Food and Chemical Toxicology 49 (2011) 539–542

Contents lists available at ScienceDirect

Food and Chemical Toxicology

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

Uptake of wetting method in Africa to reduce cyanide poisoning and konzo from cassava

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ARTICLE INFO

Article history:
Available online 25 May 2010

Keywords:
Konzo
Cyanide poisoning
Cyanogenic glucosides
Cassava
Wetting method

ABSTRACT

Cassava contains cyanogenic glucosides which are hydrolysed by an enzyme linamarase to produce cyanohydrins which breakdown to toxic cyanide. Cyanide ingestion from bitter cassava can cause cyanide poisoning sometimes leading to death and also konzo, an irreversible paralysis of the legs which occurs mainly in children and young women. In 2005 we developed a simple wetting method that reduces the total cyanide content of cassava flour 3–6-fold. It involves wetting the flour, spreading it in a thin layer in the shade for 5 h and using it the same day to make traditional thick porridge (ugali). The method was readily accepted by rural women and requires no additional equipment or water. Laminated, illustrated posters describing the method are available for free in ten languages, see http://online.anu.edu.au/BoZo/CCDN/. An equally effective treatment method is to expose wet flour in a thin layer in the sun for 2 h. Projects for rehabilitation and prevention of konzo occurred in Mozambique in 2007 and in 2008–2009 in Tanzania, funded by AusAID. The Ministry of Health in Mozambique is now using our posters in Macua. In Uvira DRC, the wetting method has been taught in many villages and over 1200 posters distributed.

1. Introduction

Cassava is the third most important food source in the tropics after rice and maize and is the staple food of tropical Africa. The use of cassava as a food source is increasing particularly in Africa, because it yields well even in poor soil without fertilizer, is drought resistant and the root can be left in the ground for up to three years as a reserve source of food. During drought the leaves drop off, the plant is kept alive by its large roots and when the rains come the leaves sprout again. The roots are very starchy and in Africa the young cassava leaves after processing are used as a source of protein and vitamins.

Amongst more than 2000 plants that use cyanide as a defence mechanism to deter predators, cassava is by far the most important human food source. The plant produces two cyanogenic glucosides, linamarin and a small amount of lotaustralin (methyl linamarin). These cyanogenic glucosides are hydrolysed using the enzyme linamarase as a catalyst, to produce a cyanohydrin and glucose and in a second reaction the cyanohydrin breaks down spontaneously above pH 5 to give hydrogen cyanide (HCN) gas and a ketone. Linamarin is present in large amounts in the leaves (Bokanga, 1994) and the peel of the roots (900–2000 mg HCN equivalents/kg fresh weight = ppm) (Nambisan and Sundaresan, 1994). Reported content of the interior of the roots (parenchyma) ranges from 1–1550 ppm (Cardoso et al., 2005). The parenchyma of some varieties of cassava has only a small amount of linamarin and is called sweet cassava, but many varieties have large amounts of linamarin which has a bitter taste (King and Bradbury, 1995) and these are called bitter cassava. Bitter cassava needs to be processed before use.

Cyanide intake from consumption of cassava can

(1) Cause acute intoxication with symptoms of dizziness, headache, nausea, vomiting, stomach pain, diarrhoea and sometimes death (Mlingi et al., 1992; Akintonwa et al., 1994).
(2) Exacerbate goitre and cretinism due to iodine deficiency (Delange et al., 1994).
(3) Contribute to the occurrence of tropical ataxic neuropathy (TAN), which causes unsteady walking, loss of sensation in hands, loss of vision, deafness and weakness (Osuntokun, 1994; Oluwole et al., 2003).
(4) Lead to konzo, an irreversible paralysis of the legs, which occurs mainly in children and women of child bearing age (Ministry of Health, 1984; Howlett et al., 1990).

In Mozambique over 2000 konzo cases have been reported in recent decades (Cliff et al., 2011) and in Tanzania some hundreds of cases (Howlett et al., 1990; Mlingi et al., this issue). There are many thousands of cases in Democratic Republic of Congo (DRC). Recent

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doi:10.1016/j.fct.2010.04.049

outbreaks have occurred in Mozambique and Tanzania due to drought and in DRC due to war. It is the purpose of this paper to consider the wetting method that reduces the cyanide content of cassava flour 3–6-fold and the uptake of this method by rural women, particularly in countries where konzo occurs.

2. Processing of cassava

2.1. Cassava flour

In northern Mozambique and southern Tanzania where konzo occurs the major methods of producing cassava flour are sun drying and heap fermentation. Sun drying involves peeling the cassava root and drying in the sun for about 7 days followed by pounding in a wooden pestle and mortar and sieving to give a white product. In heap fermentation, a small heap of peeled roots is made and left in the shade for about 4 days. The roots are then sun dried, pounded and sieved to give slightly coloured flour. Our studies in Mozambique showed that in a good year the mean total cyanide content of sun dried flour was 45 ppm and of heap fermented flour was about one half of that (Cardoso et al., 1998). Under drought conditions the total cyanide content increased more than twofold and rural women changed from sun drying to heap fermentation in order to reduce the intake of cyanide (Ernesto et al., 2002), but this was still not sufficient to prevent the occurrence of acute intoxication and konzo. The WHO safe level for total cyanide in cassava flour is 10 ppm (FAO/WHO, 1991).

In the konzo-affected areas of Bandundu in DRC, where rainfall is more abundant, Banea et al. (1992) reported that peeled roots were normally immersed in water for 3 nights which allowed good contact between water-soluble linamarin and linamarase with breakdown of linamarin and acetone cyanohydrin. A variety of products resulted from varying times of pounding and sundrying. Short cuts in the soaking time were frequent, and led to cyanide intoxication.

2.2. Gari

In West Africa gari is produced by grating the peeled root and putting the wet product in a hessian bag for 3 days during which excess liquid is squeezed out. The damp mash is then roasted in a metal pan over a wood fire to remove HCN and moisture and this produces a hard, crunchy product called gari. As summarised by Cardoso et al. (2005) from other work, the average reported total cyanide content is about 20 ppm. There is konzo in Cameroon but not further west into West Africa, probably because gari is preferred in West Africa and contains much less cyanide than the flour used in Central and East Africa.

3. Wetting method

In 2005 we developed a simple wetting method that reduces the total cyanide content of flour 3–6-fold (Bradbury, 2006; Cumbana et al., 2007). Cassava flour is placed in a bowl and the level marked on the inside of the bowl. Water is added with mixing until the wet flour comes up to the mark on the bowl. The wet flour is spread in a thin layer (<1 cm thick) on a basket to allow the ready escape of hydrogen cyanide (HCN) gas produced by the breakdown of linamarin catalysed by linamarase, and left in the shade for 5 h. The wet flour is then used the same day, by adding to boiling water to make thick porridge in the traditional way. The method was found to be acceptable to rural women in Mozambique. It requires no extra work, no extra water or equipment and the flavour of the thick porridge was preferred to that from untreated flour (Muquingue et al., 2005; Nhassico et al., 2008). We have found in laboratory experiments that an alternative faster treatment to 5 h in the shade is 2 h in the sun, but this method uses more water because some is lost by evaporation (Bradbury and Denton, 2010). The breakdown of linamarin to acetone cyanohydrin catalysed by linamarase and its further spontaneous decomposition to HCN occurs readily in wet flour (pH 6–6.5) at 30–50 °C, but with gari at pH ca 4.1, linamarase is inactive and there is no breakdown of linamarin (Bradbury, 2006).

4. Laminated coloured posters

A laminated, illustrated poster was first produced in Portuguese by Dr. Dulce Nhassico that showed with words and pictures how to use the wetting method to remove cyanide from cassava flour and prevent konzo. The poster was translated into English by Dr. Julie Cliff and then into other languages and the text modified to include an explanation of cyanide poisoning. Recently it has been modified again to include the option of shortening the treatment to two hours in the sun (see Fig. 1). The poster is now available for free in Amharic, Ateso, English, French, Hausa, Kifuliru, Kiswahili, Kiyaka, Macua and Portuguese, Several thousand of these laminated posters have been sent by courier to people in various countries in Africa, to alert rural communities who consume bitter cassava of the dangers of cyanide poisoning and konzo and to promote the wetting treatment to remove cyanide from cassava flour, see http://online.anu.edu.au/BoZo/CCDN/.

5. Uptake of wetting method by rural people

Although the wetting method which reduces the total cyanide content of cassava flour 3–6-fold was developed and successfully field tested with rural women in Mozambique in 2005 (Muquingue et al., 2005), yet in 2010 it is hardly being used even in countries where konzo occurs. This is distressing and disappointing. A summary of the current situation on a country basis follows.

5.1. DRC

We have commenced a collaborative project with Professor Banea in which the wetting method is being introduced into a village where konzo is endemic and hope by that means to reduce konzo or perhaps eliminate it altogether from that village. We will also monitor urinary thiocyanate levels in the village school children, which will give an indication of recent intake of cyanide.

In a second project, Mr. Aaron K. Karumba of APAA Congo has conducted meetings in about ten villages near Uvira, where people have been instructed in the dangers of cyanide poisoning and konzo and the wetting method described. More than 1200 hundred laminated posters in Kifuliru have been distributed. Some months later 30 people from each of 2 villages (Kawizi and Kiliba) were interviewed and asked 9 questions (Karumba et al., 2009). The results were as follows:

1. Everyone ate cassava every day and more than one third had cassava more than once per day. This shows the great dependence of communities on their staple food, cassava.
2. Nearly everyone (87%) prepared cassava flour by soaking the peeled roots in water for about 4 days, followed by sun drying, pounding and sieving. This is a good method of removing cyanide from flour.

Fig. 1. Laminated poster which illustrates the wetting method to remove cyanide from cassava flour.

3. Nearly one half know how to use the wetting method, but not many use it, partly because of the effectiveness of the 4 day soaking method in getting rid of the cyanide. However some use the wetting method to treat flour, particularly if they are unsure of the processing method used to make it.

4. The major complaint about the wetting method was that it takes too long (5 h) and some said that it required surveillance during that time to prevent stealing or spoilage. Treatment for 2 h in the sun may be an acceptable alternative treatment for these people.

5.2. Mozambique

The Ministry of Health in Mozambique has recently endorsed the use of the wetting method (Cliff et al., 2011).

5.3. Tanzania

The wetting method was recently tested and village activists were trained in its use (Mlingi et al., 2011).

5.4. CAR

Tylleskar et al. (1994) first reported the incidence of konzo in CAR. In 2008 it was reported that konzo is a serious health problem in health region 2 of CAR and a recommendation was made for a prevention program (Mbelesso et al., 2008).

5.5. Cameroon

Konzo was reported in the East Province of Cameroon by Lantum (1998). Recently refugees from a war in CAR were forced over the border into Cameroon and many were found to have konzo (Barrett, 2007). At that time we provided kits to determine total cyanide in cassava flour (Bradbury et al., 1999) to Medecins sans Frontieres (MSF) and coloured laminated posters in French.

6. Conclusion

In the future there is likely to be an increase in cyanide poisoning and konzo amongst the poorest of the poor in tropical Africa because (1) consumption of cassava is increasing, (2) there is a lack of knowledge about cyanide poisoning and no experience of proper processing methods in new areas where cassava has not been grown before and (3) droughts are increasing in frequency due to climate change (Nhassico et al., 2008). Konzo occurs during drought because the total cyanide content of cassava roots increases greatly due to water stress (Bokanga et al., 1994) and short-cut processing methods are used during food shortages (Mlingi et al., this issue). Adoption of the wetting method by rural women is an important tool to reverse these upward trends and help to eliminate cyanide poisoning and konzo.

Conflict of Interest

The authors declare that there are no conflicts of interest.

Acknowledgment

We wish to thank the Australian Agency for International Development (AusAID) for financial support for programs of rehabilitation and prevention of konzo in Mozambique and in Tanzania.

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