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Chronic Cassava Toxicity

Proceedings of an interdisciplinary workshop
London, England, 29-30 January 1973

Editors: Barry Nestel and Reginald MacIntyre



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Cyanide Toxicity in Relation to the Cassava Research Program of CIAT in Colombia

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Abstract Despite the fact that an estimated 8-10% of the global daily caloric needs of man are supplied by cassava, the crop has not been subjected to any concentrated research effort to advance the technology of its production. A serious shortage of calories in the tropics is noted and in response to this need, CIAT has undertaken a full-scale program to develop cassava as an efficient producer of calories for human consumption, as well as for the growing animal feed and industrial starch markets. CIAT research concentrates on increasing yields, lowering production costs, and developing simple storage and processing methods.

The importance of cyanide toxicity is noted as is CIAT's intention to screen its large germ plasm collection for a cultivar with a zero or very low cyanide level. However, CIAT does not intend to carry out research to develop methods of detoxification.

Relationships between cassava cyanide content and nitrogen fertilization are discussed as well as the affinity of certain insect pests to secondary chemicals associated with the cyanide.

Résumé En dépit du fait qu'environ 8-10% des calories requises chaque jour par le monde entier proviennent du manioc, cette culture n'a jamais été l'objet de recherches concertées en vue d'en améliorer les techniques de production. Réalisant les déficiences sérieuses de calories dans les régions tropicales, le CIAT a mis sur pied un programme complet visant à développer le manioc comme source efficace de calories, tant pour la consommation humaine que pour répondre aux exigences de marchés toujours croissants de moulées à bétail et d'amidon industriel. Le CIAT oriente ses recherches vers l'augmentation des rendements, l'abaissement des coûts de production et le développement de méthodes simples d'entreposage et de traitement.

L'auteur note l'importance de la toxicité du cyanure, et fait part de l'intention du CIAT de trier sa volumineuse collection de plasmas germinatifs en vue de sélectionner une variété à teneur nulle ou faible en cyanure. Cependant, le CIAT n'a pas l'intention de poursuivre des recherches dans le but de développer des méthodes de désintoxication.

Il examine les relations entre le contenu en cyanure du manioc et l'emploi de l'azote comme engrais, de même que l'affinité de certains insectes nuisibles pour les substances chimiques secondaires associées au cyanure.

THE number of people in the world dependent on cassava as a staple food is not accurately known. Estimates vary from 200 million (Coursey and Haynes 1970) to 300 million (FAO 1968). Hendershott et al. (1972) estimated that cassava

alone contributes 8-10% of the daily global caloric needs of man. Cassava, unlike the other main carbohydrate producers, wheat, maize, rice, and potatoes, is grown almost exclusively (97%) in the tropics (Gutierrez and Andersen 1972).

Because of this, cassava has not received the concentrated attention from scientists in the developed countries and hence the technology associated with its production is not advanced. This does not imply that the scientists in the developing countries have not applied themselves to the task of advancing this technology; in fact, a great deal of practical and useful knowledge has been compiled, notably in Brazil. However, there has never been at any one time a sufficient concentration of effort and resources to gain the knowledge of the plant required to really advance the technology. An example is thrips (*Euthrips* spp.) infections which we found causes damage very similar to "witches broom," a mycoplasma disease; the symptoms of this infestation have apparently never been attributed to this insect in the past.

Nevertheless, in spite of this general lack of knowledge cassava has often been quoted as a potentially efficient producer of calories. De Vries et al. (1970) suggested, after reviewing productivity of various crops, that cassava is probably potentially the most efficient calorie producer of the major crop species. Recently, there has been a tendency to regard protein as the major nutrient need of tropical zones. Although protein is very important, it should also be noted that there is a serious shortage of calories. Gutierrez and Andersen (1972) estimate that only 68% of the required calories are at present available in the tropics. When viewed in the light of the alarming increases in population, it seems evident there is a great need for an efficient producer of calories. Cassava can also be used as an animal feed or as a producer of starch for industrial use.

CIAT Program

The CIAT Board of Trustees approved a full-scale cassava program in CIAT in June 1971. This program has as its objectives: 1) to gain more knowledge on methods of production and utilization of cassava, and 2) to train people to adapt these methods to their own locality and to train people to spread this knowledge. CIAT recognizes that there are many problems associated with both production and utilization of cassava; the major ones as seen by us are: 1) Low yield; 2) High production costs; 3) Deterioration in storage; 4) Toxicity; 5) Low nutritional quality as a food; and 6) Lack of general information.

CIAT is concentrating its research efforts on increasing yields, lowering production costs, and simple on-farm methods of processing (e.g. drying), and storage. Although, of course, the importance of cyanide toxicity is well recognized it does not form a major part of the CIAT Cassava Program.

Implications of Cyanide

The problem of cyanide toxicity as a factor limiting utilization of cassava is very important. At present most cassava produced is for direct human consumption and undoubtedly most will be consumed by this group for some time to come. Philipps (personal communication CIAT-Guelph economic studies) has tentatively suggested that in the future there may be greater consumption of cassava in the livestock industry, particularly if production costs can be lowered and a better-quality dried product produced. Therefore the toxicity problem cannot be ignored if cassava is to make up a large portion of animal feedstuff, and the future potential of cassava for industrial use is to be realized. However, in the latter case high cyanide levels do not seem to be of importance. In fact, Holleman and Aten (1956) suggested that high cyanide content may be advantageous since it prevents stealing of the fresh roots from the field.

There is sufficient evidence being compiled (Ekpechi et al. 1966; Osuntokun et al. 1969; Makene and Wilson 1972) to suggest that chronic cyanide poisoning is of great importance in areas where cassava constitutes a major portion of the diet. At present CIAT does not have sufficient expertise to study this subject and also that of methods of detoxification.

Nevertheless, we recognize the need for research on these problems. CIAT probably has the largest collection of cassava germplasm in the world. This collection will be screened for types of low toxicity. Before this is undertaken it is necessary to know if the effects of cyanide toxicity are solely due to cyanide residues in the material to be eaten, or if they are also associated with hydrolysis of glycosides by acids or enzymes present in the human alimentary tract. Montgomery (1969), in a review of cyanogens, stated that the "ultimate fate of ingested cyanogenetic glucoside remains unknown, and it may quite possibly lead to an appreciable increase in the body's cyanide or

thiocyanate pool." Charavanapavan (1944) reported the death of rabbits after feeding an aqueous solution of the cassava glucoside free of enzymes.

Makene and Wilson (1972) have suggested that the levels of linamarin in varieties should be reduced. Hence, it seems necessary to screen varieties both for low cyanide and low linamarin content, with the possibility of finding either a zero-cyanide or zero-glucoside variety. For example, in white clover (*Trifolium repens*) different types have been found containing: a) lotaustralin and linamarase, b) linamarase only, c) lotaustralin only, and d) neither lotaustralin nor linamarase. The presence of both the enzyme and the glucoside is controlled by different dominant genes (Corkill 1942). Bolhuis (1972) at a Cassava Program Review Conference in CIAT reported a zero-cyanide variety which unfortunately was lost during World War II. It is not known whether this zero-cyanide variety was due to a lack of enzyme or glucoside or both. However, it encourages us to search for a zero-cyanide variety and even if this ultimate goal cannot be achieved there is very large variation in the cyanide content of different clones of cassava from which low-cyanide types can be selected (Monclova 1936; Bolhuis 1954; Pereira et al. 1960; Chadha 1961; Pereira and Pinto 1962; Wood 1965; Barrios and Bressani 1967; Bostero 1968; de Bruijn 1971).

The means of screening these varieties for low-rather than zero-cyanide content depends on adequate testing techniques. Cyanide content apparently does not vary much with the age of the plant, but varies with mineral nutrition (nitrogen increases and potassium decreases the cyanide levels), shading of the plant, and water stress (de Bruijn 1971). In spite of variations due to climatic conditions the CIAT collection can be screened crudely to find potentially low-cyanide types without regard to these factors. These low-cyanide types can then be studied in more detail.

It is unfortunate that increasing levels of nitrogen fertilizer increase cyanide levels (de Bruijn 1971) as improvement of cultural practices will almost certainly be associated with the use of more nitrogen. The use of this technology should not be relinquished so as to lower levels of cyanide.

Although Holleman and Aten (1956) suggest that bitter varieties are higher-yielding than sweet ones there appears to be no strong evidence to suggest that this is universally true. We believe

that high-yielding sweet varieties can be obtained, since two of the most promising lines being tested at CIAT, M Col 22 and Llanera, have HCN levels of 60–80 ppm.

It has been suggested that the high cyanide level in cassava may be correlated to insect resistance (Hendershott et al. 1972). However, in a general review of plant resistance to insects, Beck (1965) suggests that secondary chemicals, such as the glucosides, may actually act as attractants or stimulants to the insect pests. In the case of the Mexican bean beetle (*Epilachna varivestris*), lotaustralin and phaseolutin act as feed attractants and stimulants (Nayar and Fraenkl 1963). It is then possible that by breeding for very low or zero cyanogen levels the insect resistance of these plants might actually be enhanced. Hence, we do not feel that the requirements of low or zero cyanogen are conflicting with high levels of insect resistance.

One can only speculate on the effects that cyanogens may have on disease resistance. However, so far at CIAT there seems to be no obvious difference in resistance between clones with different cyanide content.

Conclusions

In conclusion, CIAT is looking for low or zero cyanide or linamarin varieties of cassava to be used in its breeding program so as to eliminate the problem of chronic toxicity. We do not feel that changes in cultural practices can usefully be utilized to reduce cyanide levels. CIAT will not search for new or improved methods of detoxification or attempt to investigate the mechanisms of toxicity. Nevertheless, the program is very dependent on gaining further knowledge especially concerning whether linamarin and lotaustralin are themselves toxic or only in the presence of linamarase, in order to clarify its selection criteria.

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