POST-HARVEST PROBLEMS OF THE YAMS (*DIOSCOREA*)

— *by* —

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Introduction.

Yams are major food crops in many tropical countries. The name "yam", although often applied to other tropical "root" crops, such as the sweet potato, correctly refers to the edible tubers of members of the genus *Dioscorea,* the principal genus of the family. Dioscoreaceae of the monocotyledonous Order, Liliales. The principal edible species are:—

D. alata L.	The Greater, Water or Winged Yam	(S.E. Asia)
D. rotundata Poir.	The White or Guinea Yam	(W. Africa)
D. cayenensis Lam.	The Yellow of Guinea Yam	(Africa)
D. opposita Thunb.	(=*D. batatas* Decne) The Chinese Yam	(China)
D. esculenta (Lour.)	Burk. The Lesser Yam (often known as Chinese Yam)	(S.E. Asia)
D. bulbifera L.	The Aerial or Potato Yam	(Africa and Asia)
D. trifida L.	The Cush-cush or Yampi	(Tropical American)

but numerous other species are utilized for food to a minor degree (Cobley, 1956; Coursey, 1965; 1967 b; Waitt, 1963). Other species are of use for the production of steroids for pharmaceutical use.

World production of food yam is of the order of 20 million tons/annum, about half of this total being derived from the "Yam Zone" of West Africa — a belt extending over both high forest and Guinea savannah country from the central Ivory Coast to the Cameroon mountains — and the remainder from various parts of S.E. Asia, India, Indonesia, Oceania and the Caribbean area.

Like many other tropical food crops, yams are still cultivated largely by peasant farmers, in individually small quantities, using manual methods. Although some varieties of yam are capable of yielding heavily — 10 tons/acre or more— under these conditions yields are often poor, at about one to three tons/acre. The cost of yam production, in terms of labour requirement is also exceedingly high, when compared, say, with that of potato production in Europe. Few figures are available, but those in Table 1 (a) and (b) illustrate this point well:—

Table I. (a) Costs of Yam Production

Country	Labour Requirement Man-hours/ton	Animal-hours/ton	Reference
Nigeria	360	—	Brown (1931)
Ghana	440	—	Hunter and Danso (1931)
Ghana	456	—	Bray (ca. 1958)
Trinidad	280	20	Paterson (1942)

Table I. (b) Costs of Potato Production.

Country	Labour Requirement Man-hours/ton	Animal hours/ton	Tractor hours/ton	Reference
United Kingdom (average)	14.5–16.0	—	?	Clift (1966)
United Kingdom (ideal)	7.6	—	3.2	"
Poland (small-holders)	33	15	—	Sackiewicz (1966)
Poland (state farms)	20.4	4.6	1.7	"

Yam production, using existing simple techniques involving negligible capital investment, is thus economic only where the labour force is prepared to accept a very low standard of living, which it is becoming progressively less prepared to do. It may be noted that in Trinidad, where yams have long been a staple food, they can no longer compete in price with potatoes imported from Europe during the greater part of the year (Chapman, 1965). It appears likely that a similar situation could develop in West Africa in the near future, as already, yams in urban markets in both Ghana and Nigeria fetch a price comparable with that of potatoes in Europe.

If yam production is to continue to be feasible in the changing socio-economic matrix of the present day, much needs to be done, in the improvement of cultural techniques, the selection and breeding of better strains ,and other agricultural changes, and in particular, mechanisation. These topics are beyond the scope of this paper.

However, in addition to the problems of actual economic production, there are a number of post-harvest problems connected with yams, which affect the economics of their use for food. These problems have to date received much less attention than their magnitude appears to warrant. The main object of this paper is to indicate some of these problems, and a few of the major lines of investigation in this field that can profitably be investigated. These fall conveniently into the main headings of storage, transport and processing.

Storage.

The majority of textbooks of tropical agriculture which mention the subject of yam storage at all, state merely that "yams store well", with little if any comment. There is a modicum of truth in this statement, in so far as yams can be kept for long periods without elaborate precautions or pest control measures, under the conditions of a tropical peasant's farm, without total loss occurring. Nevertheless, the few experiments which have been conducted to date (e.g. Anon, 1937: Gooding, 1960; Coursey, 1961) all indicate that very substantial losses in weight occur during storage, even when the tubers are not afflicted by any form of decay. These weight losses, although arising in part from simple water loss by transpiration, also involve a major destruction of dry matter—i.e. of food material—as a result of the natural metabolic processes of the dormant tuber. The respiration of this organ, although naturally slower when in the dormant condition than when active growth is taking place, appears still to be extremely rapid, in comparison with that of other "root" crops, such as the potato or sweet potato. The few experiments so far conducted on the use of respiratory inhibitors to reduce this high respiration rate have met with little success, although similar techniques have worked well with the potato. Gamma irradiation is another possibility, which has not been investigated, so far, in the case of the yam.

In addition to this high natural rate of loss, a number of storage rots are known (Dade and Wright, 1931; Baudin, 1956; Okafor, 1966) to affect yams. Amongst them, *Botryodiplodia theobromae* Pat. appears to be the most widespread, but several others, *Rhizopus, Fusarium, Hendersonula, Macrophomina* and *Penicillium* spp. among the fungi, and a bacterium believed to be *Serratia* sp. have also been reported. Although it is known that several types of storage decay are of major economic importance in connection with yam storage, much further work needs to be done on the incidence of the various biodeteriogens responsible, in different species and varieties of yam, and in different parts of the world, and on the correlation of visually distinct types of rot with specific organisms.

The yam tuber in store is, of course, a living organism, and its storage behaviour is therefore likely to be modified by factors giving rise to physiological stress. Adequate ventilation is a primary essential in successful yam storage, in order that oxygen be available for the metabolic processes of the tuber. Extremes of heat and cold can also disturb the metabolism. It is commonly supposed throughout West Africa that exposure to the sun adversely affects the storage behaviour of yams; it is known that when so exposed, the internal temperature of the tubers can reach 45° or even 50°C (Coursey and Nwankwo, unpublished work), which temperatures may well be high enough to induce biochemical lesions, comparable to the defect "black heart" of potatoes. Reduced temperatures also, although they result in lowered respiration rates (Coursey *et al,* 1966) also appear to produce some form of irreversible change at about 5°C. Such "chilling damage" is well known in the sweet potato (Lauritzen, 1931; Cooley *et al,* 1954) and many other tropical crops, but is only currently receiving detailed investigation in the case of the yam (Coursey, unpublished work), although first reported some time ago (Anon 1937; Czyhrinciw and Jaffe, 1951).

The post-harvest effects of nematodes—essentially a field pest—are but little understood, although the interactions of the lecions caused by these organisms with fungal invasion have long been recognised (West, 1934). A preharvest disease, believed to be caused by a virus, has recently been reported in Barbados as causing lesions in the tubers which become progressively more severe during post-harvest storage (Harrison, 1966). The available information on yam storage has recently been reviewed in detail elsewhere (Coursey, 1967 a).

Transport

Problems of transportation are, to a degree, linked with storage problems, in that, during transport, produce may often be exposed to unfavourable storage conditions. In the case of yams, these usually take the form of inadequate ventilation, or of undesirably high or low temperatures. The breakdown of the yam tissue caused by the stresses so induced appears to lead to invasion by rotting organisms to a greatly enhanced degree, and to susceptibility to attack by a wider range of organisms than normal. The mechanisms concerned are not, however, fully understood as yet.

Transport of yams in their natural condition is a basically difficult operation. Being in most species large and irregularly shaped they are difficult to pack conveniently or effectively. They contain a high proportion of water (ca. 60% to 75%) and a substantial amount of waste (ca. 15% to 20%) in the form of peel and unpalatable "heads". Thus, only a quarter or less of the bulk transported represents actual foodstuff, and that food is predominatly carbohydrate i.e. food of low nutritional quality. The large size and awkward shape of the tubers also renders them very liable to mechanical damage during transport, especially when transported by road and the damage inflicted can lead to enhanced decay. Nevertheless, on account of the strong attachment of the peoples of certain ethnic groups to yams, rather than alternative carbohydrate foods, very substantial quantities of yams are transported for long distances, especially in West Africa, even though it has been estimated (Hill, 1966) that in urban markets in this region, about a third of the price of the yams represents the cost of transport. The build-up in European countries, especially Great Britain, of immigrant populations derived from areas which are traditionally yam-eating, has stimulated a considerable international trade in yams. The problems arising in this trade, especially in terms of the market diseases associated with adverse holding conditions during transit, require urgent attention. Some investigations in this field have recently been initiated at the Tropical Products Institute.

Processing

In most parts of the world where yams are grown, the manufacture of some form of "yam flour" occurs in traditional culinary practice. The techniques of preparation vary somewhat in different districts, but consist essentially of cutting the yam tubers into slices, drying the slices in the sun, often after an initial parboiling process, and grinding the hard, dry pieces so formed with a mortar and pestle or, in more recent times, with a corn mill. The resultant flour, dried to a moisture content of a few percent, can be stored almost indefinitely, although it is liable to attack by insects and rodents.

Similar techniques, following prolonged soaking or boiling of the tubers, can be used to manufacture edible products from many of the toxic species of yam, and this is commonly done in times of famine (e.g. Corkill, 1948). The toxicity of many of the *Dioscorea* is due to alkaloids of the *dioscorine* type, which are water-soluble, and are so removed by this processing.

To date, processed food products based on the yam have been manufactured only on the domestic scale. One attempt to manufacture a form of yam flour in Western Nigeria on a small industrial scale was not successful, although this failure was due, at least in part, to the use of aluminium vessels for the parboiling process, which caused a browning reaction to take place in the yam giving rise to a dark coloured, unacceptable product. In India, as part of a campaign to alleviate food shortage, the semi-industrial processing of wild toxic yams (*D. hispida Dennst.*) into an edible flour has been proposed, and an outline for the process given (Rao and Beri, 1952).

Owing to the low moisture content of the product, the fact that peel, etc. has been eliminated during the processing, and the durability of the product, considerable reduction in transport costs of actual food material could be achieved if acceptable dehydrated yam products were readily available, especially in urban markets. Proposals for improvements in yam flour production, on a semi-industrial scale, and also for the small scale industrial manufacture of more sophisticated dehydrated products, based on traditional West African culinary practices have recently been put forward (Coursey, 1966). No very serious difficulties are envisaged in the development of such processes, although further studies of the rheological properties of the food products are needed, if the texture of the processed and reconstituted product is to correspond sufficiently closely to that of the well-known domestic product to be acceptable, in such conservative market.

It has been shown (Rasper and Coursey, 1967) that there is substantial variation in the viscous and other properties of the starches between different species and varieties of yam, which are reflected in the texture of food prepared from them.

Another aspect of the processing of yams that requires further study is the technique of peeling the large, irregularly shaped tubers by other than manual methods. Experiments on cassava—whose rhizomes are similarly shaped to many yams—have shown that when peeled by tumbling with water in a rotating drum, the peeling loss is as high as 25 to 30 per cent, and a number of small areas of skin remain, which need to be removed manually. Recently, however, it has been found (Matthews, 1966) that in the case of the long cylindrical tubers of *D. rotundata,* successful peeling, with a loss of only 15 per cent, may be achieved by chopping the tubers into pieces approximately equal in length to their diameter, and peeling in a normal rotating disc type potato peeler.

Packing of the processed product in insect-proof containers such as polythene-lined sacks, which is desirable for marketing reasons, would automatically lead to greatly enhanced storage life.

Suggestions have been made at different times for various industrial applications of yams, such as the production of power alcohol by fermentation, (Cook, 1927) and of surface-active additives for stabilizing the froth of beer (Hollo, 1964) while small quantities of yam starch sometimes appear in international trade under the name of "Guyana Arrowroot". However, the high cost of production of yam compared with that of other carbohydrate materials appears likely to preclude the use of yams for industrial applications, other than the manufacture of specialized food products, on any extensive scale.

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