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IMPROVEMENT OF CASSAVA COOKING QUALITY THROUGH MUTATION BREEDING

E. ASARE, O. SAFO-KANTANKA
Department of Crop Science,
University of Science and Technology,
Kumasi, Ghana

Abstract

Many high-yielding cassava varieties do not have the desired cooking quality. The objective of this project was to induce mutations to produce varieties with improved cooking quality while maintaining the disease-resistance and high-yielding characteristics. A cassava mutant (ISU-W) was obtained after irradiation of a variety from IITA with gamma rays and selection. Cuttings of the mutant were grown for 12 months in a field trial and investigated for tuber yield and cooking quality. Pest and disease incidence were monitored during the entire growth period. The results showed that the mutant retained the high-yield and disease resistant characters of the parent, and had improved cooking quality based on increased smoothness, mealiness and elasticity of the flour.

1. INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is an important staple crop in many parts of Africa and other tropical regions. In Ghana, it is used in many food preparations including the following: 1. Fufu - the boiled tuber is pounded alone or with boiled plantain or cocoyam into a paste and eaten with soup. 2. Gari - the peeled tuber is grated, the moisture is squeezed out during fermentation and the dry matter is fried. 3. Ampesi - the boiled or roasted tuber is eaten with a vegetable sauce. However, there is little or no information on which the plant breeder can rely to select genotypes suited for a specific use. Hence, there is a tendency by farmers to reject an otherwise improved and high yielding variety, if it is unsuitable for their particular food usage.

The cooking quality of cassava has not received as much attention as that in potato. Many research workers have shown that the cooking quality is largely associated with mealiness, colour and flavour. Of these, mealiness is the most variable [2]. Howard [2] classified cooking quality as a broad heading, since different qualities are needed according to use of the cooked product. In potato [7] and cassava [3], a positive correlation has been reported between dry matter and mealiness, when the tubers or roots were consumed after boiling.

Worldwide, several plant breeding programmes have used induced mutations to generate variations to obtain desired mutants with agronomically important traits. In the present study, mutation techniques were used to induce genetic variation for cooking quality in cassava.

2. MATERIALS AND METHODS

Seeds of cassava varieties Isunikaniyan (ISU) and 4(2)1425 from IITA were planted in 1984. Segregants of these varieties were grown and compared with two local varieties (Akosua Tuntum and Atra) for yield, disease resistance and cooking quality characteristics upto 1987. In 1988, cuttings of the segregants from these and other varieties (30474, 60142 and 30001) were given series of irradiations after the appropriate doses (25 & 30 Gy) had been determined. These were grown, and individual plants were examined for yield, mealiness, elasticity and smoothness of the pounded paste.

In 1991, a number of promising mutants were identified, especially in ISU-W. Much effort was subsequently concentrated on the M_1V_3 and M_1V_4 of this variety. Cuttings of this mutant were planted and examined for tuber yield and cooking quality. Only those plants were selected which had yield above 2 kg, and score of 3 or above for mealiness, smoothness and elasticity of the pounded paste. Thus, 32 plants were selected, and five cuttings each of the selected plants were grown.

In 1992, the M_1V_4 propagation was examined on the same basis as in the previous year; in addition, the dry matter content was determined and used as a selection criterion. In 1992, selected lines of the mutant ISU-W were planted on 0.2 ha. Cuttings of the mutant were given to the Department of Crop Services, Ministry of Agriculture for including in the multi-site on-farm trials. In addition, field experiments was conducted at the Faculty of Agriculture, University of Science and Technology, Kumasi, Ghana. The farm site is located at latitude 6°43'N and latitude 1°30'W in the forest belt with mean day/night temperatures of 30/22°C and relative humidity 60/95%, and has a mean annual rainfall of 1375-1625 mm. The soil was a well-drained sandy loam with pH 5.6.

The multi-site trials which included mutant ISU-W with three other improved varieties and a local variety were planted at a spacing of 1.0 x 1.0 m in 5 rows with 10 plants per row at eight sites representing similar agro-ecological zones. Planting was done at various sites during the major rainy season in May, 1994. Friedman's 2-way analysis was used to establish difference between the varieties at different locations.

Weeding was done as and when necessary, and insect pests and cassava mosaic virus disease (CMVD) incidence were rated during the entire growth period. Plants were harvested after 12 months, and examined for the number of tubers per plant, tuber yield and cooking quality. The cooking quality parameters considered were the mealiness of the cooked tuber and the elasticity and smoothness of the pounded paste. The method of Safo-Kantanka and Owusu-Nipah [5] was followed to determine the cooking quality. The scoring system for mealiness (texture), elasticity and smoothness was as follows:

Score	Mealiness	Smoothness	Elasticity
0	not mealy	not smooth	not elastic
1	moderately mealy	moderately smooth	moderately elastic
2	mealy	smooth	elastic
3	very mealy	very smooth	very elastic

3. RESULTS AND DISCUSSION

The seed progeny segregated into different lines and were grouped according to their stem colour. For example, Isunikaniyan (ISU) segregated into a white and dark brown-stemmed types, and was named ISU-white (ISU-W) and ISU-dark brown (ISU-DB), respectively. Similarly, 4(2)1425 produced the segregants, 1425-LB (Light brown), 1425-W (White), and 1425-DB (Dark brown).

Comparison of the segregants with the local varieties showed that the former had poor cooking quality, though some segregants were better than the others (Table I). The comparison of individual plants from the irradiated and local varieties showed varietal differences for mealiness (Table I). Howard [2] emphasized the importance of genotype in determining mealiness (texture). Only the local variety Akosua Tuntum consistently showed good cooking quality during all the years. After irradiation, ISU-W progeny produced tubers which on boiling were mealy, and had smooth and elastic consistency of the pounded paste. The importance of genotype in the control of mealiness (texture) was therefore confirmed. The study of physico-chemical properties of starch and dry matter content of the selected varieties of cassava showed that the mealier varieties had higher content of dry matter and starch (Table II). This indicates that when the gene (s) controlling mealiness are altered by mutagenic treatment, it is reflected in the size of starch granules. It appears that a point mutation might be operative, thus suggesting the simplicity of the genetic control of this complex trait.

TABLE I . COOKING QUALITY CLASSIFICATION OF CASSAVA VARIETIES[a]

Varieties	1987		1988		1990		
	Mealiness of cooked tuber	Consistency of pounded paste	Mealiness of cooked tuber	Consistency of pounded paste	Mealiness of cooked tuber	Smoothness of pounded paste	Elasticity of pounded paste
Akosua Tuntum[c]	M	SE	M	SE	2.2	2.8	2.4
Atra[c]	-	-	M	SE	3.0	1.8	0.3
ISU-W	NM	SE	M	SE	1.1	2.8	2.1
ISU-DB	NM	LI	NM	LI	1.4	1.8	1.8
30474-DB	M	LI	M	LI	0.6	1.0	1.3
30474-LB	M	SE	NM	SE	1.0	2.3	2.3
30001-W	M	LI	M	SE	1.5	0.5	0.3
30001-DB	M	SE	M	SE	0.1	1.1	1.2
4(2)1425-DB	M	SE	NM	SE	0.1	0.8	0.8
4(2)1425-W	NM	LI	NM	LI	-	-	-
4(2)1425-LB	NM	LI	NM	SE	-	-	-

a. Cooking quality classification: M - mealy, NM - not mealy, SE - smooth elastic paste, LI - lumpy, inelastic paste.
b. Score: 0-3 non-mealy to very mealy texture; 0-3 lumpy and inelastic paste to increasing degree of smooth and elastic paste.
c. Local varieties, the rest are segregants of varieties received from IITA. The letters after hyphen distinguish segregants by their stem colour: W - white, DB - dark brown, LB - light brown.

Selection of M_1V_3 and M_1V_4 plants showed that the mutants had good yield and cooking qualities [6]. Comparison of selected lines of ISU-W and other varieties showed improved cooking qualities of ISU-W (Table III), confirming the earlier claim of their superiority.

The results of the multi-site trials revealed significant differences in yield and mealiness of varieties at different locations (Tables IV & V). It has been reported that the genotype and environment influence mealiness of cooked potatoes [2]. Nix [4] found that the

TABLE II. MEALINESS OF COOKED PRODUCT, DRY MATTER AND STARCH CONTENT OF CASSAVA VARIETIES

Variety	Mealiness of cooked product Description	Score	Dry matter content (%)	Starch content (%)
Akosua Tuntum	Mealy	2.2	38.50	31.20
Atra	Mealy	3.0	36.60	30.90
ISU-DB	Intermediate	1.4	34.20	26.50
30474-LB	Intermediate	1.0	36.00	19.60
30001-DB	Not mealy	0.1	35.20	21.60
4(2)1425-DB	Not mealy	0.1	32.60	21.90
L.S.D.(5%)			1.33	1.13

TABLE III. YIELD AND COOKING QUALITY CHARACTERISTICS OF CASSAVA VARIETIES

Variety	Mean no.of tubers/ plant	Mean tuber yield/ plant (kg)	Meali-ness	Elasti-city	Smooth-ness
ISU-W (A)	7.6	5.54	2.80	3.00	2.80
(B)	8.4	5.57	2.60	2.80	2.70
(C)	7.3	5.52	2.50	2.70	2.70
30474-DB		5.20	1.20	2.40	2.20
30001-W		4.40	1.80	2.20	2.20
60142		4.91	2.00	2.00	2.00
L.S.D.(5%)		1.01	0.57	0.62	0.60

yield of crops was a function of the genotype and its response to the environmental and cultural conditions. 'Afisiafi' and 'Gblemo Duade' varieties had good yield but showed consistently poor cooking quality characteristics across the sites. It must be emphasized that in many areas where cassava is consumed as various preparations after boiling the tuber, these varieties may be rejected in spite of their high yields. The local variety gave poor yield, but had good cooking quality. No relationship between yield and cooking quality of cassava and potatoes has been established; however, positive correlation between root dry matter and mealiness has been reported [3,7].

The low yield of the local variety may be due to its genetic make-up and high incidence of CMVD, which affects photosynthesis. 'Abasa Fitaa' and 'ISU-W' varieties produced fairly good yield, and had good cooking quality from most sites. This result is important in terms of selection criterion and adoption of varieties by farmers. Results of the multi-site trials showed that the local variety was more susceptible to CMVD than the other varieties. ISU-W was more resistant to CMVD in all regions and no serious pests were observed on its plants.

TABLE IV. YIELD, COOKING QUALITY AND DISEASE INCIDENCE OF CASSAVA VARIETIES

Variety	No. of tubers/ plant	Tuber yield/ plant	Cassava mosaic virus disease (CMVD)	Cooking quality		
				Fufu Meali- ness	Ampesi Elasti- city	Gari
Abasa Fitaa	5.3	25.1	0.8	2.3	2.3	2.9
Afisi- afi	7.4	28.8	0.8	1.0	1.0	3.0
Gblemo Duade	7.4	42.6	1.6	1.0	1.0	3.0
ISU-W	5.7	27.0	0.5	2.5	2.0	2.9
Local	4.8	15.5	2.8	2.5	2.5	2.9
C.V	16.8	27.2	23.4	30.9	36.1	8.2
L.S.D. (5%)	1.0	7.6	0.6	0.6	0.6	0.67

* Score of CMVD : 0-3, None- very heavy incidence

TABLE V. ROOT TUBER YIELD (t/ha) AT DIFFERENT LOCATIONS

Variety**	1	2	3	4	5	6	7	8
1 (ABF)	22.2	23.6	15.4	18.0	16.0	49.4	30.4	26.0
2 (GDF)	25.8	26.8	20.6	56.0	44.8	90.0	48.5	28.5
3 (AFI)	22.7	28.1	13.2	32.0	34.0	60.4	25.0	15.5
4 (ISU)	27.8	18.0	13.0	35.0	25.2	58.7	24.3	14.1
5 (LOC)	14.8	9.8	11.7	12.0	13.5	36.3	15.3	11.0

*Location: 1-Duase;2-Akomadan;3-Offinso;4-Datoyili;5-Nyeshe;6-Subinso;7-Techiman;8-Nkoranza
Variety: ABF=Abasa Fitaa;GDE=Gbemo Duade;AFI=Afisiafi;ISU=Isu-W mutant;LOC=A Local Variety.

REFERENCES

[1] FRIEDMAN, M. The use of ranks to avoid the assumption of normality implicit in the analysis of variance. Principles and Procedures of Statistics, (STEEL, R.G.D., TORRIE, J. H., Eds.), McGraw-Hill Book Co., Inc., New York (1960).

[2] HOWARD, H.W. Factors influencing the quality of ware potatoes I. The genotype. Potatoes Research 17 (1974) 490-511.

[3] KAWANO, K., FUKADA, W.M.G., CENPUKDEE, U. Genetic and environmental effects of dry matter content of cassava root. Crop Sci. 27(1987) 69-74.

[4] NIX, H.A. The Australian climate and its effects on grain yield and quality. Australian Field Crops - Wheat and Other Temperate Cereals. (LAZENBY, A., MATHESON, E.M., Eds.) Angus Robertson, Sydney (1975).

[5] SAFO-KANTANKA, O., OWUSU-NIPAH, J. Cassava varietal screening for cooking quality: Relationship between dry matter, starch content, mealiness and certain microscopic observations of the raw and cooked tuber. J. Sci. Food Agric. 60 (1992) 99-104.

[6] SAFO-KANTANKA, O. Improvement of cassava cooking quality through mutation breeding. Third FAO/IAEA/ITALY Research Co-ordination Meeting on 'Improvement of Basic Food Crops in Africa through Plant Breeding Including the Use of Induced Mutations'. Nairobi, Kenya (1993).

[7] SMITH, O. Culinary quality and nutritive value of potatoes. In: Potato Production, Storing, Processing. (SMITH, O. Ed.) Avi Publishing Co. Inc., West Port, CT, USA (1968).