Food and Chemical Toxicology 49 (2011) 607–612

Contents lists available at ScienceDirect

Food and Chemical Toxicology

journal homepage: www.elsevier.com/locate/foodchemtox

Chemical safety of cassava products in regions adopting cassava production and processing – Experience from Southern Africa

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ARTICLE INFO

Article history:
Available online 21 July 2010

Keywords:
Manihot esculenta
Cassava
Cyanogenic glucosides
Food safety
Processing technologies
Southern Africa

ABSTRACT

The cassava belt area in Southern Africa is experiencing an unforeseen surge in cassava production, processing and consumption. Little documentation exists on the effects of this surge on processing procedures, the prevailing levels of cyanogenic glucosides of products consumed and the levels of products commercially available on the market. Risk assessments disclose that effects harmful to the developing central nervous system (CNS) may be observed at a lower exposure than previously anticipated. We interviewed farmers in Zambia and Malawi about their cultivars, processing procedures and perceptions concerning cassava and chemical food safety. Chips, mixed biscuits and flour, procured from households and markets in three regions of Zambia (Luapula-North, Western and Southern) as well as products from the Northern, Central and Southern regions of Malawi, were analyzed for total cyanogenic potential (CNp). Processed products from Luapula showed a low CNp, <10 mg HCN equiv./kg air dried weight, while samples from Mongu, Western Province, exhibited high levels of CNp, varying from 50 to 290 mg HCN equiv./kg. Even the lowest level is five times higher than the recommended safety level of 10 mg/kg decided on for cassava flour. Our results call for concerted efforts in promoting gender oriented processing technologies.

1. Introduction

Southern Africa is currently experiencing a rapid development in processing and marketing of food products derived from cassava (*Manihot esculenta* Crantz) root tubers (Gabre-Madhin and Haggblade, 2004), prompted by continued food insecurity due to rain dependent agriculture and climate change. This acceleration of the use of cassava follows a development in West Africa where improved varietal releases from the International Institute for Tropical Agriculture (IITA, Nigeria) triggered a surge in cassava production, trade and commercialization (Nweke et al., 2002). The southern African region now starting a similar process has, however, its own characteristics. The potential importance of cassava to enhancing regional food security goes far beyond its prospects for generating income from cassava farming, trade and processing and for moderating consumer prices for this staple (Dixon et al., 2003). The cassava belt area in Southern Africa spans across four countries, namely Malawi, Mozambique, Tanzania and Zambia. These four countries are regarded as so called ''flexible surplus production zones'' or ''food security enhancing hot spots'' (FSEHS). They are regions where substitution possibilities among multiple food staples permit highly flexible supply responses. While the neighbouring maize producing regions face regular drought and persistent demands for food aid, these cassava zones where tubers can be harvested over a 2–3 year period rarely launch food aid appeals. The FSEHS are able to adjust cassava production rapidly as well as moderating internal maize consumption, and may thus release large quantities of both maize and cassava to other regions.

Cassava contains in all its parts the compounds linamarin and lotaustralin which liberate the toxic chemical entity hydrogen cyanide (HCN) upon processing and chewing. Linamarin and lotaustralin are cyanogenic glucosides and their degradation to HCN involves cyanogenic intermediates in the form of cyanohydrins (α-hydroxynitriles). Together, the glucosides, the cyanohydrins and HCN may be termed cyanogens. The toxic effects observed after consumption includes acute poisoning (Mlingi et al., 1992). Some studies have revealed a strong association between chronic dietary consumption of insufficiently processed cassava, chronic intoxication and the disease Konzo (Tylleskär et al., 1992). Konzo,

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doi:10.1016/j.fct.2010.07.025

which mostly affects women of child bearing age and children over 2 years of age, is only observed in populations keeping to a monotonous cassava diet, but is persistent in for example Mozambique (Cliff et al., 2009) and Tanzania (Mlingi et al., 2009). Furthermore, recent risk assessments suggest that toxic effects, harmful to the developing central nervous system (CNS), may be acquired at a lower systemic exposure to cyanide than previously observed (EFSA, 2007).

Cassava consuming societies have developed and adopted effective methods to reduce the potential toxicity of products arising from the root tubers upon consumption (Brimer, 2001; Chiwona-Karltun et al., 2000; Dufour, 1993, 1994; Onabolu et al., 2002). Cassava leaves are also consumed widely (Kolind-Hansen and Brimer, 2009) and their content of cyanogenic glucosides and cyanogenic products of decomposition can be reduced significantly by processing, normally by pounding followed by boiling for at least 20 min (Ngudi et al., 2003).

Cassava cultivars are classified as sweet (cool) or bitter. Bitter taste of the tubers has been shown to correspond with higher levels of linamarin (and lotaustralin) (King and Bradbury, 1995; Chiwona-Karltun et al., 2004). Accordingly, this classification indicates whether the tubers may be eaten with or without any prior processing. Cassava is the only domesticated staple crop, where a significant part of the edible production is toxic (Hillocks et al., 2002). In areas where cassava is a main staple crop, bitter and toxic varieties are preferred, whereas sweet (cool) varieties are abundant in areas where cassava only plays a secondary role as staple food. In order for cassava to gain popularity in new regions as a food security complement or alternative as well as becoming a commercial commodity, well developed food processing techniques and food safety systems are required. These techniques and systems must function at the very local rural as well as modern urban level to assure high quality food products that are ready for consumption and chemically safe for the populations consuming them.

The present study was conducted to obtain an overview of farmers' general knowledge of the cultivated varieties/cultivars, including their taste classification of cassava. Additionally, we determined prevailing levels of cyanogenic glucosides in different products of cassava root tubers, consumed within the home. Furthermore, we investigated whether the products were commercially available.

2. Materials and methods

2.1. Study areas

The study was carried out in Malawi and Zambia, two of the cassava belt countries in Southern Africa. Within each region studied, production and consumption were sorted as being low, medium, high or major. Table 1 presents an overview of the different study areas as well as their level of production and consumption.

Table 1
Geographical regions surveyed in Malawi and Zambia.

Country	Province/ Region	District	Production and consumption
Malawi	Southern	Blantyre, Mulanje, Zomba	Major
	Northern	Karonga, Mzimba, Nkhata-Bay, Rumphi	High
	Central	Lilongwe, Nkhota-Kota	Medium
Zambia	Copperbelt	Ndola, Chingola, Kitwe	Major
	Luapula	Mansa, Samfya	High
	Northern	Luwingu	High
	Western	Kaoma, Mongu	Medium
	Lusaka	Chongwe, Lusaka	Low
	Southern	Sinazongwe, Monze	Low

Table 2
Interviews conducted in regard to kind and number of groups.

Country	Number of groups	
	Focus Group Discussion (FGD)	Key-informant interview
Malawi $n = 118$ (62 females, 56 males)	4	28
Zambia $n = 154$ (60 females, 94 males)	14	58

2.2. Field methods and tools

Participatory Rapid Rural Appraisal approaches (Pretty et al., 1995) were used to investigate at household, community, key informant, trader and industrial levels. The tools included Focus Group Discussions (FGD) with combinations of ranking priorities (preference, importance and availability), mapping of processing procedures as well as producing processing calendars and causal diagrams, with selected communities. Key informant interviews with leaders, extension workers and expert individuals in cassava processing, were performed. Secondary data related to cassava production were furthermore collected in the high, medium and low cassava producing areas of the selected districts.

2.2.1. Data collection

Research teams with the aid of trained field assistants visited the selected areas and carried out interviews. Secondary data were also collected at the end of those interviews during which availability of such data was indicated. All interviews were performed during the periods 26-07-2007–19-10-2007 (Zambia) and 08-09-2007–14-09-2007 (Malawi). A total of 272 respondents were interviewed. Table 2 illustrates the regional distribution of the interviews and the types and social characteristics of the respondents.

The focus group discussions were performed and guided by a discussion guide and the key informant interviews were guided by a semi-structured questionnaire. Statements made in interviews were documented in written form including the particulars and occupation of each of the interviewed persons.

2.2.2. Sampling of cassava products

Samples of identified processed cassava products were purchased from households and local markets.

2.3. Chemical analysis

Cassava products were analyzed for their total cyanogenic potential (CNp); i.e., the total amount of HCN released upon full hydrolysis of the glucosides and total decomposition of the cyanohydrins present or formed. The method used was the one described by Saka et al. (1998). Reading of the reaction spots was performed using the "Quantiscan" software after scanning and the scanner used was previously described by Brimer (1994). The method has previously been used in studies on the cyanogenic potential of cassava roots (Chiwona-Karltun et al., 2004; Kolind-Hansen and Brimer, 2009) as well as cassava flour (Brimer et al., 1998).

3. Results

3.1. Cultivated varieties/cultivars

Based on information gathered during the focus group interviews, the following was the overall picture. In Zambia, the high cassava consuming communities depended mostly on their own local varieties/cultivars; very few new and/or improved varieties released by research centres were cultivated. However, in the low cassava producing and consuming areas, most of the newly introduced varieties were from agricultural research stations. Farmers describe yield in terms of high or low based on the number of roots produced per plant or the size of the roots rather than in tonnes/ha. In Malawi, the scenario was quite different from Zambia. In all cassava growing areas, farmers were largely growing local varieties/cultivars; the production of improved varieties was limited except for *manyokola*, which was popular in all the areas investigated. Reasons for preferring a certain variety/cultivar were complex as described in Tables 3a and 3b, which lists varieties/cultivars, characteristics and uses.