Transformation Alimentaire du Manioc.
T. Agbor Egbe, A. Brauman, D. Griffon, S. Trèche (éd)

The effectiveness of cyanogen reduction during cassava processing into miondo

Efficacité de la diminution des composés cyanés lors de la transformation du manioc en miondo

*T. AGBOR-EGBE *, I. L. MBOME **, L. NOUBI **, S. TRECHE ***

** Laboratoire d'Etudes et de Contrôle des Aliments, Centre de Recherches en Alimentation et Nutrition, I.M.P.M., Yaoundé (Cameroun).*
*** Laboratoire de Nutrition Tropicale, Centre ORSTOM, Montpellier (France)*

- Abstract -

A study was undertaken to investigate the effectiveness of village processing techniques in reducing cyanogens to very low levels in a Cameroonian cassava based food, miondo.

The sub-processes used in the production of miondo were highly effective in reducing the total cyanogen content of the freshly harvested and unpeeled cassava (396.2-512.0 mg HCN Kg^{-1}) to very low levels in the final product (1.4-2.8 mg HCN Kg^{-1}) ready for consumption ; this accounted for a mean overall reduction in total cyanogens of 99.5 % (range 99.3-99.6%). On the third day of soaking when the roots had fermented and softened, an appreciable decrease was found in both pH and cyanogen levels which coincided with increases in cyanohydrin contents. In the later stages of processing, most of the residual cyanogens found in the fermented cassava pulp were in the form of cyanohydrins which were partially removed during boiling of the final product. In this study, the most important stages in the production of miondo, with regard to cyanogen reduction, were the soaking, mashing and dewatering sub-processes.

- Résumé -

Cette étude a été entreprise pour mesurer l'efficacité des procédés technologiques traditionnels pour réduire suffisamment les teneurs en composés cyanés lors de la préparation d'un produit dérivé du manioc du Cameroun, le miondo.

L'ensemble des procédés utilisés pour la production de miondo s'est révélé très efficace puisqu'il a permis de réduire les teneurs en cyanures totaux dans les racines entières fraîchement récoltées (396,2 à 512,0 mg HCN/kg) à des niveaux très bas dans le produit fini (1,4 à 2,8 mg HCN/kg) ce qui correspond à une réduction globale de 99,5 % (99,3 % à 99,6%). Au cours du troisième jour d'immersion dans l'eau, après que les racines aient fermenté et se soient ramollies, on a observé une diminution importante au niveau du pH et de la teneur en composés cyanés et, simultanément, une augmentation de la teneur en cyanhydrines. Au cours des dernières étapes de la transformation, la majeure partie des composés cyanés résiduels de la pulpe de manioc fermentée était sous forme de cyanhydrines qui ont disparu partiellement durant la cuisson par ébullition aboutissant au produit fini. Dans cette étude, les étapes les plus importantes de la production de miondo, en regard de la réduction des teneurs en composés cyanés, ont été l'immersion dans l'eau, l'écrasement à la main et l'égouttage.

Introduction

Cassava (*Manihot esculenta* Crantz) is a tropical root crop which is a staple food and a major source of calories for over 800 million people in developing countries (Cock, 1985). However, the roots contain cyanogenic glucosides, linamarin and lotaustralin which are responsible for chronic toxicity associated with the continued ingestion of poorly processed cassava products (Howlett *et al.*, 1990 ; Mlingi *et al.*, 1992). Due to the perishability and high cyanogen contents in the roots, several village processing techniques have led to the development of different cassava products for animal feed and human consumption (Lancaster *et al.*, 1982). These village processes which comprise combinations of either soaking, fermentation, drying, dewatering or boiling are meant to reduce toxicity, improve palatability and convert the perishable fresh roots into relatively stable food products.

In Cameroon, cassava roots are processed into a wide range of products (Ambe and Foaguegue, 1988). Miondo is a fermented cassava food widely consumed in the coastal regions of Cameroon. Earlier studies have reported the nutritional changes occurring during the processing of cassava into some food products (Favier *et al.*, 1971 ; Joseph, 1976 ; Oke, 1983 ; Ezeala, 1984 ; Cooke *et al.*, 1985). Despite the importance of miondo as food, there are no studies in the literature on the effectiveness of various sub-processes in reducing cassava cyanogen levels.

The objective of this study was to investigate the effectiveness of village processing techniques in reducing cyanogens to more acceptable levels in a cassava product.

MATERIALS AND METHODS

1. Miondo processing

The processing of cassava roots into miondo was studied at Bikoko Yabaki, a village 5 Km west of Douala in the Littoral Province of Cameroon. Two-year old cassava roots (local red skin variety) were harvested early in the morning, transported from the farms to the village and cleaned of any adhering soil. After cutting away the heads and tails of the roots, the unpeeled cassava was washed and soaked under water contained in large plastic drums. The water was collected from the local stream. During the soaking period under tropical ambient temperatures (28-32.5 °C), the roots had fermented and softened. The fermented roots were removed from the soak-water, peeled and mashed manually to remove central fibres and excess water. The mash was placed in an old fertilizer sack and pressed between strongly tied wooden poles, overnight. Following dewatering, the mash was ground in a hammer mill, kneaded into long cylindrical shapes (length 15-20 cm, diameter 1.5-2.0 cm), wrapped in large leaves (*Zingiber officinale*) and bound with raffia. Each bundle of the final product contained 20-single pieces of packaged miondo which was steam boiled for 40 to 55 min. The village processing of cassava roots into miondo is schematically shown by a flow-diagram in Figure 1.

CASSAVA ROOTS

Freshly harvested and cleaned of any adhering soil. Root heads and tails cut off.

⇓

SOAKING

Roots placed under water contained in a large plastic drum and left under tropical ambient temperatures for 3 days.

⇓

PEELING / MASHING

Fermented and softened roots were mashed manually to remove peelings, central fibres and excess water.

⇓

DEWATERING

Pulp placed in an old fertilizer sack and pressed between strongly tied wooden poles, overnight.

⇓

MILLING

Pulp ground in a hammer mill.

⇓

PACKAGING

Pulp kneaded into long cylindrical shapes, wrapped in large leaves and bound with raffia. Each bundle of mionda contained 20-single pieces of the packaging.

⇓

BOILING

In water for 40 to 50 min.

⇓

MIONDO

Figure 1

Processing of Cassava into miondo

2. Sampling for chemical analysis

Four market-orientated miondo processors were selected at random for sampling from amongst the households surveyed in a preliminary study on cassava processing. Results obtained in the survey indicated that the processing methods used in the production of miondo did not vary in details from one household to the other and no considerable differences were noticed in other villages found within the studied region.

Samples used this study were obtained from each of the four processors during 4 different miondo preparations. At the beginning of each processing, twenty-five randomly selected cassava roots were collected from each processor. Slices 2 cm-thick were taken from the proximal, centre and distal ends, washed, cut into small cubes, thoroughly mixed together, placed in screw-capped bottles and frozen. At later visits to the village, samples (800 g) were drawn from each sub-process and frozen. When the sampling was over, the frozen samples were stored in an ice-box and transported to the laboratories of the Centre for Food and Nutrition Research, Yaounde in Cameroon for the extraction of cyanogens and subsequent chemical analyses. The temperatures and pHs of the water used in the soaking of the roots were measured daily (1200 and 1600 h), at the surface and bottom of the drums.

3. Chemical analysis

Moisture content was estimated by drying fresh and processed samples (5 g) at 105 °C to constant weight while the pH was determined with a combination electrode on a sample (10 g) homogenised with distilled water (20 ml). The extraction and estimation of cyanogens (cyanogenic glucoside, cyanohydrin and hydrogen cyanide) was by the Cooke (1978, 1979) method as modified by O'Brien *et al.* (1991).

Results and discussion

1. Cyanogen levels in freshly harvested cassava

The total cyanogen content of the freshly harvested and unpeeled cassava roots, expressed on a dry weight basis, ranged from 396.2 to 512.0 mg HCN Kg^{-1} (Table 1). These ranges are similar to those reported for different cassava varieties (137-884 mg HCN Kg^{-1} : Gomez *et al.*, 1984 ; 397.6 mg HCN Kg^{-1} : Sokari *et al.*, 1992 ; 91-1515 mg HCN Kg^{-1} : O'Brien *et al.*, 1992). The major cyanogen found in the freshly harvested roots was in the form of cyanogenic glucoside, linamarin. However, in spite of the rapid preparation of the roots for chemical analysis, a certain amount of enzymic hydrolysis had occurred which resulted in the small quantities of cyanohydrins and hydrogen cyanide (HCN).

Table 1

Variations in cyanogen levels during cassava processing

PROCESSING TECHNIQUES	CYANOGEN LEVEL (mg HCN Kg-1)				pH
	GLUCOSIDES	CYANOHYDRINS	HCN	TOTAL	
Fresh	401.9 ± 50.2 (366.1-474.6)	25.1 ± 2.8 (23.2-29.2)	7.1 ± 0.8 (6.6-8.2)	434.2 ± 53.7 (396.2-512.0)	6.85 ± 0.05 (6.80-6.92)
Soaking 24 h	386.2 ± 48.3 (353.7-456.5)	27.1 ± 2.8 (25.3-31.3)	6.6 ± 0.8 (6.0-7.8)	419.6 ± 51.8 (385.6-495.6)	6.64 ± 0.08 (6.55-6.71)
48 h	338.3 ± 41.1 (310.5-398.3)	33.3 ± 4.5 (30.2-39.9)	6.6 ± 0.5 (6.0-7.0)	378.1 ± 45.6 (347.3-445.1)	6.41 ± 0.08 (6.34-6.51)
72 h	133.7 ± 10.4 (119.7-144.0)	62.3 ± 3.5 (58.9-66.4)	6.9 ± 0.7 (6.3-7.9)	202.8 ± 13.7 (186.4-218.3)	5.73 ± 0.05 (5.68-5.79)
Mashing	18.3 ± 5.9 (10.1-24.1)	33.6 ± 10.4 (21.9-46.4)	3.9 ± 0.7 (3.2-4.7)	55.9 ± 13.9 (44.4-73.9)	4.35 ± 0.02 (4.32-4.37)
Dewatering	5.2 ± 2.1 (3.8-8.3)	10.2 ± 5.4 (7.1-18.2)	2.0 ± 0.2 (1.8-2.2)	17.4 ± 7.6 (13.1-28.7)	4.46 ± 0.06 (4.42-4.54)
Milling	0.9 ± 0.5 (0.8-2.4)	4.3 ± 1.4 (2.2-5.4)	0.7 ± 0.1 (0.6-0.9)	6.4 ± 1.7 (4.4-8.2)	4.51 ± 0.03 (4.47-4.55)
Boiling	0.5 ± 0.3 (0.2-0.8)	1.4 ± 0.6 (0.9-2.3)	0.4 ± 0.1 (0.3-0.4)	2.3 ± 0.6 (1.4-2.8)	4.59 ± 0.08 (4.49-4.67)

Mean values with standard deviations.
Ranges in parenthesis.

2. Effects of processing on cyanogen levels

The sub-processes used in the production of miondo were highly effective in reducing the levels of cyanogens to very low contents (Figure 2). The mean overall reduction in total cyanogens of 99.5 % (range 99.3-99.6%) obtained during the production of miondo corroborate results from other studies that unmodified village processing techniques are capable of effective cassava detoxification (Mahungu *et al.*, 1987 ; Maduagwu, 1979 ; Vasconcelos *et al.*, 1990). Despite the wide range in total cyanogen contents of the freshly harvested roots, it was also observed that during processing similar reduction levels were obtained for the product by all the miondo processors studied (Figure 3). In this study, it was observed that the most important stages, with regard to cyanogen reduction, were the soaking, mashing and dewatering sub-processes. The residual cyanogens in the later stages of processing were in the form of cyanohydrins (Table 1). It has been reported that, in cassava products which have been fermented and processed, most of the residual cyanogen content is likely to be in the form of cyanohydrins and/or HCN (Maduagwu, 1979).

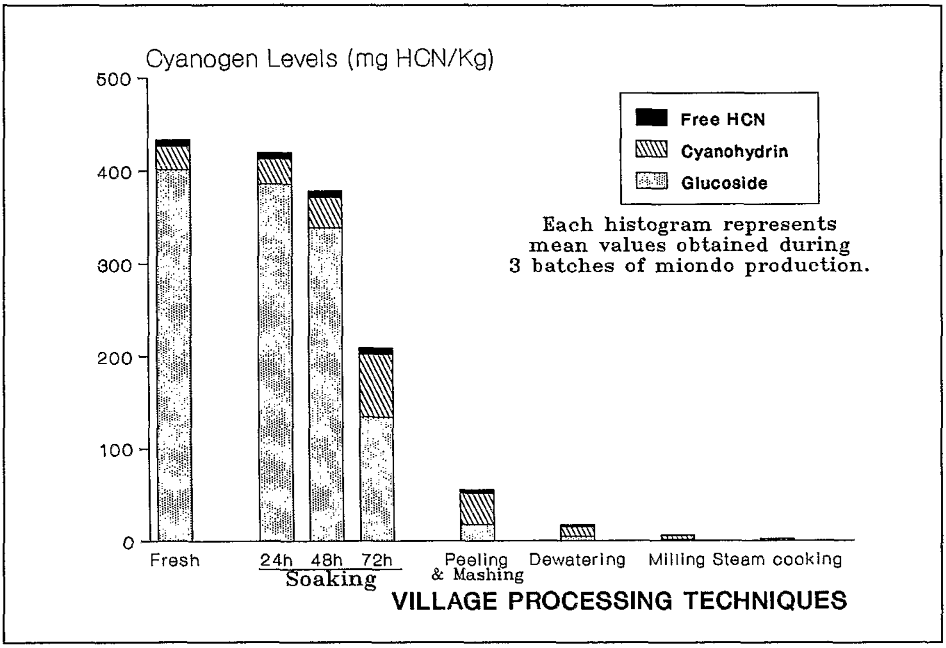

Figure 2

Variations in cyanogen levels during cassava processing into miondo

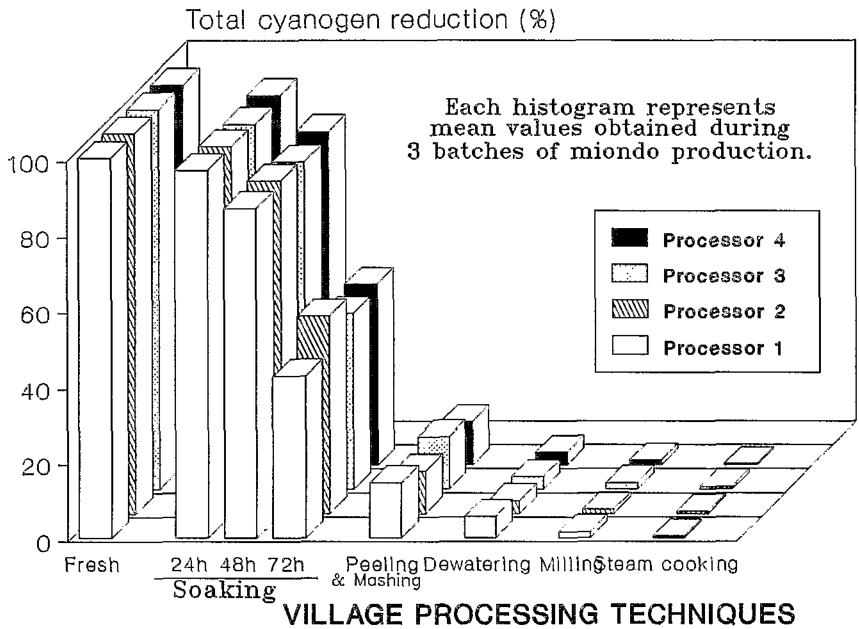

Figure 3
Total cyanogen reduction levels obtained by the miondo processors

2.1 The role of root soaking

The low total cyanogen levels obtained for the miondo samples (1.4-2.8 mg HCN Kg^{-1}) was made possible by the initial submerged fermentation of the cassava roots. After two days of soaking, small changes in pH and cyanogen levels occurred in the cassava samples. However, on the third day when the roots had fermented and softened, an appreciable decrease was found in both pH and cyanogen contents (Table 1). These changes which coincided with significant increases in the levels of the intermediate product of hydrolysis, cyanohydrins, indicate that the roots were more susceptible to the actions of linamarase. Soaking and fermentation of the roots facilitated contact between the endogenous enzyme, linamarase and the cyanogenic glucoside substrate. Cyanogenic glucosides are hydrolysed by the enzyme linamarase to form cyanohydrins, which in turn are hydrolysed by the enzyme hydroxynitrile lyase, to yield HCN (Cooke, 1978).

This hydrolysis occurs spontaneously at pH 4 and above (Fomumyam *et al.*, 1985). The optimum pH of linamarase activity has been shown to be between 5.5 to 6.5 (Cooke, 1978 ; Yeoh, 1989). As shown in Table 2, the temperatures (29-31 °C) and pHs (4.32-6.23) of the soak-waters were conducive in promoting rapid microbial growth and enzyme activity. Results obtained in the Congo have shown that during the production of chikwangue and fufu the reduction of cyanogen levels was fastest when the soak-waters had an optimum temperature of 32 °C (Brauman *et al.*, 1994).

Table 2

pHs and temperatures of soak-waters during cassava processing

The rates of roots softening and PH reduction have been shown to be related to the size of the root pieces (Okafor *et al.*, 1984). In this investigation,

PROCESSORS	DAY 0		DAY 1		DAY 2		DAY 3	
	pH	°C	pH	°C	pH	°C	pH	°C
N° 1	6.18	29	5.91	29	5.20	31	4.52	30
N° 2	6.22	29	5.98	30	5.00	30	4.45	31
N° 3	6.14	30	5.88	30	5.18	29	4.42	30
N° 4	6.23	29	5.94	31	4.98	31	4.32	31

Average values of two measurements.
Temperature measured at the surface and bottom of soak-water contained in the large plastic drums.

softening occurred only after three days of soaking whole unpeeled cassava roots. Fermentation of cassava roots has been attributed to lactic acid bacteria (Okafor *et al.*, 1984 ; Regez *et al.*, 1988) while root tissue softening has been associated with an increase in the activity of some cell wall degrading enzymes such as polygalacturonase, pectinase and cellulase (Okolie and Ugochukwu, 1988). The fermentation of roots is essential for preserving and developing the sensory attributes of cassava products (Dougan *et al.*, 1983 ; Oyewole and Odunfa, 1990).

2.2 The effects of the mashing and dewatering stages

During the mashing and dewatering stages a sharp decline occurred in total cyanogen levels with a corresponding steady fall in pH of the softened and fermented samples from 5.68-5.79 to 4.32-4.54. The mild acidic conditions in the samples reduced the rate of cyanogenic glucoside hydrolysis and promoted the spontaneous breakdown of cyanohydrins to yield HCN. The water-solubility and volatility (the boiling temperature of HCN is 25.7 °C) of hydrogen cyanide provide easy removal from the fermented cassava pulp during the subsequent processing steps in the production of miondo.

Conclusion

The sub-processes used in the village production of miondo were highly effective in reducing the levels of cyanogens to very low contents. It is evident in this study that, the rates of linamarase activity and the breakdown of cyanohydrins were influenced by the pH of the fermented and softened cassava roots during the different production sub-processes. The various stages used in miondo preparation had the effect of reducing pH and cyanogen levels. Boiling of the final product was necessary in removing some of the residual cyanogen content.

Acknowledgments

The authors gratefully acknowledge the funds provided by the International Foundation for Science (IFS) and the Institut français de recherche scientifique pour le développement en coopération (ORSTOM).

Bibliography

AMBE (J.T.), FOAGUEGUE (A.), 1988 - The place of cassava in Cameroon. *In* Collaborative Study of Cassava in Africa. Working Paper n° 3, IITA, Ibadan, Nigeria, 4-10th September 1988 : 1-6.

AMPE (F.), BRAUMAN (A.), TRECHE (S.), AGOSSOU (A.), 1994 - Cassava retting : Optimisation of traditional fermentation by an experimental research methodology. *J. Sci. Food Agric.*, 66 : 355-361.

COCK (J.H.), 1985 - *Cassava, A New Potential for a Neglected Crop.* (IADS Development Oriented Literature series). Boulder and London, Westview Press.

COOKE (R.D.), 1978 - An enzymatic assay for the total cyanide content of cassava (*Manihot esculenta* Crantz). *J. Sci. Food Agric.*, 29 : 345-352.

COOKE (R.D.), 1979 - « Enzymatic assay for determining the cyanide content of cassava and cassava products ». *In* Brekelbaum (T.), Gomez (G.), éd. : *Cassava Information Centre*, Centro Internacional de Agricultura Tropical (CIAT), Cali, Columbia, Series 05EC-6, 14 p.

COOKE (R.D.), RICKARD (J.E.), THOMPSON (A.K.), 1988 - « Nutritional aspects of cassava storage and processing ». Proceed *7th Symp Intern Soc Trop Root Crops*, 1-6 July 1985, Gosier, Guadeloupe, pp 635-648.

DOUGAN (J.), ROBINSON (J.M.), SUMAR (S.), HOWARD (G.E.), COURSEY (D.G.), 1983 - Some flavouring constituents of cassava and of processed cassava products. *J. Sci. Food Agric.*, 34 : 874-884.

EZEALA (D.O.), 1984 - Changes in the nutritional quality of fermented cassava tuber meal. *J. Sci. Food Chem.*, 32 : 467-469.

FAVIER (J.C.), CHEVASSUS-AGNES (S.), GALLON (G.), 1971 - La technologie traditionnelle du manioc au Cameroun : influence sur la valeur nutritive. *Ann. Nutri. Alim.*, 25 : 1-59.

FOMUMYAM (R.T.), ADEGBOLA (A.A.), OKE (O.L.), 1985 - The stability of cyanohydrins. *Food Chem.*, 17 : 221-225.

GOMEZ (G.), VALDIVIESO (M.), CUESTA DE LA (D.), KAWANO (K.), 1984 - Cyanide content in whole-root chips of ten cassava cultivars and its reduction by oven drying or sun drying on trays. *J. Food Technol.*, 19 : 97-102.

HOWLETT (W.P.), BRUBAKER (G.R.), MLINGI (N.L.V.), ROSLING (H.), 1990 - Konzo : An epidemic upper motor neuron disease studied in Tanzania. *Brain*, 113 : 223-235.

JOSEPH (A.), 1976 - Influence de la technologie traditionnelle du manioc sur les teneurs en éléments minéraux et en phosphore phytique. *Ann. Nutri. Alim.*, 27 : 127-139.

LANCASTER (P.A.), INGRAM (J.S.), LIM (M.Y.), COURSEY (D.G.), 1982 - Traditional Cassava-Based Foods : Survey of processing techniques. *Econ. Bot.*, 36 (1) : 12-45.

MADUAGWU (E.N.), 1979 - Cyanide content of gari. *Toxicol. Lett.*, 3 : 21-24.

MAHUNGU (N.M.), YAMAGUCHI (Y.), ALAMAZAN (A.M.), HAHN (S.K.), 1987 - Reduction of cyanide during processing of cassava into some traditional African foods. *J. Food Agric.*, 1 : 11-15.

MLINGI (N.L.V.), ASSEY (V.D.), POULTER (N.H.), ROSLING (H.), 1992 - « Cyanohydrins from insufficiently processed cassava induces konzo, a newly identified paralytic disease in man ». *In* Westby (A.), Reilly (P.J.A.), éd. : *Proced Regional Workshop on Traditional African Foods-Quality and Nutrition*. Intern. Foundation for Science, 25-29 November 1991 : 163-169.

O'BRIEN (G.M.), TAYLOR (A.J.), POULTER (N.H.), 1991 - Improved enzymic assay for cyanogens in fresh and processed cassava. *J. Sci. Food Agric.*, 56 : 277-289.

O'BRIEN (G.M.), MBOME (L.), TAYLOR (A.J.), POULTER (N.H.), 1992 - Variations in cyanogen content of cassava during village processing in Cameroon. *Food Chem.*, 44 : 131-136.

OKAFOR (N.), IJIOMA (B.), OYOLU (C.), 1984 - Studies on the microbiology of cassava retting for fufu production. *J. Appl. Bacterio.*, 56 : 1-13.

OKE (O.L.), 1983 - « Processing and detoxification of cassava ». *In* Delange (F.), Ahluwalia (R.), éd. : *Cassava Toxicity and Thyroid. Research and Public Health Issues IDRC-207[e]*, Ottawa, Canada : 129-133.

OKOLIE (P.N.), UGOCHUKWU (E.N.), 1988 - Changes in activities of cell wall degrading enzymes during fermentation of cassava (*Manihot esculenta* Crantz) with *Citrobacter freundii*. *J. Sci. Food Agric.*, 44 : 51-61.

OYEWOLE (O.B.), ODUNFA (S.A.), 1990 - Characterization and distribution of lactic acid bacteria in cassava fermentation during fufu production. *J. Appl. Bacterio.*, 68 : 145-152.

REGEZ (P.F.), ZORZI (N.), NGOY (K.), BALIMANDAWA (M.), 1988 - Evaluation de l'importance de quelques souches de *Lactobacillus* spp. pour l'acidification de différents aliments de base de manioc. *Lebensm. Wiss u. Technol.*, 21 : 288-293.

SOKARI (T.G.), KARIBO (P.S.), WACHUKWU (C.K.), 1992 - « Reevaluation of the role of fermentation in cassava detoxification during processing into foods ». *In* Westby (A.), Reilly (P.J.A.), éd. : *Proced Regional Workshop on Traditional African Foods-Quality and Nutrition*. Intern. Foundation for Science, 25-29 November 1991 : 151-155.

VASCONCELOS (A.T.), TWIDDY (D.R.), WESTBY (A.), REILLY (P.J.A.), 1990 - Detoxification of cassava during gari preparation. *Intern J. Food Sci. Technol.*, 25 : 198-203.

YEOH (H.H.), 1989 - Kinetic properties of beta-glucosidases from cassava. *Phytochem*, 28 (3) : 721-724.