used in Zambian foods. Figures in brackets are standard deviations and are based on six determinations. All other figures are means of three determinations. The pH of 1% sodium bicarbonate was 8.4

Material	Moisture (%)	Total ash (%)	Acid-insoluble ash (%)	Alkalinity of ash (as % Na_2CO_3)	pH (1% ash-water suspension)
Charcoal	3.29 (0.03)	2.26 (0.09)	0.1	95.6	12.0
Banana leaves (dried)	8.13 (0.28)	6.84 (0.75)	1.0	74.3	11.2
Bean stalks and leaves (dried)	8.21 (0.15)	5.40 (0.51)	0.2	95.2	11.3
Groundnut shells (dried)	7.82 (0.21)	3.93 (0.54)	0.1	62.6	11.0
Coal briquettes	0.68 (0.01)	18.81 (0.20)	9.1	13.0	9.8

were below 8.5% because samples were either dry, or dried prior to use. The average ash contents of all materials except coal briquettes, ranged from 2.26 to 6.84% (Table 1). The ash content of coal briquettes was 18.8% and contained 9.1% sand or dirt (Table 1). Coal slurries used in preparing briquettes contain a substantial amount of silica. The process of preparing coal briquettes involves the addition of lime, thus explaining the observed high levels of ash in the briquettes. Ash contents of banana leaves and bean stalks and leaves of 6.8 and 5.4%, respectively, were much greater than those of groundnuts and charcoal which were 3.9% and 2.3%, respectively (Table 1). The use of ash from groundnut shells, banana leaves and bean stalks and leaves is still very popular amongst Zambian rural housewives, presumably because these raw materials are more readily available in a rural set-up than alternative materials. Charcoal ash is more widely used in peri-urban areas where most households also use it as a source of energy.

Alkalinity and pH values of the ashes

Table 1 shows alkalinity and pH values of ash of the five raw materials investigated. Alkalinity and pH values of ash are attributed to the presence of salts of acids such as citric, malic etc., which on incineration are converted into the corresponding carbonates (Josyln, 1970). Except for the coal briquettes (alkalinity = 13.0% and pH = 9.8), all samples show high alkalinity and pH values of over 60%, and 11.0, respectively. It should be noted, therefore, that one of the functions of ash water filtrates is to induce high pH values.

Studies by Sherman & Burton (1926) showed that alkalinity, temperature and duration of heating are among important factors that can contribute to the destruction of thiamine. They found that the extent of thiamine destruction can be as high as 90–100% when a juice of canned tomatoes (pH = 10.9) is heated at 100°C for 1 hour. The findings of other workers on charcoal concentrate support Sherman and Burton's results that alkaline conditions destroy thiamine (Guha & Drummond, 1929). It has also been demonstrated that the destruction of riboflavin is 75–100% when the extract from brewer's yeast (pH = 8.7–9.9) is autoclaved at 124°C for 4 h (Chick & Roscoe, 1930). In addition, Kuhn & Moruzzi (1934) observed the disappearance of the green fluorescence resulting from the destruction of thiamine in alkali. Therefore, despite the popularity of using ash water filtrates in food preparations, the merits of their continued use should be weighed against the destruction of some important nutrients *in situ*.

Mineral contents of the ashes and products

Table 2 shows the distribution of mineral contents in the ashes. Groundnut shells were the richest in sodium (88.1 ppm), potassium (2785 ppm), iron (187 ppm), iodine (8800 ppm) and phosphorus (6.8%). Banana leaves had the highest values of calcium (7296 ppm) and magnesium (2364 ppm). Comparatively, coal briquettes were relatively lower in all minerals except calcium and iron.

Table 3 shows that chikanda products were high in sodium (6300–9500 ppm) and potassium (1600–4600 ppm) but were low in calcium (9.6–15.4 ppm), iodine (42–69 ppm) and phosphorus (0.07–0.09%). This high level of sodium content can be attributed to the addition of common salt and sodium bicarbonate or ash water filtrates. In the preparation of chikanda products, the potassium-rich groundnuts are added. This can contribute to high levels of potassium in products observed in this study. It is not clear why calcium, iodine and phosphorus are not absorbed to a large extent in the products. Mainga (1984) analysed for calcium, phosphorus and iron in the traditionally prepared chikanda. The product contained 40 ppm calcium, 0.07% phosphorus and 13 ppm iron. However, the investigation did not identify the type of additive used and level at which the additive was applied in this traditional chikanda product.

Table 2. Mineral content of some Zambian ashes. Figures in brackets are standard deviations and are based on six determinations. All other figures are means of three determinations

Minerals	Charcoal	Banana leaves	Bean stalks and leaves	Groundnut shells	Coal briquettes
Sodium (ppm)	51.4 (7.1)	23.6 (2.0)	63.1 (3.8)	88.1 (0.9)	31.4 (3.3)
Potassium (ppm)	1259 (408)	459 (205)	650 (109)	2785 (127)	278 (14)
Calcium (ppm)	3754 (701)	7296 (5400)	2539 (13)	212 (16)	3754 (701)
Iron (ppm)	26 (4)	28 (9)	41 (3)	187 (15)	63 (21)
Copper (ppm)	0.01	0.01	4.0	3.0	0.01
Magnesium (ppm)	282 (10)	2364 (1600)	360 (6)	1560 (80)	64 (0.4)
Iodine (ppm)	1400	2100	3500	8800	540
Phosphorus (%)	2.4	6.4	4.4	6.8	3.8

Table 3. Moisture, pH, ash, mineral contents and plunger penetration distance in chikanda products. The water content of a commercial smoked beef polony was 60% and that of chikanda with no additives was 74.9% and their pH values were 6.5 and 5.6, respectively. The resistances to penetration of smoked beef and chikanda with no additive were 19 mm and more than 40 mm, respectively. All figures are averages of three determinations

Type of product	A	B	C	D
Type and level of additive	Sodium bicarbonate (1.5% w/v)	Charcoal ash water filtrate (2% v/v)	Groundnut shells ash water filtrate (2% v/v)	Ash water filtrate (not known)
Moisture %	74.6	75.1	74.9	74.3
pH	7.2	7.9	7.6	8.5
Ash %	2.3	2.8	2.7	3.7
Sodium (ppm)	8400	6300	7000	9500
Potassium (ppm)	2200	4600	1600	4400
Calcium (ppm)	9.6	9.6	9.6	15.4
Iron (ppm)	29	37	42	69
Copper (ppm)	1.5	1.1	0.7	2.2
Iodine (ppm)	65	42	69	54
Phosphorus (%)	0.08	0.09	0.07	0.08
Plunger penetration distance (mm)	23	24	26	32

A, B and C are chikanda in polony casings prepared using standardised procedures and D is a traditionally prepared chikanda.

Between samples investigated, there is on an overall higher mineral content in chikanda prepared using a traditional method than other standardised procedures (Table 3). Excessive amounts of ash water filtrates and/or sodium bicarbonate are often used in traditional chikanda preparations. This fact can be supported by the high pH and high ash values of 8.5 and 3.7%, respectively, found in the traditional product (Table 3). From these data, it appears that ash water filtrates do, to a certain extent, provide some mineral nutrients to foods to which they are added. It is important, however, to critically evaluate these minerals for actual nutritive availability for humans.

The role of ash water filtrates and sodium bicarbonate in texture and flavour of chikanda

Table 3 shows the extent to which the plunger penetrated though various samples. The resistance to penetration was highest in the commercial beef smoked polony (19 mm) obtained from the Zambia Cold Storage Corporation Ltd. This is to be expected because this product is from animal origin and contains substantial amounts of fibrous matter. In the case of simulated meat products from chikanda tuber, the highest resistance to penetration was 23 mm and was obtained when sodium bicarbonate (1.5% w/v) was added to prepare the product. Charcoal and groundnut shell ash filtrates gave 24 and 26 mm resistance to penetration, respectively. The observed differences in resistance to penetration for products made using either charcoal or groundnut shell ash water filtrates could be explained by the differences in alkalinity and pH values between them (Table 1). It is interesting to note that when no additive was present the resistance to penetration was extremely low and exceeded 40 mm and the pH of the product was not basic (pH = 5.6, Table 3). It was also observed that, when chikanda was prepared in a traditional way, the resistance to penetration was comparatively lower (32 mm) than with chikanda prepared in casings. This could be due to the fact that, in the traditional recipes, the raw materials are not partly gelatinised before use. It appears, therefore, that one of the functions of ash water filtrates or sodium bicarbonate is the provision of firmness in the products. In preparing some products from protein/polysaccharide mixtures which imitate meat in appearance, alkaline conditions could be necessary (Imeson *et al.*, 1980). It was further observed that the soapy taste that is normally associated with chikanda products is a result of the addition of these additives. This is supported by the fact that sodium bicarbonate does contribute to a soapy taste of the product (Manley, 1991).

CONCLUSION

The use of ash water filtrates or sodium bicarbonate is very popular in Zambian dishes. The ashes, in addition to providing some of mineral nutrients in foods, do contribute to the firmness and soapy taste in chikanda products. Although the importance of ashes in Zambian foods cannot be doubted, their continued use should be critically assessed against the accompanying deleterious effects such as destruction of some vitamins, particularly such vital nutrients as thiamine and riboflavin. These vitamins are present in substantial amounts, especially if groundnuts are added when preparing chikanda.

It appears from these studies that coal briquettes ashes are unsuitable for food use, at least at present. The high levels of non-mineral matter, low pH and alkalinity militate against their use.

ACKNOWLEDGEMENTS

The author thanks the Secretary General, National Council for Scientific Research, Lusaka for supporting this work. The author also thanks Messrs Augustine Kaunda and Peter Longwe for technical assistance. The Zambia Cold Storage Corporation Limited and Mrs Peggy Simpasa are also sincerely thanked for providing smoked meat polony and traditional prepared chikanda, respectively.

REFERENCES

AOAC (1970). *Official Methods of Analysis of the Association of Official Analytical Chemists*, ed. W. Horwitz, 11th edn. AOAC, Washington, DC.

Chick, H. & Roscoe, M. H. (1930). XV. Heat-stability of the (anti-dermatitis, 'anti-pellagra') water-soluble vitamin B. *Biochem. J.*, **24,** 105–12.

Guha, B. C. & Drummond, J. C. (1929). XCVII. observations on the concentration of vitamin B_1. *Biol. Chem. J.*, **23,** 880–97.

Imeson, A. P., Mitchell, J. R. & Ledward, D. A. (1980). Rheological properties of spinning dopes and spun fibres produced from plasma–alginate mixtures. *J. Food Technol.*, **15,** 319–27.

Josyln, M. A. (1970). Ash content and ashing procedures. In *Methods in Food Analysis*, ed. M. A. Josyln, 2nd edn. Academic Press, New York, pp. 112–40.

Kuhn, R. & Moruzzi, G. (1934). Dissociation constants of flavins, dependence of the fluorescence on the pH. *Ber. dtsch. Chem. Ges.*, **67B,** 888–91.

Mainga, A. M. (1984). Analysis of the nutrients contents of some indigenous Zambian food plants with some studies on processing and storage. M.Sc. Thesis, University of Zambia, Lusaka, pp. 108–26.

Manley, D. (1991). *Technology of Biscuits, Crackers and Cookies*, 2nd edn. Ellis Harwood, New York, pp. 196–7.

Pearson, D. (1970). *A Chemical Analysis of Foods*. J. A. Churchill, London, pp. 539–40.

Ranganna, S. (1977). *Manual of Analysis of Fruits and Vegetable Products*. McGraw-Hill, New Delhi, pp. 108–9.

Sherman, H. C. & Burton, G. W. (1926). Effect of hydrogen ion concentration upon the rate of destruction of vitamin B upon heating. *J. Biol. Chem.*, **70,** 639–45.

Whitby, P. (1972). *Zambia Foods and Cooking*. UNDP and Zambia National Food and Nutrition Commission publication Lusaka, pp. 33–42.