

The biochemical effects on occupational exposure of workers to HCN in cassava processing industry

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Abstract: This study focuses on the impact arising from the cassava production and processing at Salem District in Tamil nadu. The outcome of the study reveals that the workers complained of headache, dizziness on continuous exposure to food HCN. Hence, further investigations oriented towards the biochemical parameters that are related to cardiovascular and other effects. It is done with the liver enzymes, blood glucose, creatinine and total protein. The outcome of the investigation suggested that impairment in energy metabolism linked to thyroid dysfunction as cyanide interferes with Iodine uptake.

Introduction

Cassava is an important raw material for the starch and sago industries and established in Salem and Dharmapuri District of Tamil Nadu. About 650 to 700 units are engaged in cassava processing in Salem District (Tamil Nadu State). Tapioca Sago production is one of the major food industries in Southeast Asia. The Sago industry is an agro based seasonal industry using cassava root as the basic raw material. Currently the plant is cultivated in about 90 countries throughout the world. In Tamil language it is called 'Maravallikizhangu' whereas in Malayalam language it is known as 'kappa'. Its scientific name is *Manihot esculenta* Crantz. Tapioca grows naturally in Central and South America. Tapioca was introduced in India by the Portuguese during 17th century particularly in Kerala. There is about 30 to 35 percent starch content in cassava. World production of cassava root was estimated to be 184 million tonnes in 2002. The majority of production is in Africa where 99.1 million tonnes were grown, 51.1 million tonnes were grown in Asia. India is one of the leading countries in cassava production.

Cassava an important staple food contains cyanogenic glycosides. The potential toxicity of cyanogenic plant depends primarily on its consumption, which will produce HCN that is toxic to humans. When the edible parts of plants are processed the hydrogen cyanide is released (Oke, 1979, 1980). In human the HCN is detoxified by rhodanase forming thiocyanate and excreted in urine (Lang, 1933; TRS, 2004). The detoxification requires sulfur donors such as dietary sulfur containing aminoacids (Lang, 1933). By adequate processing the hydrogen cyanide content in the cassava product may be reduced thus significantly

reducing the potential health hazard (Vetter, 2000). The other aspect is the processing of plants containing cyanogenic glycosides, which can leads to HCN consumption.

There are several minor reactions that detoxify ingested cyanide.

- 1) Reaction with cystine to form iminothiozolidine compound that is excreted through saliva or urine.
- 2) Minor amount may be converted into formic acid and excreted in urine.
- 3) Cyanide may combine with hydroxyl cobalamin (vit. B₁₂) and excreted in urine and bile.

Thus the detoxification of HCN is influenced by the nutritional status, especially of B complex vitamins like riboflavin, B₁₂, and sulphur containing aminoacids provided by a good quality protein (Bradbury & Holloway, 1988; TRS, 2004). Now the processing includes processes to eliminate the HCN content, so consumption of processed material reduces the toxicity of HCN. However the process involves production of HCN to which the factory workers are exposed. Mostly the workers of cassava industry are from low economical status; hence the present study is taken how well they can combat the reported effects of chronic exposure to HCN such as neurological, respiratory, cardiovascular and thyroid defects (Blanc *et al.*, 1985; Rosling, 1994).

Objectives

The main objective of the study is to analyse the health impact of HCN of cassava processing industry workers.

Area of the Study

Salem is one of the major city is involved in Cassava Processing, producing sago and its products. Presently about 650 to 700 cassava processing units are functioning in and around salem. The present study was done at Rakkipatti village. This village is placed in perumagoundampatti post, Salem District. Rackipatti is situated 22 Km from west side of the Salem city with a population of 5686 (Male-2894, Female-2792). Out of this 40% of them are involved in cassava processing. Hence the present study is to find the biochemical effect on exposure of HCN among workers in Cassava industry.

The properties of HCN present in cassava

Hydrogen cyanide is a potent metabolic poison. One key food plant that contains significant amounts of cyanide is cassava. HCN is a small

molecule composed of a carbon and nitrogen atom joined by a stable triple bond. This poison is best known for its inhibition of many enzymes that are important in metabolism.

Several factors are important in this toxicity. The first aspect is the processing of plant products containing cyanogenic glycosides when the edible parts of the plants are macerated, the catabolic intracellular enzyme beta -glucosidase can be released, coming into contact with the the glucosidase this enzymes hydrolyses the cyanogenic glycosides to produce hydrogen cyanide and glucose and ketones.

The second aspect is the direct consumption of the cyanogenic plant. The third aspect is that the cyanogenic glycosides taken up in fact with the food are hydrolysed by the β-glucosidase activity of the bacteria of the flora of humans (Conn, 1979 a,b; Oke, 1979, 1980; Nartey, 1980; Rosling, 1987).

Linamarin is chemically similar to glucose but with cyanide attached which is present in cassava plant. When the plant tissue is damaged rupture of the vacuole release a cell wall associated beta glycosidase hydrolysis of linamarin yield an unstable hydroxyl nitrile intermediate, acetone cyanohydrin, plus glucose. Acetone cyanohydrin spontaneously decomposes to acetone and HCN at PH> 5.0 (ATSDR, 2006).

The inadequately processed cassava food may pose threat of being exposed to potential hydrogen cyanide. Upon consumption of a cyanogenic plant, β-glycosidase will be released during digestion and remain active until deactivated by the low pH of the stomach. This enzyme will hydrolyse the cyanogenic glycoside and release at least part of the potential hydrogen cyanide content of the plant (WHO, 1993).

The possibility of exposure to HCN as occupational health hazard to workers in cassava based factories

Several reports indicate that chronic low exposure to HCN can cause neurological, respiratory, cardiovascular, and thyroid effects and as long term exposure to inhaled cyanide produces CNS and thyroid effects (Chandra *et al.*,1980; Blanc *et al.*, 1985).

The biochemical and toxicological effects of occupational and dietary exposure of humans to cyanide poisoning from large-scale cassava processing and ingestion of cassava foods were investigated using spectrophotometric and enzymatic methods (Okafor

PN, Okorowkwo CO and Maduagwu EN, Department of Biochemistry, College of Medicine, University of Ibadan, Ibadan, Nigeria, available online 7 June, 2002). The samples from exposed people were subjected to various tests for urinary and serum thiocyanate, alanine aminotransferase (ALT) and alkaline phosphatase, total protein, serum albumin and creatinine levels.

Exposure to HCN during factory processing

Conventional processing usually involves peeling and grating and then soaking in warm water for several days. This allows the cassavas own natural enzymes to convert the linamarin to glucose and hydrogen cyanide gas.

Materials and methods

Empirical study is based on both primary data

Table 1. Clinical symptoms with various combinations

Clinical symptoms	No.of workers
Head ache + Eye irritation	10
Eye irritation + Dizziness	1
Head ache + Eye irritation + Dizziness + Vomiting + Chest pain	1
Vomiting	1
Head ache + Eye irritation + breathing difficulties	3
No symptoms	4

Source: Primary data

and secondary data. While the secondary data are to large extent documentary the primary data have been collected on an interview schedule. The problem of the cassava industrial workers health problem was approached by fielding-separated questions. The interview schedule included information such as age, sex, habits, family history and health problems of the workers. The interview schedule completed coded and subsequently transported to a database by clinical system of workers were taken blood parameters studied with fasting blood sample.

This study includes 20 workers from the cassava industry along with an age matched control group. By a questionnaire the clinical symptoms of workers were taken. The following blood parameters are studied with fasting blood sample with standard methods (Young, 1997;

Table 2. Comparison of FBS, total protein, AST, ALT and creatinine between cassava workers and control

Parameters	Control	Workers	p value	Significance
Blood sugar (mg/dl)	80 ± 9.7	82 ± 9.1	0.6998	----
Total protein (gm/dl)	6.9 ± 0.38	7.2 ± .49	0.0750	----
AST (IU/L)	23 ± 6.3	31 ± 14.9	0.0468	Marginal
ALT (IU/L)	24 ± 6.4	26 ± 11	0.5070	----
Creatinine (mg/dl)	0.97 ± 0.15	1.1 ± 0.23	0.0280	Significant

Source: Primary data



Schumann *et al.*, 2002): Blood sugar, ALT (Alanine Transaminase), AST (Aspartate Transaminase), Serum Total protein, Total cholesterol, Triglycerides, HDL cholesterol and Creatinine.

Results

About 80% of the workers complained of headache/ dizziness/ vomiting/ eye irritation/ breathing difficulties and chest pain in various

combinations, as reported earlier 20% of the workers had no complaints (TRS, 2004; Rosling, 1994; Chandra *et al.*, 1980).

Table 2 represents comparison of biochemical parameters between cassava workers and controls. The mean value of cholesterol, Triglyceride, high-density lipo protein, very low-density lipo protein, Aspartate transaminase and creatinine is increased in cassava workers, when compared with control group. Data were expressed in Mean \pm SD for 20 workers and 20 controls.

1. The mean value of blood sugar is comparable to the control group because hydrogen cyanide inactivates many metallo enzymes. It shifts the aerobic metabolism to anaerobic metabolism due to decrease in ATP /ADP Ratio (ATP-adenine tri phosphate, ADP-adenine di phosphate). Thus it activates glycogenolysis, which is responsible for maintaining the blood glucose levels (Blanc *et al.*, 1985).
2. Total protein and alanine transaminase values are within the normal range suggesting liver function is not altered.
3. The mean value of aspartate transaminase is within the normal range but however on increase that shows marginal significance in cassava workers is observed (P=0.05). The previous studies have also reported an increase in AST. AST is a marker enzyme for myocardial infraction (Okafor, 2002).
4. Though the creatinine level is with in the normal range for the workers a significant p value (0.0280) is seen in cassava workers when compared to the control group.

Table 3 represents the lipid profile of cassava

Table. 3 Lipid profile of cassava workers and control

Parameter	Control	Workers	p value	Significance
Cholesterol (mg/dl)	167 \pm 16.6	200 \pm 48.65	0.0123	Significant
Triglycerides(mg/dl)	121 \pm 29	219 \pm 82	0.0001	Significant
HDL(mg/dl)	39 \pm 3.4	45 \pm 7.6	0.0065	Significant
LDL(mg/dl)	101 \pm 15	109 \pm 37	0.4009	-----
VLDL(mg/dl)	20 \pm 3.0	45 \pm 15.2	0.0001	Significant

Source: Primary data

workers and control:

1. The mean value of cholesterol is with in the normal range but significant increase is seen in cassava workers compared to the control group.
2.
 - i. The marked increase of TGL (Triglyceride) is seen in cassava workers. This is due to HCN, which decreases Glycolysis inhibiting TCA (Cycle-Tricarboxylic acid cycle) Cycle (Tri Carboxylic Acid Cycle) and the energy availability in the cells. Moreover it shunts glucose to HMP (shut-Hexose Mono Phosphate shunt) Shunt. Hence the sugars are converted to TGL endogenously (Blanc *et al.*, 1985).
 - ii. TGL level may also increase by Insulin resistance. Hence the present study is in agreement with earlier study that one of the toxic effects of HCN is Diabetes Mellitus (TRS, 2004).
 - iii. TGL may also increase in impaired thyroid function. A triglyceride level of 200 mg / dl are more is an increased risk factor for heart disease Studies have linked that high blood level of TGL to an increased risk of stroke (Antonio,1998).
3. Though significant increase HDL (High Density Lipo Protein) value is seen in cassava workers this is not a good indicator when compared with TGL/HDL ratio which is given in 3 Table
4. LDL is with in the normal range. The main function of low-density lipoprotein is to transport cholesterol from liver to other tissues. The cholesterol value of cassava worker is normal, so the LDL formation is also normal in cassava workers.
5. The significant increase of VLDL is seen in cassava workers when compared to control. The main function of very low-density lipoprotein is transport of endogenously synthesized Triglycerides. In cassava workers TGL level is increased so the VLDL synthesis also increased.

It is shown that TGL/HDL ratio is a more accurate predictor of heart attack than HDL/LDL ratio. The TGL/HDL ratio (Gohoam,1998) of workers 4.9:1 is higher than the control value 3.1:1 while the HDL/LDL ratio is the same for both control group and the workers. The Higher (4.9:1) TGL/HDL ratio cassava workers predict higher risk for heart diseases (Table 4)

Conclusion

The present study is a preliminary study. However the early symptoms and an increase in TGL



Table. 4 TGL/HDL ratio

	Ratio of TGL to HDL	Ratio of HDL to LDL
Control	3.1 : 1	1 : 2.6
Test	4.9 : 1	1 : 2.4

Source: Primary data

suggest a defect in energy metabolism, which may be overcome by routine blood tests and supplementation with vitamins like Riboflavin, vitamin B₁₂, and good quality proteins. Further study on the thyroid hormones and regular lipid profile test and enzyme tests (AST, ALT) may throw more light on the toxic effect of chronic exposure to HCN and help in developing protective steps.

Abbreviations

HCN-hydrogen cyanide, ALT-alanine transaminase, AST-aspartate transaminase, VLDL-very low density lipo-protein, LDL-low density lipo-protein, FBS-fasting blood sugar, CHO-cholesterol, TGL-triglyceride, HDL-high density lipo-protein, TP-total protein, P Value-probability value, HMP shunt-hexose mono phosphate shunt, TCA Cycle-tricarboxylic acid cycle. TRS - Technical Report Series.

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