Making cassava flour safe using the wetting method

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Abstract

Many people, particularly in Africa, suffer various conditions from eating bitter cassava which contains poisonous cyanogens. As well as poisoning, which sometimes causes death, these conditions include konzo, an irreversible paralysis of the legs, which affects mainly children and young women, impaired neurocognition in children, tropical ataxic neuropathy in older people, and aggravation of iodine deficiency disorders (such as goitre and cretinism) in iodine deficient areas. The wetting method removes residual cyanogens, and is an additional method of processing cassava flour after its preparation by one of the traditional methods. The wetting method is simple and easy to use, the traditional thick porridge (fufu or ugali) made from the treated flour tastes very good, and the method is readily accepted by rural women in East and Central Africa. Regular use of the wetting method by rural women in 13 villages in the Democratic Republic of Congo has prevented konzo amongst more than 9,000 people. We recommend that the wetting method be used as an additional method to traditional methods to remove cyanogens from cassava flour in tropical Africa.

Introduction

Cassava is the third most important food source in the tropics and the staple food of tropical Africa. Cassava:

- is easy to grow,
- produces a good yield of starchy roots in 6-9 months even in poor soils without added fertilizer,
- is drought resistant; the roots are a reserve source of food in drought and famine conditions [1].

However the cassava plant makes cyanogenic glucosides, (linamarin and a small amount of lotaustralin), and the enzyme linamarase, that catalyses their hydrolysis to liberate poisonous hydrogen cyanide (HCN), when the plant is attacked by predators. This defense mechanism is used by more than 2.000 plants to deter predators [2]. If the cassava plant is stressed during drought it makes 2-4 times more cyanogens than normal [3,4]. The cyanogens are present in all parts of the plant, however with 'sweet' cassava the inside of the starchy root has only small amounts of cyanogens. Those cassava cultivars with high cyanide content, called 'bitter' cassava, are dangerous to eat and must be processed before consumption.

Cyanide is extremely toxic to humans, animals, insects and plants. It causes many health problems in Africa, especially where cassava is being introduced into new areas to help feed a rapidly increasing population [1]. There are many traditional methods for processing bitter cassava roots, but these often leave large amounts of cyanogens in the resultant cassava flour [5]. The wetting method [6-8] removes residual cyanogens from cassava flour and should be used as an additional method before the flour is cooked in the traditional way to give a thick porridge called ugali or fufu. This is eaten with a sauce to give it flavor and more nutrients. In this article we propose that the wetting method should be widely used to ensure the safety of cassava flour amongst the cassava eating populations of Africa.

Cassava cyanide diseases

- **Acute cyanide poisoning** from bitter cassava causes dizziness, nausea, headache, abdominal pain, vomiting, diarrhoea, weakness and sometimes death. The lethal dose of cyanide is proportional to body weight, so children tend to be more susceptible to poisoning than adults. There are widespread accounts of acute cyanide poisoning from Asia, the South Pacific and tropical Africa [9].
- **Konzo** is an upper motor neuron disease that occurs mainly in children and young women and is associated with high cyanogen intake amongst very poor people living on a monotonous diet of bitter cassava – which is also deficient in the sulfur amino acids methionine and cysteine/cystine [10,11]. These amino acids are needed to detoxify cyanide to thiocyanate in the body; analysis of urinary thiocyanate gives the best measure of recent cyanide intake. We have found a significant correlation between the percentage monthly incidence of konzo and the percentage of children with high urinary thiocyanate content. Therefore konzo is very likely due to high cyanide/low sulfur amino acid intake from bitter cassava [12].

Konzo occurs suddenly, is non-progressive and produces a visible spastic walk with exaggerated knee and ankle jerks and often impaired vision and speech (Figure 1). Konzo occurs in the Democratic Republic of Congo (DRC), Mozambique, Tanzania, Cameroon, Central African Republic and Angola. Reported cases to 2009 were 6,788 [13], but in DRC alone an estimate made by the Ministry of Health in 2002 was 100,000 [14]. Recently konzo has spread geographically into many new areas [13]. Konzo epidemics occur due to:

- o war, where people are forced to eat poorly processed bitter cassava,
- o drought, when the cassava plant produces increased amounts of linamarin [4], and
- o short cut processing [15].

- **Neurodegeneration of children.** There are reported neuropsychological effects in children exposed to high cyanide intake from bitter cassava associated with konzo. Motor proficiency skills are affected and neurocognition is reportedly impaired compared with children from a non-konzo area [16].
- **Tropical ataxic neuropathy (TAN),** also called "ataxic polyneuropathy," is a neurological disease which generally occurs in older people in Nigeria, Tanzania, Uganda, Kenya, West Indies and South India. Symptoms are burning sensations in the soles of the feet, numbness in hands, unsteady walking, blurred speech, blindness and deafness. The condition is endemic in south west Nigeria and is probably due to long term consumption of cyanogens from gari [17].
- **Aggravation of iodine deficiency disorders** which are caused by reduced production of thyroxin by the thyroid due to deficiency of dietary iodine. Where there is already dietary iodine deficiency, intake of cyanide from cassava exacerbates the disorders [18].

Processing of cassava

Low cyanide sweet cassava can be just boiled and eaten, but higher cyanide bitter cassava roots must be processed to remove cyanogens. Traditional processing methods developed over many years are very diverse, but the major ones used in tropical Africa are:

- **Sun drying.** The peeled root is dried in the sun, then pounded into flour, using a wooden pestle and mortar, and sieved. This method is used widely in East and Central Africa, but leaves about one third of the linamarin in the flour [5].

Figure 1. Boy with konzo supported by his father (credit J. Howard Bradbury).

- **Heap fermentation.** The peeled roots are placed in a small heap on the ground for about 3 days after which the roots are sun dried, pounded and sieved. This leaves about one sixth of the linamarin in the flour [5]. Village women in Mozambique change to this method when cyanide intoxication occurs during drought [4], but this change is insufficient to prevent konzo.
- **Soaking.** The peeled cassava roots are soaked in water in a large vessel or a running stream for 3-4 days. This causes the roots to soften and the enzyme breaks down linamarin and HCN gas bubbles off. The roots are dried in the sun, pounded and sieved to produce flour [19]. This method, used in the wet tropics, removes cyanogens satisfactorily, but if the soaking time is reduced to 1-2 days (called short soaking) cyanogens are only partially removed and cassava flour has high cyanide content [15]. Short soaking can happen if:
  - o there is an urgent need for food for the family,
  - o there is the likelihood that the roots may be stolen from the river, or

o flour is being produced to be sold to traders [20].

- **Gari** is made throughout West Africa, particularly in Nigeria. The peeled cassava root is ground up mechanically and left in a cloth bag for 3 days. The bag is dewatered in a press and the damp product roasted in a metal dish while stirred to prevent burning. The gari contains about 10-20 ppm cyanide, compared with the World Health Organization (WHO) maximum value for cassava flour of 10 ppm. Lactic acid fermentation also occurs during preparation that reduces the pH to about 4.

Figure 2. Sister Mandombi showing Kay Kalenge women how to mix cassava flour with the correct amount of water, the first step in the wetting method (credit Jean Pierre Banea)

Wetting method [6-8]

Cassava flour produced by sun drying, heap fermentation or short soaking nearly always contains more cyanide than the WHO safe level. The wetting method is an additional method to remove residual cyanogens after one of these traditional methods.

The poster on page 24 illustrates the wetting method. Cassava flour is placed in a bowl and the level of the flour marked on the inside of the bowl. Water is added with thorough mixing. The level of the flour initially drops and then rises again to the mark. The wet flour is spread on a mat in a layer not thicker than a finger nail for 2 hours in the sun or 5 hours in the shade to allow the produced HCN gas to escape. This removes nearly all residual cyanogens. The damp flour is then cooked in the usual way.

The wetting method is accepted by rural women because it requires little extra work or equipment and produces fufu that is no longer bitter [21]. The free poster on page 24 (back cover) is available in 13 languages - see http://biology.anu.edu.au/hosted_sites/CCDN/.

Use of the wetting method in DRC

In 2010 the wetting method was taught to the women in Kay Kalenge village, Popokabaka Health Zone, Bandundu Province, DRC, where there were 34 konzo cases (Figure 2). Over the intervention there were no new cases of konzo and the urinary thiocyanate of the school children fell to safe levels [22]. Fourteen months later we found no new cases of konzo in Kay Kalenge, the women were still using the wetting method, the school children had low urinary thiocyanate levels and the wetting method had spread to three nearby villages [21].

When teaching the wetting method, it is important to convince the women that konzo is due to a poison in their cassava, (Figure 2) so that they continue to regularly use it.

We have used the method in DRC villages with over 9000 people. The first intervention took 18 months [22], the second 12 months [20], the third [12] and fourth interventions only 9 months, which has reduced the per capita cost."

The wetting method does not work with gari because of its acidity (pH 4), but if the pH is raised to 4.8 or higher by mixing it with flour or by some other method, then 50% of the cyanide can be removed using the wetting method [23].

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