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EFFECTS OF CURING ON STORAGE OF YAMS

B.O. Been, A.K. Thompson and C. Perkins
Ministry of Industry, Commerce and Tourism
Storage and Infestation Division
20 Hope, Road, Kingston 10
Jamaica, West Indies.

INTRODUCTION

Exposure of certain tubers to high temperature and humidity has long been known to bring about rapid wound healing by encouraging suberization and wound periderm formation (Appel, 1906; Artswager 1927 and Artswager and Starrett 1931). It is now standard commercial practice to cure potatoes (Artswager, 1927) and sweet potatoes (Lutz and Simmons, 1958) before storage. Apart from report from Gonzalez and Callazo de Rivera on Dioscorea alata L. there is little information on the effects of curing yams prior to storage.

Farmers in Jamaica successfully store D. alata tubers under ambient conditions for up to ten months after placing them in direct sunlight for three days to two weeks. Cut surfaces are usually brushed with lime or crushed broad bean (Vicia faba) leaves immediately after harvest. In West Africa, exposure of yams to direct sunlight is considered to have a detrimental effect on storage (Coursey and Nwankwo, 1968). In Jamaica few attempts are made at long term storage of any species other than D. alata.

Yams are probably the major staple food grown in Jamaica and export of D. rotundata Poir and D. cayenensis Lam. tubers to North American markets has been increasing. Both species, especially the latter, are characterized by high wastage on arrival at export markets (Burton,1970) and even in local markets. In addition both species are available in certain seasons only while there is a year-long demand.

The investigations reported in this paper were carried out to determine what effects curing under different conditions had on the storage of D. rotundata and D. cayenensis.

MATERIALS AND METHODS

Tubers of D. rotundata and two varieties of D. cayenensis - Roundleaf and Bottleneck - were used. All experimental material was harvested and transported in the traditional manner. Except in one experiment (Expt C, Table I) all tubers were selected, washed, air-dried, cut to remove the "head" - that end to which the vine is attached - numbered and individually weighed. In experiment C tubers were unselected and cured in a semi-commercial two ton quantity whereas in other experiments 20 to 30 tubers per treatment were used. Curing temperature ranged from 19°C to 45°C and relative humidity from 52 to 100%. After curing, which lasted from one day to seven days, tubers were stored at ambient or 13°C. During storage tubers were weighed at regular intervals and scored for surface mould on a scale of 0 to 5, where 0 = absence of mould and 5 = complete coverage. Necrosis was assessed at the end of each experiment after cutting each tuber in two longitudinally. Anatomical studies were done on fresh and preserved material.

RESULTS

The results obtained from the five experiments considered here were typical of those obtained from a large number of experiments carried out over a three-year period.

Anatomy

The anatomy of the D. cayenensis tubers is similar to that of D. rotundata described by Ayensu (1970). Wound healing was normal in most ways and suberization always preceded wound periderm formation. When a tuber was cut the peripheral layers of cells lost their starch grains and became suberized under ideal curing conditions. The outer most layers composed largely of cut or injured cells retained their starch grains. A cambium developed within the starch free zone and cut off cells to the outside only and these became suberized and formed the wound periderm.

The rapidity with which wound healing took place depended on humidity and temperature. When humidity was low, less than about 70% relative humidity, suberization and wound periderm formation were delayed, the cut surface dried out and a thick scab formed; there was a wide suberized starch free zone and a deep seated cambium. If the temperature was low - less than 26°C - suberization was delayed; if high - above 35°C - periderm formation proceeded rapidly, the starch free zone was narrow and the cambium superficial.

Weight loss

Bottleneck tubers cured at high temperature and humidity, above 35°C and 90% relative humidity, lost 30% fresh weight after 105 days storage and this was significantly less than 45% lost by tubers cured under ambient conditions (Expt A, Table I). Similar results were obtained in Expt. C and to a lesser extent in Expt. B (Table I). Curing for more than two days at 36 °C and 95 to 100% relative humidity did not seem to significantly affect weight loss at ambient. Roundleaf tubers cured under ambient conditions lost more weight than those cured at high temperature and humidity, but the differences were not as marked as with the Bottleneck.

Curing D. cayenensis tubers under different conditions did not seem to significantly affect the pattern of the rate of weight loss during storage at ambient - an early high rate, then a decline until about the sixth or seventh week and a gradual increase.

The effects of curing on weight loss of D. rotundata tubers were similar to those on Bottleneck tubers. Curing at high temperature even when the relative humidity was low significantly reduced weight loss during storage at ambient, Table 2, Expt E. There was some indication, however, that after about two months' ambient storage the effects of curing weight loss were not very marked. Curing at high temperature and humidity followed by storage at 13°C resulted in lowest weight loss. The pattern of rates of weight loss were similar to that of D. cayenensis, but cured tubers stored at 13°C did not show an increase in rate.

Mould

When tubers of both species were selected and trimmed before curing at 35°C to 42°C and 95 to 100% relative humidity they were free from surface mould growth during storage at ambient but not at 13°C (Tables I and 2). Superficial moulds grew on 47% of the unselected, untrimmed Bottleneck tubers cured at 36°C to 38°C and 75 to 87% relative humidity and stored at ambient (Table I, Expt C) and on 100% of those stored at 13°C. In the same experiment all t ers cured at

ambient had surface mould. Most moulds which grew on tubers cured at high temperature and humidity were saprophytic and generally dried up after two or three weeks storage. Those which grew on tubers cured at ambient, mostly Penicillium and Aspergillus, were associated with necrosis. Tubers of D. rotundata and Roundleaf cured at ambient also had superficial mould growth during curing and storage.

Necrosis

Bottleneck tubers cured at high temperature and humidity (Table I) consistently had significantly less necrotic tissue than those cured under ambient conditions. The effects of curing were not as pronounced on Roundleaf (Table I, Expt A). Curing at high temperatures also reduced necrosis in D. rotundata tubers (Table 2).

Sprouting

There was some indication that curing at high temperature prior to storage at ambient hastened sprouting. After about three or four weeks storage, a number of small protuberances, associated with root development, were evident on the tubers and these became larger as storage progressed. Storage at 13°C suppressed sprouting regardless of curing conditions.

DISCUSSION

Yams (Dioscorea spp.) were cured at different temperatures and humidities and stored under conditions comparable to those in cellars and sheds where local farmers store their crops, at 13°C.

Suberization and wound periderm formation, normal in most ways, were favoured by high temperature and humidity - 35°C to 40°C and 95 to 100% relative humidity. Curing under these conditions for one to seven days gave best results: it significantly reduced weight loss and rotting, usually prevented growth of moulds and extended storage of Yellow Yams (D. cayenensis Lam.) from one week to six weeks. The traditional method of sun drying prior to storage was found to have beneficial effects.

Consumers showed a preference for cured tubers.

Because of harvesting difficulties, careless handling and the practice of saving a portion of the tuber for planting, few damage-free yams enter commerce. The cut surface of a tuber offers a very suitable medium for growth of micro-organisms and decay follows rapidly if changes in cell walls beneath do not take place to form a barrier to impede the progress of pathogens. A temporary yet effective barrier is secured through suberization of peripheral cells, but wound periderm is more permanent and offers a more effective protection against entry of pathogens (Weimer and Harter, 1921; Lauritzen and Harter, 1929 and Priestley and Swingle, 1929).

The reduced weight losses, small amounts of necrosis and reduction of mould growth after tubers had been exposed to high temperature and humidity for as little as one day, were probably a consequence of rapid wound healing. Because of delayed wound healing under ambient conditions pathogens were able to penetrate the tubers with resulting increased rotting and weight loss and shortened storage.

The good results obtained when tubers were exposed to direct sunlight prior to storage suggest that drying out of injured cells, like in sweet potato (Weimer and Harter, 1921), may exert some retarding or inhibiting action against organisms.

The increase in rate of weight loss of D. cayenensis tubers after 50 days storage at ambient appeared to be associated with sprouting. This was supported by the tendency of the rates of weight loss of cured and uncured tubers to convergo during storage since curing hastened sprouting. Weight loss of cured D. rotundata was also partly associated with sprouting. For tubers that sprouted an increase in the rate of weight loss was associated with time of sprouting whereas this increase was absent when tubers did not sprout.

The presence of superficial mould on tubers stored at 13°C suggested either incomplete curing or low temperature injury.

Over 80% of the D. cayenensis grown in Jamaica is of the Bottleneck variety which has a storage life of generally less than a week and cannot be exported by air. We have found that properly cured Bottleneck tubers can be successfully marketed locally even after six weeks storage at ambient conditions. Tubers stored for periods longer than this are normally unattractive because of protrusions associated with sprouting and shrivelling due to increased weight loss.

Tubers not sold on the fresh market can subsequently be used as seed material since they remain relatively free from rotting and sprouting is normal

Curing, in addition to reducing wastage on the local market, makes it possible to export D. cayenensis by sea.

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TABLE 1. Effects of curing on certain storage parameters of D. cayenensis tubers.

	Cultivar	Curing °C	Curing RH(%)	Curing days	Storage °C	Storage RH(%)	Storage days	%fresh weight loss	% tubers with mould	% necrosis
Expt A	Roundleaf	35-40	95-100	1	25-34	64-92	105	18.8C	0C	15B
	Bottleneck	"	"	"	"	"	"	30.3B	0C	22B
	Roundleaf	25-34	64-92	"	"	"	"	22.4BC	36B	21B
	Bottleneck	"	"	"	"	"	"	44.5A	78A	55A
Expt B	Bottleneck	36	95-100	1	21-31	55-77	98	20.6B	0B	1.6BC
		"	"	2	"	"	"	18.7B	0B	2.5B
		"	"	3	"	"	"	18.7B	0B	1.8B
		"	"	4	"	"	"	18.1B	0B	1.2C
		23-31	55-77		"	"	"	35.1A	80A	5.1A
Expt C	Bottleneck	36-38	75-87	2	19-21	65-83	30	14.7	46.7B	2.9± 1.0C
		"	"	"	13-14	-	"	13.2	100.0A	3.7± 0.6C
		19-21	81-83	"	19-21	65-83	"	16.4	100.0A	40.0± 4.3A
		"	"	"	13-14	-	"	-	100.0A	20.4± 3.3B

Figures followed by the same letter do not differ significantly (P = 0.05).

TABLE 2. Effects of curing on certain storage parameters of D. rotundata tubers.

	Curing °C	Curing RH(%)	Curing days	Storage °C	Storage RH(%)	Storage days	%fresh weight loss	fungal score	% necrosis
Expt D	36-40	96-100	1	13	95-100	106	18.1B	2.2	7B
	"	"	"	21-31	52-68	"	29.7A	0.0	2B
	24-31	56-68	"	13	95-100	"	32.1A	2.6	64A
	"	"	"	24-31	52-68	"	30.4A	0.0	17B
Expt E	Direct sunlight		7	29-33	90-94	60	22.5B	0.9B	7B
	38-42	95-100	"	"	"	"	20.9B	0.0C	6B
	29-33	90-93	"	"	"	"	36.1A	1.3A	21A
	24-29	58-71	"	"	"	"	35.5A	1.0B	27A

Figures followed by the same letter do not differ significantly (P = 0.05).