CHAPTER 9

Assessment of sweetpotato cultivars for suitability for different forms of processing

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9.1 Introduction

Sweetpotato storage roots are bulky and perishable. The main forms of deterioration have been discussed in Chapter 5. The bulkiness and perishable nature of the roots are major constraints on the marketing and availability of the crop. One way in which these constraints have been addressed is through processing. Processing is defined as the transformation of the raw material (fresh root) into the end product. The end product, which is usually a value-added product, may be more attractive, palatable, nutritious, less bulky and less perishable to permit continuous use. The major part of processed sweetpotato in sub-Saharan Africa is utilized for human consumption and the methods are limited. Two main types of sweetpotato processing, traditional and commercial processing, are discussed in this chapter.

9.1.1 Traditional processing

Traditional processing methods are simple and are practised at household level to produce products for direct use as human food. Boiling or steaming (cooking) roots is the main method used for the preparation (processing) of sweetpotato for home consumption.

In some dry areas of Uganda and Tanzania, sun-drying sliced pieces is practised during the dry season, primarily as a means for storing the roots. At maturation,

sweetpotato roots are subject to deterioration that lowers quality and quantity adversely if they are not harvested timely. The primary causes of root deterioration, as discussed earlier, include physiological processes: tissue

metabolism and sprouting; mechanical factors due to poor harvesting, packaging, transportation and storage that result in bruises and wounds; and biotic factors, i.e. insects, nematodes, rodents and microbes (Hill, 1984; Chalfant *et al*., 1990). At present there are few appropriate storage and curing methods, especially at smallholder subsistence farm levels, that could enhance the shelf-life of roots during post-maturation (Agona, 1998). One strategy to ensure the availability of sufficient food, especially during the lean seasons and where sweetpotato cultivation is limited to only one season in a year, is to process the roots into dried chips and store them in this form. The dried chips are either reconstituted by boiling or are ground into flour which may or may not be mixed with millet/sorghum flour for making thin and thick porridge. Methodologies for the improvement of traditional drying at farm level to produce higher quality primary products that can either be stored without spoilage or used to process value-added products are being explored.

9.1.2 Commercial processing

Sweetpotato processing for human consumption in many countries is not yet commercialized. Studies in some countries have, however, investigated the feasibility of sweetpotato as a partial substitute for imported wheat flour in snack products. Substitution of wheat flour, either with fresh, grated roots or sweetpotato flour, is gaining a foothold in the snack product market in Kenya and Uganda. Promotion of commercial processing of primary products would increase the utilization of sweetpotato flour as an ingredient in snack product processing.

There is great variation in the processing characteristics of sweetpotato cultivars but generally dry matter is an important characteristic.

9.1.3 Objectives

In this chapter, we will consider the development of methods to assess and evaluate cultivars for cooking quality and suitability for processing into crisps, dried chips and sweetpotato flour.

9.2 Methods

9.2.1 Assessing cultivars for cooking quality

In Chapter 2, we reported that farmers usually prefer varieties that take a short time to cook. Cooking sweetpotatoes for the correct time is important, since over-cooking reduces nutrient content, while under-cooking results in high levels of anti-nutrients (such as proteinase inhibitors) which can cause indigestion or illness. The simplest method to assess cultivars for cooking quality is thus to measure cooking time. When the root is boiled, it softens and if over-cooked it may disintegrate. Variation in cooking time is closely related to dry matter content. Therefore, in assessing cultivars for cooking quality, determination of cooking time, dry matter content, and sensory evaluation of the *cookedness* of the roots are all important.

A study was carried out in Uganda in which a wide range of cultivars were assessed for cooking qualities. Cooking time was evaluated instrumentally using the matson bar drop cooker method. This is a simple, reproducible and rapid method. The matson bar cooker, illustrated in Figure 9.1, consists of sharp metal rods that puncture and drop through the product being tested as the product becomes soft during cooking. The cookedness of the sweetpotato pieces was determined using sensory evaluation methods.

9.2.2 Assessing cultivars for crisp production

During frying, sugars usually contribute to the darkening of the final product due to the maillard reaction which occurs between reducing sugars and amino acids at high temperatures. It is known that dry matter content affects yield and oil content of the final product as roots with a high water content produce crisps with a higher oil content. Oiliness has been found to be one of the most important problems affecting the acceptability of sweetpotato crisps, and economically, as oil is expensive, it will affect the cost. The simplest and most sound method for assessing cultivars for suitability for crisp processing is to measure sugar and dry matter content. However, it is also important to take

Methods Used in Assessing Cooking Qualities of Cultivars in Uganda

Sweetpotato storage roots used in the experiments included local and released varieties. The sweetpotatoes were planted in farmers' fields in Dokolo sub-county, Soroti, during the long rains of 2000 and harvested after 5 months.

Immediately after harvesting, dry matter of sweetpotato varieties was determined by the oven method. Chopped pieces of sweetpotato roots were dried to a constant weight in a forced air oven set at 60 ºC. Dry matter was calculated as dry weight/fresh weight x 100.

The middle portion of average sized sweetpotato roots was cut into cubes of 1.5 cm in height and diameter. The prepared samples were placed under the sharp metal rods of a matson bar drop cooker which was put in a saucepan containing 1 litre of boiling water. The time that each rod took during the cooking process to drop down after penetrating the piece of sweetpotato was recorded as cooking time.

For the sensory evaluation, the cooked pieces of sweetpotatoes were presented to regular consumers of sweetpotato to assess the degree of cookedness. The five panelists were staff from the research institute. Assessment involved scoring for the degree of cookedness on a nine point scale shown in Table 9.1. Clean water was provided to rinse the mouth between variety testing.

Figure 9.1 The matson bar cooker

Table 9.1 Sensory scale for evaluation of cooked s

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9	

into account consumer acceptance of the final product. Important characteristics that influence consumer acceptance of products are colour, taste and texture. A study was carried out in Kenya to assess cultivars for

Methods Used in Assessing Cultivars for Processing into Crisps in Kenya

Sweetpotato storage roots used in the experiment were grown at the University of Nairobi, Kabete Campus farm during the long and short rains of 1994 and at the Regional Research Centre in Kakamega during the long rains of 1994. All roots were harvested at a maturity age of 5 months.

Dry matter was determined by drying chopped root samples at 65 ºC for 72 h in a forced air oven. Percentage dry matter was calculated as dry weight/fresh weight x 100.

Processing of sweetpotato into crisps was done by cutting peeled and washed sweetpotato roots into 1–1.5 mm slices. The slices were washed in cold tap water to remove surface starch and dried on a clean towel. Frying was carried out in a domestic deep fat fryer containing about 3 litres of Elianto corn oil at a constant temperature of 170 ºC for 5 min. The crisps were removed from the oil and drained for 30 s. Oil content in the crisps was determined using the method described by Lulai and Orr (1979). Crisps were finely ground in a blender. A 5 g portion of powder was put into a thimble and a 6 h soxhlet extraction conducted using petroleum ether as described. Percentage oil content was calculated as weight oil/weight original sample x 100.

Acceptability of the crisps was determined by the sensory evaluation method. Crisps were presented to a panel consisting of staff of the National Potato Research Centre, Tigoni to score for flavour and texture on a 1–5 scale (i.e. 1 = very poor; 2 = poor; 3 = fair; 4 = good; 5 = excellent).

9.2.3 Assessing cultivars for dried chip processing and subsequent susceptibility to insect infestation

Dried chip processing involves the selection of big and undamaged roots, peeling, wilting in the sun for a few hours, slicing and drying on stabilized drying yards. Sweetpotato cultivars that are high yielding, have big roots, store well in the ground after attaining maturity, are not easily damaged by insects and are 'delicious' are particularly preferred for dried chip processing (Agona, 1998). The dried chips are considered 'inert materials' and thus not liable to biochemical and physiological deterioration factors. The main constraints of dried chips are losses associated with poor drying and inefficient storage practices that encourage insects and microbial infection (Hall *et al*., 1998). Damaged chips are characterized by pulverization, tunnelling and mouldiness (Fowler and Stabrawa, 1993). This is accompanied by production of powdery wastes, development of bitter and pungent off-flavours and tunnels packed with larval faecal droppings.

Farmers' practices of mitigating losses involve regular inspection and re-drying in the sun and, to a lesser extent, opening the granary roof to allow the photophobic insects to escape. Although farmers are aware of differences between varieties in susceptibility to storage insect pests, all sweetpotato varieties are processed and stored in the same unit indiscriminately. Farmers define susceptible cultivars as those that are easily damaged within a few months of storage, while the 'resistant' ones as those that store for long periods with insignificant damage. The main reasons for non-varietal selection during processing include good food blend, differences in varietal yields, limited planting materials for suitable varieties, preventing further insect damage, development of root sponginess and difficulty in providing each variety with its own storage structure (Agona, 1998).

Methods Used in Assessing Cultivars for Processing into Dried Chips in Uganda

Source of roots and processing into dried chips

Roots of 13 different sweetpotato cultivars were harvested at about 180 days after planting at Kawanda Agricultural Research Institute. The optimal growth period was 6 months for all the cultivars to ensure synchrony in maturity (Badillo and Lugo, 1977; O'Hair *et al.*, 1986).

Farmers' traditional methods of dried chip processing were simulated. The chips were dried under the sun for 4 days until a constant moisture content (MC) of 11–12% was attained in all the cultivars processed. Chip MC was monitored twice at 4-h intervals during the day, by drying 10 g of ground sweetpotato slices in a ventilated oven at 130 °C for 1 h.

Screening chips for susceptibility to insect infestation

The dried chips were packed separately in waterproof polyethylene bags and kept in a deep freezer for 3 days to disinfest the chips of any prior infestation during drying. The frozen chips were removed and placed in 2 litre plastic bottles fitted with perforated lids and conditioned under prevailing ambient conditions in the laboratory for 1 week. After conditioning, the dried chips were divided into two 500 g lots. The first lot was retained for varietal screening for resistance, and the second lot was sub-divided into two sub-lots of 250 g each and used for conditioning 0–3-day-old *A. fasciculatus* females and males for 3 weeks. The females and males were kept separately to allow acclimatization of the different varieties and synchrony with the maximum oviposition period (Agona, 1998).

The 500 g samples conditioned for varietal screening for resistance were weighed into three different 100 g sub-lots and kept in 1 litre Kilner jars fitted with perforated lids with the neck coated with Fluon® (this provides a slippery surface which prevents the insects from climbing out). The chips in each jar were infested with six female- and three male-acclimatized adults aged 18–21 days. Gravid females were allowed 3 days to oviposit and then removed. The use of older adults, lower number of males and shortened oviposition period was to ensure maximum oviposition (Sayed, 1935), to avoid oviposition interference (Kumar and Karnavar, 1986) and to reduce the duration between the first and last adult emergence dates (Agona, 1998), respectively. The infested chips were retained in the jars under ambient conditions until all the F1 progeny had emerged. The total number and time taken by 50% of the F1 progeny to emerge was determined. The data were used to calculate the susceptibility indices (Dobie, 1974, 1977) of the sweetpotato varieties under test using the formula:

$$SI = \frac{\text{Log}_e (F1) \times 100}{D}$$

where SI = susceptibility index

F1 = total number of adults that emerged

D = time taken by 50% of the progeny to emerge from mid-oviposition

The data of susceptibility indices, development time and emergent adult numbers were analysed as completely randomized design using the MSTATC statistical package. Each sweetpotato variety constituted a treatment and was replicated three times.

A study was conducted in Uganda to determine the development and infestation rate of the coffee bean weevil, *Araecerus fasciculatus* (Degeer), on dried chips made from a range of different sweetpotato cultivars. The cultivars were obtained from farmers' fields in Kumi district (Agona, 1998), which are enriched with a large germplasm collection of sweetpotato and where dried chip processing and utilization are predominant. *Araecerus fasciculatus* is a major pest of dried sweetpotato chips in storage (Agona, 1995).

9.2.4 Assessing cultivars for flour processing (low browning)

Sweetpotato flour is a raw material for various processed food products. One major constraint associated with sweetpotato is the browning reaction which takes place when the roots are exposed to air during processing. This results in an undesirable discoloration. In traditional processing, browning is not considered a disadvantage, however, it is a major obstacle in some products incorporating sweetpotato flour.

A study was conducted in Kenya in which roots were assessed for their tendency to brown when cut.

Methods Used to Assess Cultivars for Browning

Sweetpotato storage roots used in the experiment were grown at the University of Nairobi, Kabete Campus farm during the long and short rains of 1994 and at the Regional Research Centre in Kakamega, during the long rains of 1994. All roots were harvested at 5 months. Sweetpotato clones were screened for flour processing by recording the browning rate. The roots were cut into slices using a stainless steel kitchen knife and exposed to air at room temperature. The change in colour was observed at intervals of 0.5 h, 1 h, 3 h, 6 h, 18 h and 24 h. At the end of each interval, the rate of browning in sweetpotato was evaluated using a hedonic scale of 1–5 as follows: 1 = no discoloration; 2 = light discoloration; 3 = fair discoloration; 4 = heavy discoloration; 5 = very heavy discoloration.

9.3 Results

9.3.1 Cultivar cooking qualities

9.3.2 Cultivar suitability for crisp production

Table 9.2 Dry matter content, cooking time and me sweetpotato pieces

Variety	Dry matter content (%)	Cooking time
Naspot 5	27.7	2.8e
Naspot 1	36.0	3.3*d
SPK 004	32.2	3.3d
Haraka	31.4	3.5d
Osopat	29.4	3.6cd
Ateseke	33.1	3.6cd
Sowola	38.6	4.1*bc
Naspot 3	33.4	4.5ab
Tanzania	34.3	4.6a
Naspot 2	30.3	4.8a

* Small sized roots were used in the experiment.
Means with different letters within columns are significantly different at $P = 0.05$.

Table 9.3 Dry matter content, oil content and crisp acceptability of sweetpotato clones and varieties

Clone	Dry matter (%)	Oil content (%)	Flavour acceptability	Texture acceptability
440006	15.8	27.72	2.8	2.5
440111	17.4	33.98	3	3
440243	18.4	22.59	3.4	3.3
440185	18.4	31.55	3.8	3.5
420029	18.5	27.84	3.5	3.5
400005	20.7	26.70	2.6	2.8
KSP 20	21.2	21.91	2.6	3.1
440186	21.5	25.14	4.2	4.1
440062	23	24.2	3	3.6
440198	23.4	25.28	4	3.4
440089	23.4	22.53	3.1	3.8
440098	23.5	21.87	3	3.6
440050	25.4	18.99	3.7	3.4
420024	25.4	25.53	4.2	3.5
420014	29.3	29.5	3.3	3.8
KSP 11	29.5	21.04	3.6	3.3
440024	29.8	25.53	2.3	3.5
440103	30.5	21.4	4.1	3.6
Mwezi Tatu	31.5	21.77	3.9	3.2
440129	32.2	19.65	3	3.9
420026	32.2	27.05	3.1	3.9
Kemb 33	32.3	13.95	3.2	3.7
Kemb 23	32.5	19.68	3.3	3.4
Kemb 36	32.9	15.25	3.7	3.4
SPK 004	33.4	20.88	3.1	3.3
Kemb 10*	33.6	19.86	3.1	3.2
SPK 013*	34.5	18.51	3.2	3.2
Kemb 20	36.1	17.15	3.5	3.9

*Local checks.

higher scores, but this was barely statistically significant (r = 0.355 significant to 10%). The varieties that we consider to have greatest potential for processing into crisps were those with a high dry matter and crisps of low oil content and high acceptability. These varieties were identified as SPK 013, Kemb 36, Kemb 33, Kemb 20, Kemb 23, SPK 004, 440050 and 440129.

9.3.3 Cultivar suitability for dried chip processing in terms of resistance to insect infestation

Significant differences ($P<0.05$) occurred between varieties for the number of *Araecerus fasciculatus* F1 progeny that emerged from the dried chips (Table 9.4). Similarly, the median development periods of *A. fasciculatus* varied between varieties (Table 9.4). The results further showed significant variation in the susceptibility (SI) of the varieties to *A. fasciculatus* in which varieties with the highest number and shortest median development period of the pest were classified as the most susceptible (Category III). Those with low numbers of emergent adults and with protracted development periods were classified as less susceptible (Category I). Those varieties with intermediate qualities were placed in Category II. The results showed that all the dried chips of the 13 varieties screened were susceptible to *A. fasciculatus* infestation, but to varying

Table 9.4 Varietal effects on *A. fasciculatus* emerg and susceptibility indices

Sweetpotato variety	Number of adults emerged*	Median dev
Mbiyombiyo	11.0 ± 3.2	5
Ecuru	10.3 ± 1.3	6
Emaderait	11.3 ± 2.2	6
Tanzania	10.7 ± 5.2	6
Oceger	6.3 ± 1.5	6
Odopelap	7.3 ± 2.3	6
Ojeite-edula	6.0 ± 1.5	6
Ateseke	5.7 ± 0.9	6
National	4.7 ± 0.7	5
Epura-amojong	6.3 ± 2.4	6
Ebyoloto	4.3 ± 0.3	6
Ebokorait	4.0 ± 0.6	6
Haraka	3.3 ± 0.3	6
CV (%)	53.7	
SED (26 d.f.)	3.1	

* Each datum is given as mean ± SE.

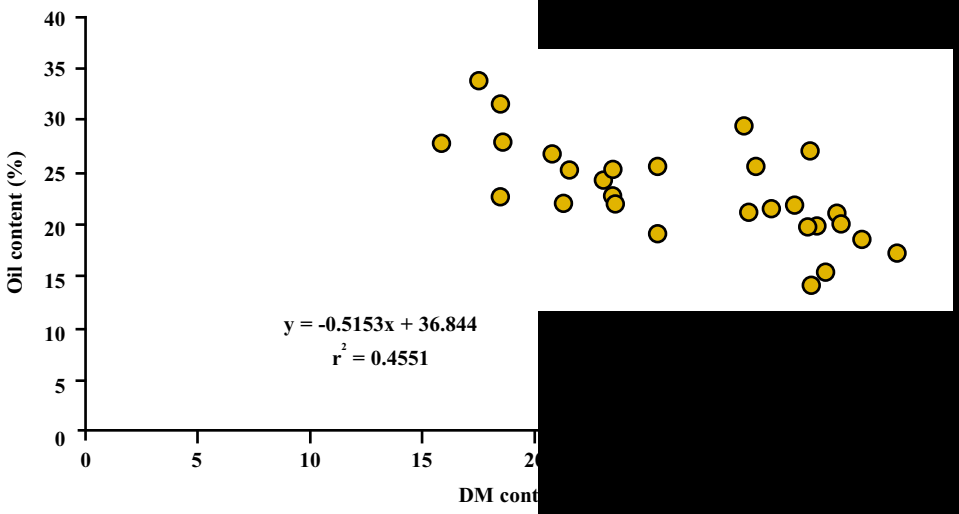

Figure 9.2 The oil content of deep fried sweetpotat 28 sweetpotato varieties

degrees. The results agree with the farmers' belief that there are differences between varieties, especially in the onset of infestation and damage levels (Agona, 1998).

9.3.4 Variation in root browning among cultivars

Results from the study showed that there was a wide range in browning among cultivars (Table 9.5). There was no relationship between dry matter content and rate of browning. Cultivars with a high dry matter content which showed lower browning, i.e. SPK 004, Wendo,

Table 9.5 Rates of browning (oxidation) of sweetpotato roots after slicing

Clone	Percentage dry matter	0.5 h	01 h	3 h	6 h	24 h
KSP 20	21.2	2.5	2.9	2.9	3.0	3.4
SPK 013*	34.5	2.0	2.4	2.6	3.2	3.0
Kemb 36	32.9	1.5	1.5	1.8	1.8	2.4
Kemb 10*	33.6	2.1	2.0	2.1	2.4	3.0
KSP 11	29.5	2.2	2.0	2.1	2.5	2.8
Mwezi tatu	31.5	4.6	4.9	5.0	5.0	5.0
Kemb 23	32.5	1.0	1.9	2.0	2.2	3.7
Ogur Iwe*	35.0	1.0	1.5	1.8	3.0	3.2
Kemb 33	32.3	1.0	1.4	1.0	3.0	3.2
Kemb 20	36.1	2.8	3.0	3.0	3.4	3.2
SPK 004	33.4	1.2	1.8	2.4	2.8	2.9
Wendo modhial*	34.5	2.4	2.4	2.2	2.5	2.8
188001.2	35.4	1.0	1.2	1.4	1.8	2.2
420009	28.1	2.4	2.4	2.4	2.6	3.0
Sandak*	30.1	2.0	2.2	2.0	2.4	3.0
Ex diani	29.8	2.4	2.7	2.5	3.0	3.2
Mafuta	37.0	2.8	3.0	3.2	3.3	3.5
440078	29.0	2.2	2.2	2.1	2.2	2.5
Mtw13	24.0	1.7	1.9	2.4	2.5	2.7
440078	29.0	2.2	2.2	2.1	2.2	2.5
Mtw13	24.0	1.7	1.9	2.4	2.5	2.7
440037	26.5	2.5	2.9	2.8	2.9	2.9
440062	23.0	4.4	4.9	5.0	5.0	5.0
420026	32.2	2.9	2.8	3.1	3.2	3.0
420027	21.7	2.1	2.9	3.3	3.4	3.3
440024	29.8	2.5	2.8	3.2	3.3	3.4
440098	23.5	2.1	2.6	3.2	3.3	3.4
440009	26.2	2.5	3.1	3.4	3.5	3.6
420025	28.7	4.3	4.8	5.0	5.0	5.0

* Local checks.

Note: Work is underway to determine the effect of chemical composition and functional properties of cultivars on quality and consumer acceptability of products made using sweetpotato flour. Further information can be obtained from C. Owori.

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Sweetpotato breeding methodologies and targets in sub-Saharan Africa

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I.1 Introduction

Plant breeding can be defined as the art and science of changing plants genetically (Allard, 1960). It is crop evolution directed by man through a conscious decision to keep the progeny of chosen parents similar in performance to ideotypes (Jones *et al*., 1986). Steps involved in plant breeding are:

- finding or developing populations from which selections can be made
- selection
- the use of selections in commercial/useful production.

Root and tuber crops are vegetatively propagated, thus the breeding methods most suitable for these crops are somewhat different from those used for seed propagated crops. Vegetatively propagated crops are characterized by the following advantages:

- as long as they are propagated vegetatively and in the absence of spontaneous mutation, no genetic segregation takes place even if they are genetically heterozygous
- superiority of F1 plants results from both additive and non-additive effects
- heterosis can be vegetatively fixed, it lasts permanently and it is, therefore, possible to select individuals having desirable traits in the F1 generation.

Vegetatively propagated crops have their own disadvantages in breeding which include:

- many cultivars do not flower under natural conditions
- the inheritance of characters is usually complicated due to heterozygosity and polyploidy
- exchange of breeding materials is difficult because of local quarantine regulations: these govern the export and import of vegetative materials to restrict the spread of pests and diseases which are transmitted through vegetative propagation.

The appropriate method of population improvement must, therefore, be chosen to suit facilities, available funds and the variation (both genetic and environmental) in the population under improvement. The basic requirements of prolonged progress are common to all crops and methods: good parents, good derived populations, adequate number, adequate genetic variability and efficient selection.

It is important to involve the end-user in the selection process. This can be done by identifying the farmers' needs and incorporating them into the selection

process or involving the farmers themselves in the selection process so that they pick what they want. It is important for the researcher and farmer to come to a compromise since, for example, the farmer may choose a variety which, unknown to him, is susceptible to disease or insect attack, while the researcher with his additional knowledge can discount such a variety.

I.2 Sweetpotato breeding objectives

A plant breeding programme must have well defined objectives which are both economically and biologically reasonable. Economic objectives are important, even if not stated in strictly monetary terms, because the breeder must be assured that he/she is trying to produce varieties that farmers and end-users want. The 'biological objectives' are determined by scientific and general knowledge of the crop. Biological objectives are dominated by yield and quality factors (fitness for purpose), although a few additional features that do not fall under either of these headings can also be recognized.

I.3 Obtaining and evaluating new sweetpotato clones

1.3.1 Justification for new varieties

The selection of new varieties is an important aspect of sweetpotato crop improvement. New varieties can provide farmers with improved yields, early maturity, control of diseases and pests, and quality characteristics, at little or no additional cost. Those interested in the selection of new varieties include agricultural researchers, development and extension workers and, of course, farmers.

1.3.2 Sources of starting material

The starting material for a sweetpotato variety selection programme may be either sexual seed or previously existing clones. Sweetpotato is a vegetatively (also called clonally or asexually) propagated crop, but new varieties come principally from seeds produced by cross-pollination. While large populations of seeds are the starting material used by established breeding programmes, the process of their initial evaluation takes longer, and thus is more expensive than the evaluation and selection of previously existing clones. Previously existing clones are the logical first step for evaluation and selection by newly established variety selection programmes, and are also valuable to established breeding programmes as a source of potential new parental material and varieties.

Several sources of previously existing clonal germplasm are available for testing, including experimental clones and varieties released from breeding programmes, as well as farmer-selected landrace varieties. Within a country, sources of clones for testing may include breeding programmes, germplasm collections (gene banks) and farmers, or clones may be obtained internationally. The International Potato Center (CIP) maintains a large collection of pathogen-tested sweetpotato clones available for international distribution and testing. This collection includes important landrace and released varieties from many countries, and elite experimental clones from leading sweetpotato breeding programmes around the world. The decision on which source(s) of clonal germplasm to use and how to proceed with evaluation should be based on an understanding of current and previous sweetpotato varietal selection efforts in the target area.

Key elements in variety evaluation

In any standard procedure, the following should be considered for a successful breeding programme.

i) Multiply clones for trial and verify their identities.

Pathogen-tested sweetpotato clones may be distributed internationally as *in vitro* plantlets or, in some cases, as cuttings. Take care to verify and maintain the identity of clones during multiplication and evaluation.

ii) Conduct preliminary evaluations of adaptation and acceptability.

Although some introduced clones will probably perform well in the target environment, many probably will not, because they will be poorly adapted to climate, soils or agronomic practices, or susceptible to diseases and pests. In addition, introduced clones may not have desired root or foliage quality characteristics. We recommend that introduced clones should initially be evaluated in observational trials with small plots, replicated once or twice, under agro-ecological and agronomic conditions representative of the target environment.

iii) Incorporate clones into a routine selection scheme.

In an ongoing breeding programme, we suggest that introduced clones be incorporated directly into your standard trial scheme as explained in section I.4.

I.4 Sweetpotato standard trial scheme

The trial scheme described below involves teamwork where breeders, pathologists, entomologists, agronomists, food technologists, socio-economists, extension/farmers and industrial participation are equally important. All the breeding trials are conducted with no fertilizer application to simulate farmers' cropping systems in Africa. Although selections are made on monocrops, attention should be paid to morphological characteristics suitable to the predominant cropping system of the area/region.

Every breeding trial should include one local variety and one improved standard variety as checks. The local variety should be that most cultivated by farmers in the area. These two checks provide the basis for selection of new varieties which must be superior at least to the local check (genetic progress *vis a vis* local population) and to the standard improved variety (genetic gain *vis a vis* the breeding programme).

Basically, sweetpotato breeding involves sowing the F1 seeds obtained by full-sib (two known parents) and/or half-sib (only the female parent known, i.e. open pollinated [OP] seeds) progenies. As sweetpotato is heterozygous, there is a segregation of traits in the F1 population. Clonal selection is applied from F1 for identification of superior clones. Thus, there is no rationale in going to F2 before starting the selection.

Below is a summary of breeding stages taking into consideration the prevailing climatical and biological conditions. The breeding procedures provided here have some limitations considering the time taken to develop good acceptable varieties, and also the availability of resources within many national programmes in sub-Saharan Africa. The *CIP Research Guide* No. 6 by Carey and Reynoso (1997) provides an explanation of flexible procedures that should be used to take on-board evaluation of existing pathogen-tested germplasm. This can be used at different stages as explained, hence reducing the breeding cycle and maximizing available resources.

The following steps are taken after a sufficient number of seedlings have been raised and cloned from the source population. The selected clones must have been screened for resistance to viruses, weevils, root conformation and other desirable characteristics.

Step one: sweetpotato seedling nursery

Approximately 10,000 to 50,000 seedlings are raised, but 5000–15,000 seedlings are adequate depending on availability of resources. During the growing period, the seedlings are screened monthly for 4 months for resistance to major diseases and pests. The seedlings are harvested after 5 months. This is done for one season. Root conformity, shape and weevil damage are assessed. The selection should be rigorous. All selected clones are advanced to step two: sweetpotato clonal evaluation trial.

Step two: sweetpotato clonal evaluation trial

The selected seedlings from each station (which may number up to 2000) are cloned and planted in a single row plot of 5 x 1 m or 5 x 0.8 m (where land is scarce). Spacing between plants is 0.3 m in most countries. Two standard local varieties are planted after every 10 clones for comparison (check-plot design). At this stage, the observations made during the first year on diseases and pests are confirmed for each clone. At

Step three: sweetpotato preliminary yield trial

Step four: sweetpotato advanced yield trial

Step five: sweetpotato uniform yield trial

this trial can be tested on-farm. To ensure yield stability and adaptability the trial should be repeated for 2–3 seasons.

Step six: national sweetpotato variety trial

The UYT in the second year is referred to as UYT2 and the trial is planted in 5 row plots (10 plants/rows) with 4 replications at each location. Only the central three rows are harvested for yield estimation. Promising clones from UYT2 are advanced to farm level testing with farmers' participation. While carrying out on-farm testing, nucleus multiplication of breeder seed is initiated so as to have a sizeable quantity of material if any promising lines have to be pushed forward. This happens alongside the national variety trial (NVT). The best clones selected from AYT and from different main agro-ecologies are pooled and tested in a UYT design throughout the country. This will help to identify clones with a wide adaptation to many environments contrary to those which have a specific adaptation to a particular environment.

Step seven: sweetpotato on-farm variety evaluation

As mentioned earlier, farmers participate in the assessment of trials at the AYT stage. In order to obtain more information on performance at farm level where soil conditions, land quality, management practices, etc., differ, it is important to test the varieties on-farm. For this evaluation, the participatory research methodology (Ashby *et al*., 1989) is used. The key basic elements come together, i.e. experimental materials + research team + farmer. This evaluation can be included in every type of advanced trial, and must be adapted to the conditions characteristic of each trial zone. The farmers (women and men) who participate in the evaluation carry out two types of test: taste tastes and agronomic evaluations. Details on the procedure is presented in Chapters 2 and 3 and *CIP Research Guide* No. 5 (Fonseca *et al.,* 1994).

Summarized sweetpotato standard trial procedures

Year	Season	Breeding stage	Number of clones, plots and replications	Major tasks and evaluations
1	1st	Source population	10,000 seedlings	Raise seedlings in the nursery for 1 month
	2nd	Preliminary observation (optional)	10,000 clones Plant 2 plants per clone	Screen for resistance to virus, weevil, root conformity and characteristics
2	1st	Clonal evaluation I	500 clones Plant single row plots, 1 replication	Confirm the first year's evaluation Evaluate yield potential and dry matter
	2nd	Clonal evaluation II (optional)	250 clones Plant single row plots, 1 replication	Screen for resistance to weevils, virus and drought (where important) Evaluate yield potential
3	1st and 2nd	Preliminary yield trial	100 clones Plant single row, with 20–30 plants per plot, 2 replications, two dates of harvest	Evaluate for yield and preliminary consumer acceptance by station workers **Note:** To reduce inter-plot competition effects, plant the same number of cuttings, in shorter 2-row plots, or by grouping clones according to their growth habit
4	1st and 2nd	Advanced yield trial (AYT)	25 clones Plant 3 rows, 60 plants per plot with 3 replications, one date of harvest (150 days), repeated over several locations and seasons	Evaluate agronomic and yield potential Conduct assessments by farmers of agronomic and yield performance Conduct consumer acceptance by farmers
5	1st and 2nd	Uniform yield trial (UYT)	5–10 clones Plant 4 rows, 60 plants per plot, 4 replications, repeated over several locations	All other assessments as in AYT Select varieties for on-farm testing

Note: At this stage a national variety trial can be established with several distinct agro-ecologies.
Adapted from *CIP Research Guide* No. 6 (Carey and Reynoso, 1997).

I.5 Data collection

The following forms were designed by CIP for data collection when testing sweetpotato clones distributed by CIP. However, they are also suitable for testing locally derived clones.

To facilitate analysis and decision-making, raw data should be transformed into reference units of general acceptance. For instance, the number of harvested plants divided by the number of planted cuttings will give the

Form 1 General Trial Information

This form requests essential information on trials, such as location, plot size and trial management practices. It also provides space for the results of soil analyses and meteorological data which, if available, will help in the interpretation of trial results.

1. Name of scientist(s) conducting trials_____

2. Institution and address_____

3. Trial location latitude____ Agro-ecology longitude____ Altitude (m)___

4. Trial name_____ Design_____

   No. replications_____ No. clones____ No. checks____

5. Date of planting_____ Date of harvest_____ Duration_____ Season_____

6. Plot size_____ No. cuttings_____ No. rows_____

   Length (m)_____ Spacing (m)_____

7. Trial planted on ridges, mound or flat?_____

   Irrigation volume_____ Fertilization_____

   Pesticides_____ Previous crop_____

8. Soil type_____

   Texture_____ pH_____ Organic matter %_____

   CEC meq/100g_____ Aluminium saturation %_____

   EC mmhos/cm _____ $CaCO_3$ %_____

   Nutrient analysis_____

9. Meteorological data during trial (means by month or fraction of month)

	Month					
Meteorological data	1	2	3	4	5	6
Mean temperature (°C)						
Mean maximum temperature (°C)						
Mean minimum temperature (°C)						
Rainfall (mm)						
Radiation (MJ/m^2)						

10. Other_____

Form 2 Agronomic Data

Trial location_____ **Trial name**_____

Date of planting_____ **Date of harvest**_____ **Name of check(s)**_____

		Clone														
Plot	**Replication**	**CIP number**	**Name**	**Cuttings**	**NPH**	**YT**	**NPWSR**	**NLR**	**NSR**	**YLR**	**YSR**	**CRACK**	**RD**	**ER**	**RSC**	**RFC**

a) To be filled out at time of planting:

Plot = Plot number
Replication = Replication number (if any)
Clone = CIP number and name of clone
Cuttings = Number of cuttings planted

b) Data to be taken at harvest:

YT = Yield of the tops of the plants (leaves + stems) in grams
NPH = Number of plants harvested
NPWSR = Number of plants with storage roots
NLR = Number of large roots
NSR = Number of small roots
YLR = Yield of large roots in grams
YSR = Yield of small roots in grams
(A cut-off value for considering a root as large or small may be 100 g.)

CRACK = Root cracking, scale 1–9.

RD = Root defects: 1 = alligator-like skin; 2 = veins;
3 = shallow horizontal constrictions,
5 = shallow longitudinal grooves;
7 = deep constrictions and grooves; 8 = other (specify).

This trait combines information on root size, shape, uniformity and smoothness. Use a 1–9 scale. Points should be taken off for each defect.

Root colour can refer to skin or flesh as follows:

Root skin colour (RSC)	Root flesh colour (RFC)
1 = White	1 = White
2 = Cream	2 = Cream
3 = Yellow	3 = Dark cream
4 = Orange	4 = Pale yellow
5 = Brownish-orange	5 = Dark yellow
6 = Pink	6 = Pale orange
7 = Red	7 = Intermediate orange
8 = Purple-red	8 = Dark orange
9 = Dark purple	9 = Strongly pigmented with anthocyanins

Form 3 Evaluation of Diseases, Pests and Abiotic Stresses

Diseases, pests and abiotic stresses vary among locations and seasons, and may not even occur in some trials. We provide a flexible form, which allows the scientist to fill in the reaction against them and the corresponding date. A standard scale of 1-9 is suggested for all evaluations.

Trial location_____ Date of planting_____

		Clone		Disease		Pest		Abiotic stress	
Plot	**Replication**	**CIP number**	**Name**	**1**	**2**	**1**	**2**	**1**	**2**
Date of evaluation									

Form 4 Post-harvest Quality Evaluations

Clones with acceptable agronomic performance should be evaluated for post-harvest quality traits important in your target region. These may include eating quality and dry matter content. Detailed methods on the evaluation of these traits to suit the existing conditions are given in Chapter 4.

Trial location_____ **Date of planting**_____ **Date of harvest**_____

		Clone		Dry matter		Eating quality					Industrial quality	
Plot	Replication	CIP number	Name	Fresh weight	Dry weight	Appearance	Texture	Sweetness	Fibre	Other	1	2

Form 5 Storage Evaluation and Production of Cuttings from Bedded Roots of Selected Clones

Trial location_____

Date of storage_____

Curing conditions: Temperature (°C)_____ Time_____ RH (%) _____

Storage conditions: Temperature (°C)_____ Time_____ RH (%) _____

				Sprouting		Rotting		Production of cuttings	
Plot	Replication	CIP number	Name	1	2	1	2	1	2
Date of evaluation									

Storage characteristics

In some tropical areas, storage may be of interest, and in temperate regions, storage of roots is necessary. Columns are provided to evaluate sprouting and rotting periodically. Use a 1–9 scale. Indicate the trait evaluated, date, and curing and storage conditions used. (For a description of curing see Chapter 6.)

Sprout production

This is an important trait for those regions where roots are used to produce cuttings. The evaluation should use a 1–9 scale (1 = bad; 9 = excellent; 2 to 8 indicate intermediate values) to answer the question: "How good is the production of cuttings by this clone?" Total numbers, early maturity, uniformity and sturdiness of cuttings should be considered in making this evaluation.

Form 6 Summary of Clonal Evaluation

Clone			Selected			Comments
CIP number	Name	Discarded	Varietal	Breeding	Use	

This form is designed to summarize results of trials and indicate whether experimental clones are discarded or selected.

List clones and indicate whether the clone has been rejected (will not be evaluated again) or selected for further evaluation. Note whether you consider that selected clones have potential for varietal release, or for use as parents in a breeding programme. In addition, note the main end-use, i.e. table, industry, feeding, or other, for which you think a selected clone has potential. Important strengths or weaknesses of clones should be noted in the comment column.

Details on data analysis and clonal selection can be obtained from *CIP Research Guide* No. 6 (Carey and Reynoso, 1997).

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APPENDIX II

Measurement of dry matter content

D. Rees

II.1 Background

In Africa, mealiness or starchiness, has been identified as an important consumer criterion. There have been several cases where cultivars with acceptable production characteristics have been rejected because they are not sufficiently mealy for African tastes. Mealiness is closely, although not completely, associated with root dry matter content. Studies have indicated that the mealiness of cooked sweetpotato is also associated with the extent to which cells break apart when cooked sweetpotato is bitten. This in turn relates to the extent to which starch grains swell during cooking, causing cells to deform and detach from neighbouring cells. In those cultivars with amylases which are stable to heat, much starch is broken down during cooking, such that swelling and cell separation are less. These cultivars tend to have a moist taste. Thus, when determining consumer acceptability, although the measurement of dry matter content is a useful indicator of mealiness, it is not completely reliable, and for advanced cultivar testing should be supported by taste tests (see Chapter 4).

In cases where sweetpotato is processed for starch, dry matter content is of direct relevance, as most of the dry matter is starch.

II.2 Measurement of dry matter content

Dry matter content is generally measured by oven-drying.

Dry matter content can vary between roots, and also for different parts of the same root. In addition, the growth environment can have a significant effect. Thus, measurements for each cultivar should be made at least in duplicate, using two different roots. Where roots are obtained from a replicated field yield trial, a measurement should be made for each plot (i.e. for each cultivar in each replicate).

II.2.1 Suggested procedure

(i) For each variety and replicate, cut thin transverse slices of the root material. Cut the slices again into small sticks or 'matchsticks'. If large roots are used, such that there is excess material, the slices should be taken from the central part of the root. Mix the pieces thoroughly. Small pieces are used, as these will dry more easily.

(ii) Each sample requires a suitable container (such as an aluminium foil tray or weighing tray). The container should be labelled with date, treatment, variety and an additional label such as *a* or *b* to distinguish samples

wherever more than one measurement is taken for each replicate. **Note**: Paper bags are not good containers as they absorb moisture and, therefore, will lose weight during drying.

(iii) Weigh the container [C].

(iv) Add *approximately* 100 g of material and record the exact total weight [FW] + [C].

(v) If possible dry the samples in an oven at 70–80 °C. If an oven is not available, it is possible to get consistent results by sun-drying. This can be especially effective in a greenhouse (glasshouse) or solar dryer.

(vi) After 48 h of drying, reweigh the sample in the container [DW] + [C], and return the sample to the oven (or greenhouse). **Note**: Do not remove the sample from its container.

(vii) Reweigh the sample in the container every 24 h, recording the weight each time, until no further weight loss is seen.

(viii) Calculate the percentage dry weight as 100 x {[DW] +[C] - [C]}/{[FW] + [C] - [C]}.

An example of a form for recording the data for dry matter measurement is given below.

Dry Matter Content Data Sheet

Variety and replication	Weight of container [C] (g)	Fresh weight of container and sample [FW] + [C] (g)	Date and time of measurement				DMC
			Dry weight of container + sample [DW] + [C] (g)	Dry weight of container + sample [DW] + [C] (g)	Dry weight of container + sample [DW] + [C] (g)	Dry weight of container + sample [DW] + [C] (g)	

ABBREVIATIONS

AYT	advanced yield trial
ANOVA	analysis of variance
CIP	International Potato Center
COSCA	Collaborative Study of Cassava in Africa
DM	dry matter
FSR-NCU	Farming Systems Research-National Co-or
HPLC	high performance liquid chromatography
IITA	International Institute for Tropical Agricult
ISAR	Institut Des Sciences Agronomique du Rw
LI	Lignification Index
LSD	least significant difference
LZARDI	Lake Zone Agricultural Research and Deve
MC	moisture content
NARL	National Agricultural Research Laboratory
NARO	National Agricultural Research Organizatio
NRI	Natural Resources Institute
NVT	national variety trial
OP	open pollinated
PCA	principal component analysis
PDA	potato dextrin agar
PRAPACE	Programme Regional de la Pomme de terre
PYT	preliminary yield trial
SADC	Southern Africa Development Community
SARRNET	Central Africa and Southern Africa Root C
SI	Susceptibility Index
SMA	sweetpotato meal agar
SPVD	sweetpotato viral diseases
TNRTCP	Tanzanian National Root and Tuber Crops
USDA	US Department of Agriculture
UYT	uniform yield trial