Working together to eliminate cyanide poisoning, konzo, tropical ataxic neuropathy (TAN) and neurolathyrism

CCDN News

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Editorial

With this December issue of CCDNNews we wish our network members and readers a satisfying and peaceful 2016. The year 2015 has been eventful in several ways and in several parts of the world. Globally, 2015 has also been an exceptionally warm year. The future may explain whether there is a link between global warming, El Niño, droughts and increased risk for neurolathyrism and konzo. Both cassava and grass pea are more tolerant to drought than other food crops. After droughts they are the cheapest food available and become a more important part of the diet of the very poor, making them more vulnerable for neurolathyrism or konzo.

We have no accurate records of new cases in 2015. Also in the literature neurolathyrism and konzo remain neglected diseases. According to the Science Citation Index there were only 3 papers mentioning neurolathyrism and 5 mentioning konzo in 2015. Three of the latter papers are authored by Dr Oluwole, who contributed an interesting review on konzo, neurolathyrism and ataxic polyneuropathy in this issue. When screening the scholar.google database, which is less restricted to higher ranking publications, we find 59 papers on neurolathyrism and 98 on konzo for the same period. The higher number of reports on konzo might be linked to the interest in cassava as the main staple food in sub-Saharan Africa and as an industrial product while grass pea is staple food mainly in the case of food insecurity.

In grass pea growing areas of India and Bangladesh there appear to be no new cases of neurolathyrism when the market value of grass pea seed is higher than the price of rice. If this is confirmed then activities or research that may increase the market value of grass pea or cassava roots can indirectly help in the prevention of neurolathyrism and konzo. This economic aspect may have been overlooked by some. The many questions remaining in the molecular etiology, epidemiology and environmental aspects of the diseases demands further study and investment.

For the breeding of totally toxin free grass pea and more nutritious cassava roots, the potential of genetic engineering should more seriously be considered.

Professor Thorkild Tylleskär informed us on the publication of the second edition of “Neurology in Tropics” (which is on sale) with an updated review on konzo authored by himself and Professor Désiré Tshala-Katumbay. Information of this book can be obtained from Indiacontact@Elsevier.com. Information on the chapter from the authors (Thorkild.Tylleskar@uib.no or tshalad@ohsu.edu).

The website with all issues of CCDNNews has been updated and can be found on http://ipbo.vib-ugent.be/projects/ccdn/ccdn-news

Fernand Lambein and Delphin Diasolua Ngudi

Climate, Konzo, Neurolathyrism, and Ataxic Polyneuropathy

Abstract

Neurolathyrism, konzo, and ataxic polyneuropathy are attributed to exposure to food toxins. Neurolathyrism and konzo are spastic syndromes, while ataxic polyneuropathy is a sensory polyneuropathy. The three neurological syndromes occur in epidemic and endemic forms, but epidemics of neurolathyrism and konzo occur during droughts, while severity of endemic ataxic polyneuropathy changes seasonally. Consumption of *Lathyrus sativus*, a drought tolerant legume, is associated with neurolathyrism, while consumption of cassava (*Manihot Esculenta* Crantz), a drought resistant root crop, is associated with konzo and ataxic polyneuropathy.

Cassava production has been shown to increase during droughts of El Niño. It has also been shown that epidemics of neurolathyrism and konzo lag El Niño. Thus, occurrence of neurolathyrism or konzo depends on the dominant food during drought. Ataxic polyneuropathy remains endemic in parts of Nigeria and India, where consumption of cassava food is high. Food programmes are needed to eradicate these syndromes.

Keywords: El Niño, La Niña, influenza, flu, epidemic, climate

Clinical neurology

Neurolathyrism is a neurological syndrome of spastic paraparesis[1,2], which develops acutely or subacutely in previously healthy subjects. Maximum deficit may, however, take as long as 2–7 months to develop[1,2]. Males are affected predominantly, but male to female ratio vary from 3:1 to 8:1[2,3]. Mortality is not associated. Konzo is a neurological syndrome of spastic paraparesis or quadriparesis, dysarthria, impaired visual acuity, and nystagmus[4,5], which develops acutely or sub-acutely in previously healthy subjects. Maximum disability is reached within a day in 90 % of cases, and within three days in the rest6. Although neurolathyrism and konzo share neurological features and outcome, konzo subjects are predominantly <15 years of age, unlike neurolathyrism with older subjects[4,7]. Further, females predominate in konzo[4,7]. Thus, the lesions of konzo are more extensive than neurolathyrism, and the two differ in age and sex distribution. The neurological features of ataxic polyneuropathy are sensory polyneuropathy, sensory ataxia, neurosensory deafness, optic nerve neuropathy, and myelopathy[8–10]. The natural history of the epidemic form is abrupt resolution, but endemic form worsens progressively, although fluctuations have been noted during rainy seasons. The highest age specific prevalence was 24 % in the 60–69 years age group in women[9]. Mortality in cases was twice that of controls in an endemic community, but five times that of controls in a non-endemic community[11]. Thus, ataxic polyneuropathy differ from both konzo and neurolathyrism in neurological features and outcome.

Epidemiology

Neurolathyrism, konzo, and ataxic polyneuropathy have occurred in disparate geographical regions shown in Figure 1. Neurolathyrism epidemics occurred in France, Germany, Spain, India, and Algeria from early 19th century to early 20th century, and in Bangladesh[12], Afghanistan[13], India[14,15], Nepal[16] and Ethiopia[17] from the late 20th century to early 21st century. Historical records show, however, that neurolathyrism was documented about 500 BC by Hippocrates.

Konzo, which was first described in the late 1930s from the Kahemba region of Bandundu district, DR Congo[18], has occurred in several geographical areas of DR Congo in 1928, 1932 and 1937[19,20], 1978 and1981[21], 1986 and 1996[22,23], and in 2004 and 2005[24,25]. In Mozambique konzo epidemics occurred in 1981[4], 1988 and 1992[26], 1998 and 2005[27,28], while in northern Tanzania konzo epidemcs occurred in 1979 and 1989 in the Tarime District[5,7], and in Mtwara and Mbinga Districts in Southern Tanzania in early 2000s[29]. Konzo epidemics have also occurred in Central African Republic and East Cameroon[30].

Epidemics of ataxic polyneuropathy occurred in lowland and coastal areas of Jamaica[31,32] in 1897 and 1918, while sporadic or endemic cases were reported in Trinidad, Barbados, Montserrat, Antigua, and El Salvador in the 1960s[33]. Cases were also reported in Chinese, Malayan, Indian, and European prisoners in Singapore and Johore in 1935[34], and in India in 1975[35]. Epidemic of ataxic polyneuropathy, and optic atrophy occurred in Cuba between 1991–1994[36], and in Tanzania in 1997[37]. Sporadic ataxic polyneuropathy has been described from Sierra Leone[38], Senegal[39], Liberia[40], and Tanzania[41]. Ataxic polyneuropathy is, however, endemic in southwestern Nigeria[9,42,43], and in Kerala, India[44].

Risk factors

The neurotoxicant of neurolathyrism is β-N-oxalyl-L-α,β-diaminopropionic acid (β-L-ODAP), an amino acid which is present in *Lathyrus sativus* L., a drought tolerant legume that is grown for human food and livestock feeds. Unlike for neurolathyrism, cassava

(*Manihot esculenta* Crantz), is the dominant food during droughts in konzo affected areas[45]. All cassava cultivars contain two cyanogenic glycosides, linamarin [46,47] and lotaustralin [46,48], which are usually reduced to negligible concentrations following different methods of processing. Processing, which is usually inadequate during droughts in konzo affected areas, has been implicated for the presence of high concentrations of cyanogens in cassava foods [27,29,49]. Although cyanide which is released from the cyanogens have been suspected as the neurotoxicant of konzo, the lesions of konzo are not consistent with cyanide poisoning. Putative neurotoxicants of konzo include linamarin [50] the cyanogenic glycoside in cassava, cyanohydrin [51], the breakdown product of linamarin, cyanide [52], which is released from cyanohydrin, and metabolites of cyanide, like thiocyanate, cyanate, and iminothiazolidine-4-carboxylic acid. Cyanate [52,53] and iminothiazolidine-4-carboxylic acid [54] have not been shown in experimental studies to induced lesions consistent with konzo. Thiocyanate (SCN−), the major metabolite of cyanide, which accumulates in supraphysiological concentrations has been proposed the most likely neurotoxicant of konzo [55,56]. Exposure to cyanide from cassava food was proposed the risk factor for ataxic polyneuropathy n 1935[57]. Studies in the 1960s in Nigeria [8,58] and in the early 1970s in Tanzania [59] implicated exposure to cyanide. In the early 2000s evidence of exposure to cyanide was present in the endemic communities in southwest Nigeria [60], but a case control study did not show exposure to cyanide [61]. Global cassava food supply and occurrence of ataxic polyneuropathy and konzo showed that cassava food supply ≥ 180 kcal/person/day was associated with GDP per capita ≤ \$534, $p < 0.0001$, and with occurrence of ataxic polyneuropathy or konzo, odds ratio 19 (95 % CI, 5–70)[62]. In Nigeria consumption of cassava foods in the endemic area was more than twice that of non-endemic areas[63]. The endemic areas co-localized with areas of highest cassava cyanogenicity[64].

Climate, Neurolathyrism, Konzo, and Ataxic Polyneuropathy

El Niño-southern Oscillation (ENSO), which modulates precipitation of most parts of the earth through teleconnections, has been linked to changes in cassava production, and epidemics of konzo and neurolathyrism. Occurrence of neuroathyrism epidemics was associated with El Niño phases of ENSO, odds ratio 378 (95 % 32–4475), while spectral coherence were at 2.0–3.5 and 4.5–5.0 years for ENSO and neurolathyrism $p < 0.0001$. The droughts of El Niños has been proposed to initiate dependence on *Lathyrus sativus*, which exposes the population to neurotoxic β-L-ODAP [65].

A study done to determine the relationship of droughts and cassava production in Tanzania, where konzo occurs, and in Brazil, where there is no konzo showed that warm phases of ENSO and PDO were associated with high cassava production in Tanzania, but with low cassava production in Brazil[66]. It has also been shown that all konzo epidemics of the past century occurred during warm climate regimes[67]. Of 19 warm phases of ENSO from 1974–1996 in DR Congo, 17 were coupled to konzo epidemics, while of 4 cold phases of ENSO, 1 was coupled to konzo epidemic, odds ratio 26 (95 % CI, 2–378). Global spectral of ENSO and konzo showed dominant periodicity of 5 years, while spectograms showed significan periodicities and coherence between 3–6 years. Spatial distribution of konzo is restricted to the area of maximal impact of El Niño on precipitation in Africa[67]

Conclusions

The geospatial distribution of neurolathyrism and konzo in non-overlapping areas during severe droughts can be attributed to differences in the foods on which the population depends for supply of calories Neurolathyrism occurs in areas where the population depends solely on *Lathyrus sativus*, while konzo occurs where the population depends solely on cassava. Strong El Niño induces severe drought and food shortages. Populations that depend on cassava are exposed to cyanide and its metabolites, while populations that depend on *Lathyrus sativus* are exposed to β-L-ODAP. The impact of climate on food and water appear central to epidemics of neurolathyrism and konzo. Although epidemics of ataxic polyneuropathy have occurred in the Carribean and Tanzania, its endemicity appears restricted to geographical areas in Nigeria and Tanzania. High cyanogenicity of cassava cultivars in the endemic area of Nigeria, implies that climate also contributes to occurrence. Public health control of these neurological syndromes, therefore, requires monitoring of climate and food production.

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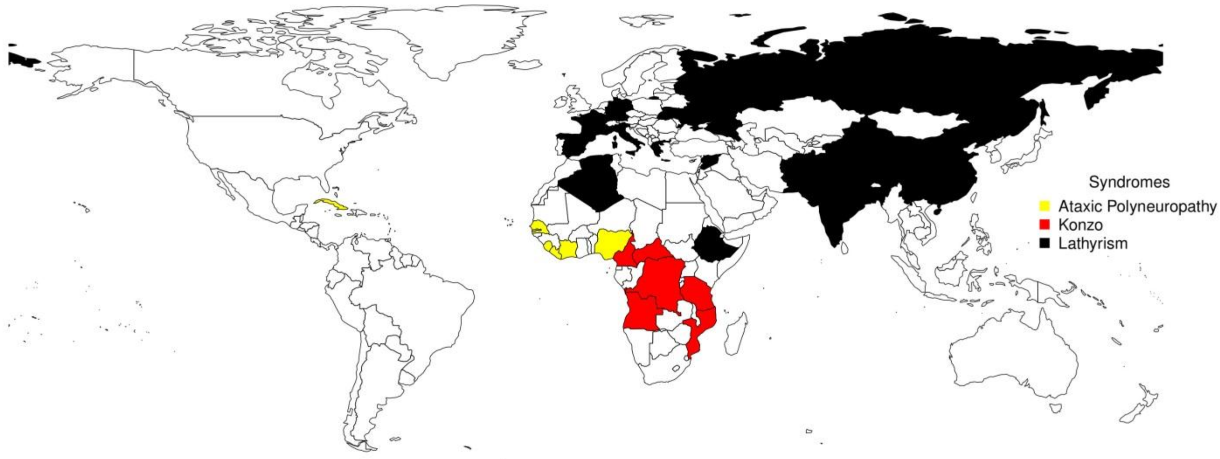

Cassava leaves as an additive (protein source) in fish and goat feed in India

The potential of cassava leaves as a nutrient source in animal feeds has not been exploited. At present the major source of carbohydrate in feeds is provided by cereals, while the protein component is generally provided by animal and fish protein or oilseed cake. The unavailability of these materials and their cost is often a problem in the feed industry and so the use of alternative and cheaper nutrient rich materials can be advantageous.

Cassava leaves have good potential as a livestock feed component. The leaves are a good source of protein and vitamins which can provide a valuable supplement to a carbohydrate diet. The leaves contain approximately 7% protein on fresh weight basis, and 30% on dry weight basis, 10mg carotene and 300 – 500mg ascorbic acid /100g fresh weight, 300mg Ca and 7.6mg Fe /100gdw.[1,2] A major limitation in the use of cassava leaves as food/feed is that they contain cyanogenic glucosides (linamarin and lotaustralin) which by the action of the endogenous enzyme linamarase, releases toxic hydrocyanic acid. The leaves also contain tannins which can interfere with protein digestion. However adequate processing of cassava leaves can reduce cyanoglucosides and tannins to low levels and make them totally safe for human or animal consumption. Cassava leaves can be processed by simple technique (air drying followed by sun drying) to obtain cassava leaf meal containing <10mgcyanide/kg recommended by the Codex Alimentarius Committee of FAO for cassava flour (FAO/WHO 1995)[3] The potential of cassava as a protein rich source can also be exploited by the preparation of leaf protein concentrates which can replace/supplement protein component in feeds. Leaf protein concentrate is an extremely nutritious food made by mechanically separating indigestible fibre and soluble anti nutrients resulting in a product rich in protein, carotenoids, iron and calcium and free from cyanogens.[4,5]

This article highlights the results of investigations on i) cassava leaf protein concentrate as a fish meal substitute in fish feeds using black molly (*poecilia* *sphenops)* as a model and ii) utilization of cassava leaves in animal feed using goats as an experimental model. The studies revealed that both leaf protein concentrate and cassava leaf meal can supplement/partially replace conventional protein sources in these feeds without producing deleterious effects.

i) Evaluation of cassava leaf protein concentrate as a fish meal substitute in fish feeds using black molly (*Poecilia sphenops)* as a model

Leaf protein concentrates (LPC) were prepared from aqueous extracts of fresh cassava leaves with 0.5 - 2% sodium metabisulphite, pH 9.0. The aqueous extract was adjusted to pH 4.0 - 5.0 by addition of acid, and heated to 90^{0}C. The coagulated protein was collected by centrifugation, washed with water and dried. The yield of LPC obtained from cassava leaf was 6.0g/100g fresh leaf. Cassava LPC had a protein content of 52%, cyanogen 4-9ug/g, phenols 1.6-mg/100mg, amino acids 0.7mg/100mg[6]

Cassava leaf protein concentrate (CLPC) was incorporated in ornamental fish feeds and evaluated for its propensity to replace fish meal. The experiment was carried out in the Central Institute for Fisheries Technology, Cochin (Kerala, India). Cassava LPC was incorporated at 0, 10, 20, 30, 40 and 50 percent levels replacing fish meal in the formulations. Black molly (*Poecilia sphenops)* a popular freshwater ornamental fish was chosen as the model fish for testing the acceptability of feeds containing LPC and the resultant growth and longevity.

In a series of six isoproteic (38%) and isocaloric feeds (17-20 MJ kg^{-1}), fish meal content varied from 0 to 50 percent which was replaced with LPC at 10 percent intervals. Black mollies of uniform size (200 ± 15 mg) were acclimatized to the experimental conditions which consisted of 18 glass aquaria (50 L each) in a recirculation system with biological filters. Feeds were produced in a twin-screw extruder with a time-temperature combination for slow sinking pellets of 2 mm diameter which were crushed and sieved to 0.75 mm which is the size appropriate for feeding these fish.

The results showed that the acceptability of the feeds was good. Growth was found to be higher in all the treatments as compared to the control group (fed commercial shrimp feed from Amalgam Nutrients & feeds, Cochin, Kerala) as well as to the LPC0 group, which was a positive indicator. Table 2 shows the weight gain at 30, 60, 90 and 120 days respectively.

On termination of the experiment (120 days), the nutritional optima in terms of growth (weight gain) and specific growth rate (SGR), feed intake, feed conversion ratio (FCR) was observed to be with a feed containing 20 % LPC. It was concluded that cassava leaf protein concentrate could replace the fish meal component in feed in black molly ornamental fish without deleterious effects. The optimum performance was observed for 20% replacement of fish feed by cassava leaf protein concentrate

Table 1. *Proximate composition of the feeds*

Proximate composition of the experimental feeds (% dry on matter basis)						
Feed identity	**CP**	**EE**	**NFE**	**CF**	**Ash**	**AIA**
LPC 0	39.17	9.78	31.37	0.73	18.95	1.07
LPC10	38.85	9.91	32.99	0.95	17.30	1.11
LPC20	38.57	10.72	34.82	1.00	14.90	0.84
LPC30	38.90	10.97	37.01	0.49	12.63	0.55
LPC40	38.16	11.87	38.36	1.63	9.98	0.46
LPC50	38.85	12.69	39.60	1.13	7.73	0.46

CP-Crude protein (Nx6.25), EE-Ether extract, NFE-Nitrogen free extract, CF-Crude fiber and AIA-Acid insoluble ash.

Table 2. *Growth of black molly (Poecilia sphenops) in 120 days on feeds containing ascending levels of LPC*

		LP C0	LP C1 0	LP C20	LP C30	LP C40	LP C50	Con trol
Weight gain 30 days		400	466	300	350	283	211	66
	SE	±21	±17	±17	±15	±13	±16	±15
Weight gain 60 days		561	655	450	500	444	455	222
	SE	±26	±25	±16	±36	±23	±19	±21
Weight gain in 90 days		761	850	827	722	650	550	350
	SE	±63	±73	±70	±62	±54	±57	±34
Weight gain in 120 days		944	966	1144	1050	827	711	477
	SE	±21	±23	±21.	±26	±23	±17	±21

ii) Nutritive evaluation of cassava leaves in animal feed using goats as an experimental model.

Fresh cassava leaves were processed into leaf meal. The upper leafy portion of cassava stems from 10 month old cassava plants was harvested and allowed to dry in the shade for 24 h. The leaves were then detached and dried again for 24 h – 48h. The dried leaves were then coarsely powdered. Dried cassava leaves contained 28% protein, 7.0% crude fibre, cyanogen (range 60 – 200ug/g DW) total carotene content was 25 - 30mg/100g DW, phenols 3-6 mg/100mg, amino acids 1.8mg/100mg and phytin 160mg/100g.

Sixteen Malabari goat kids of 3 - 4 months age were selected from the KVASU Goat farm and were fed for 3 weeks with normal goat feed and green forage which served as the control period. After three weeks of feeding the kids were divided into four groups of 4 animals each in such a way that the average body weight of all the groups were similar. The four groups were allotted four dietary treatments designated as A, B, C, D where cassava leaf meal constituted 0, 10, 20 and 30% of the ration, respectively.

The composition of the different feeds is indicated in Table 3. The four groups were fed with 2 kg concentrate and 4 kg of green fodder daily

Table 3. *Composition of different feeds*

Ingredients	Ration – A	Ration – B	Ration-C	Ration – D
Maize	30 parts	30 parts	30 parts	30 parts
Wheat Bran	38 parts	33 parts	30 parts	18 parts
Gingelly oil cake	30 parts	25 parts	18 parts	20 parts
Cassava leaf meal	------	10 parts	20 parts	30 parts
Mineral Mixture	1.5 parts	1.5 parts	1.5 parts	1.5 parts
Salt	0.5 parts	0.5 parts	0.5 parts	0.5 parts

Table 4. *Body weight recorded on fortnightly basis*

	Experimental period			
	Body Weight (kg)			
Treatments	Control period	1st fortnight	2nd fortnight	3rd fortnight 6th fortnight
I (control)	9.5	11.25	13.75	16.25 18.25
II (10%)	9.75	11	13.5	18.0 18.75
III (20%)	9.25	11.25	15	17.5 18.25
IV (30%)	9.25	10.75	13.5	16.75 18.50

The results showed that the groups fed with cassava leaf responded satisfactorily. There was similar weight gain in animals fed with control feed and 10 - 30% cassava leaf. The acceptability of the feed was good, even up to 30 % replacement. Cassava leaf meal was also observed to possess anthelmintic properties, which was a beneficial attribute that however needs further study. It was concluded that cassava leaf meal could be incorporated at 30% level in goat feed without deleterious effects .

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Cassava plantation, consumption and post-harvest processing in Ethiopia

Overview of cassava in Ethiopia

The introducer of cassava in Ethiopia is not well identified. Some authors say cassava was first introduced by the British [1, 2],others say a man called *Grazimach* Damite Dawe, an Aristocrat land lord of *Buriji* introduced cassava from Kenya in 1948 [3]. Although there is a lack of reliable statistical and empirical evidence on the area and production of cassava in Ethiopia, the crop has been in cultivation, particularly, in South, south west, and Western parts of Ethiopia since its introduction [1] (**Figure 1**). Ethiopia with its diverse agro-ecologies and suitable environments, allows the growth of numerous root and tuber crops by smallholder farmers particularly in the southern parts of the country [4].

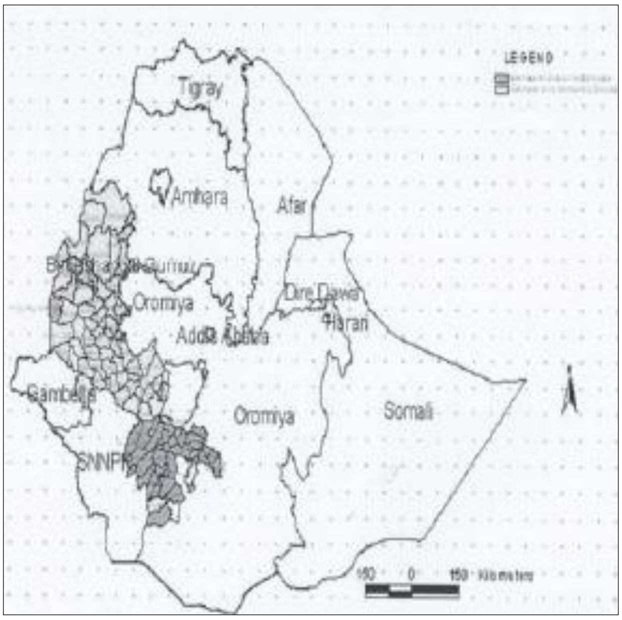

Figure 1. *Pictorial representation of cassava growing regions of Ethiopia*.

Cherinet, et al. [5] reported a study in 3 villages (Kodowono, Lotte and Woidewashe) of Gamo-Gofa region and indicated that total goiter rate increased with increasing rate of cassava consumption. Therefore, goiter prevalence and health problems attributed to cassava consumption necessitate an intervention program to control iodine deficiency disorders by developing appropriate processing techniques to eliminate cassava toxicity and educate villagers on how to prepare safer meals from cassava and also on reduction/elimination of inherently found toxicants such as cyanide and other anti-nutritional factors.

Cassava production in Ethiopia

Cassava is perennial root crop grown almost anywhere in areas between the latitude of 30^{o} N and 30^{o} S of the equator. Ethiopia is located within the cassava growing latitude, and it is introduced in Ethiopia in the middle of the nineteenth century [1, 3]. Grown and adapted in some areas of an altitude range of 400-1800 m.a.s.l., annual temperature of 15-30^{o} C and rainfall of 600-1500 mm [1]. The range of indigenous tuberous vegetables available to the country is extremely small. Those were about 0.7 million tons of root and tuber crops estimated to be produced annually [6]. Even though the total cultivated and produced amount of cassava in Ethiopia had not been recorded, estimated yields from 2003/4 to 2010/11 for eight years were reported by the SNNPRS region agricultural Bureau as indicated in **Figure 2.** The highest production had been estimated at 2.5 Million Quintals in 2010/11 from 12,812 hectares of cultivated land. Generally, the data show increasing yields from year to year.

Presently, cassava is planted in the northern parts of the country although the growers are not yet acquainted with the utilization of the crop [7].Since cassava is not a priority crop for research, very few attempts were made in the past years on adaptability, yield potential, variety trial, spacing trial & harvesting trials and only some preliminary data have been obtained. Over twenty local and identified cultivars that vary in their morphology, agronomic characters and cyanogenic glucosides content are cultivated in the research center and some regions of Ethiopia [1]. It is not popular due to its poor food value, lack of knowledge in its preparation and the presence of toxic substance in some cultivars. Consumption of insufficiently processed cassava roots resulted in health complaints [5].

Using cassava as food security crop in Ethiopia

Agriculture is the backbone of Ethiopia's economy. It contributes about 50% of the gross domestic product (GDP), 60% of exports, provides a livelihood for 85 % of the total population and generates nearly 90 % of foreign exchange earnings. Nevertheless, the country continues to suffer from serious food shortage and recurrent drought. The majority of the Ethiopian population depends mainly on cereal crops as their main food source. The food potentials of most horticultural crops particularly that of root and tuber crops like cassava have not been fully exploited and utilized, despite their significant contributions towards food security, income generation and resource base conservation.

Therefore, cassava is among these important crops that could greatly alleviate seasonal food shortage and help the country in achieving food security [8]. In Ethiopia, cassava is cultivated extensively in densely populated and low rainfall areas of the south and south western parts of the country [4] where it is an important food source and plays critical roles in rural diets among the communities [3, 9]. In some cases, it fills food shortage gaps during the months when maize and other foods run short and in years of drought [10]. A preliminary survey, which involved the special woreda's Konso and Amaro, showed that the consumption of cassava is high among low-economic families [7, 11]. One of the main problems with cassava consumption is the lengthy and tedious method required to process it, particularly the types which contain toxic substances [11, 12]. To alleviate the toxicity problem blending the cassava flour to other protein foods crops/cereals have also advantage [13, 14].

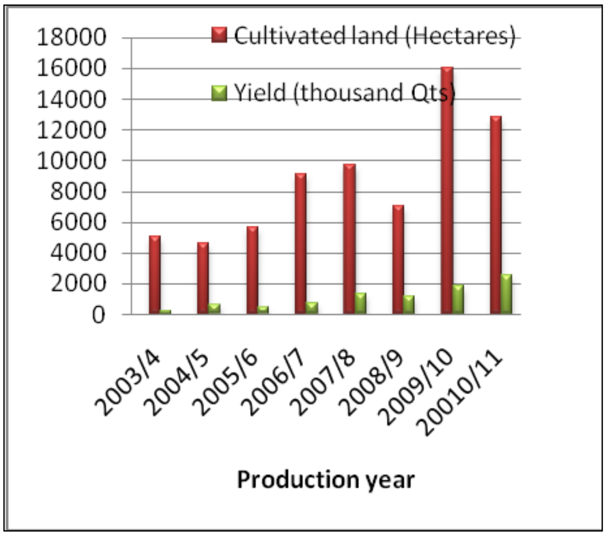

Figure 2. *Eight years estimated cassava roots cultivated land in hectares and production in quintals. Source: from yearly (2003/4-2010/11) SNNPRS Agricultural Bureau reports.*

Postharvest practices of cassava roots

The food potentials for most ''horticultural'' crops in particular root and tuber crops like cassava have not been fully exploited and utilized, despite their significant potential as food security crops, for income generation, and as resource base conservation [2, 8, 15]. The most common post-harvest techniques of cassava consuming area of Ethiopia were peeling, boiling, grating or manually chopping, sun drying, crushing by stone grinder and then fermenting, and grinding or changing to flour by pestle and mortar in the rural area of southern part of the country [7,16, 17]. The most common utilization of cassava roots as food was mixing with cereals to make injera or bread, or using the flour for preparing alcoholic drinks/beverages (local drink name *Tella and Arake*). The roots were peeled and boiled then served with spices for breakfast or snack foods. It is also used to make a stew with common beans, cabbage or kale and spices for eating with injera or flat-bread. Furthermore the powder is used for preparing porridge or gruel by mixing with cereal or legume.

In Ethiopia, cassava is cultivated extensively under sub-optimal conditions in densely populated and low rainfall areas of the Southern parts of the country, although it is an important food source among poor communities and plays critical roles in rural diets. As an underutilized crop of the country, cassava needs better consideration to develop the full potential of this crop. Some of the industrial uses of this crops like starch extraction (textile, glue), ingredients for confectionery, ethanol production, etc. are yet untouched.

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