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THE CAMIOTA (NON-SWEET SWEET POTATO), ORIGIN, BREEDING, PHYSIOLOGICAL CONTROL, UTILIZATION, AND POTENTIAL FOR THE CARIBBEAN

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INTRODUCTION

Today I want to review for you the status of an important potential root crop for the Caribbean, termed the camiota. This is a kind of sweet potato that is not sweet.

The Sweet Potato, *Ipomoea batatas* (L.) Lam., the sixth or seventh most important food crop of the world, is aptly named for the sweetness of the cooked foods prepared from it. Sweetness varies among cultivars, however, and varieties are recognized for their relative sweetness. The very sweet as well as the low sweet have been important for traditional food uses. The so-called starchy sweet potato with more starch, and with less sugar, but nevertheless, it is still sweet.

The sweetness of the sweet potato depends on both reducing and non-reducing sugars. The non-reducing sugar of most importance is sucrose, and the content varies among cultivars from about 2 to 25 percent. In addition, reducing sugars, especially maltose, contribute to sweetness. The raw sweet potato has a low, often less than one percent, concentration of reducing sugars. However, when the sweet potato is cooketed the enzyme beta amylase is activated and degrades part of the starch to short chains, called dextrins, and to the reducing sugar maltose (Shen and Sterling, 1981). Baking seems to do this most effectively, whereas during boiling some sugars are lost in the water. While cooking is the major factor increasing sweetness, curing and aging of the sweet potato also increase sugars, both reducing and non-reducing (Sistrunk, et al., 1954).

Accompaning the increased sweetness there is also in increase in the perceived moisture of the cooked sweet potato. This is due to the

decrease in long chain and the increase in short chain starch molecules. These changes are of course the work of beta amylase in degrading starch. Cultivars with a relatively small amount of starch degredation have a dry mouthfeel, unpleasant for some people, preferred by others.

It has long been recognized that sweetness and mouthfeel are under genetic control and can be changed by breeding. However, truly non-sweet potatoes are a recent development.

ORIGIN AND BREEDING OF NON-SWEET SWEET POTATOES

In an effort to develop low-sweet or non-sweet sweet potatoes that could serve in the tropics as substitutes for the Irish potato, a sweet potato breeding program was begun in 1980. A decision was made to use the polycrossing technique for changing entire populations in the directions desired, without the need for hand pollinations. Cultivars were obtained form the Caribbean and the United States, and seeds from widely scattered parts of the world. From this initial collection, plants were grown for evaluation in the laboratory. At first, sweetness was determined only by taste tests. Plants to include in the polycross were selected on the basis of low sweetness, white flesh, superior yields, and other horticultural traits. The seeds from the polycross were planted for a second round of testing and selection, and so on.

In the first generation of seedlings an exceptionel clone was found with no sweetness after cooking and with a dry mouthfeel. This seedling, given the temporary number 99 (Ninetynine), proved to be the first of a small number of seedlings of the non-sweet type. It serves as a prototype of the non-sweet potato, although since its origin, exceptionally fine clones on the non-sweet type were produced.

Some of the non-sweet clones were given names to help us remember them. I've always found something sterile with just numbers. Some of these clones are still available in Puerto Rico. These illustrate something of the range of types possible in non-sweet sweet potatoes.

Name of Clone	Characteristics	Limiting Factora
Bugsbunny	Orange flesh, Excellent shape	virus susceptible
Dune	Large roots, heavy yields	Poor kitchen quality
Ivoire	Early, makes Excellent food	Somewhat irregular shape
Margarita	Excellent flavor, color, and texture	Yields not dependable, Virus susceptible
Mojave	Very dry flesh	Yields not dependable Susceptible to virus
Ninetynine	Very dry flesh	Yields not dependable
Tapato	Heavy yields,	Large, irregular shape slightly sweet

Since my finding of non-sweet sweet potato, other persons have become interested and have found other non-sweet types elsewhere. The non-sweet variety Satsumahikari has been developped in Japan (Kukimura, et al., 1988).

In summary so far, there seems to be ample potential for breeding sweet potato cultivars of white or orange flesh with no sweetness and with any combination of other desired characteristics. All that is necessary are the starting materials, a breeding program, the techniques and the time and, above all, the will to do it.

PHYSIOLOGICAL CONTROL ON NON-SWEETNESS

The sugar contents of Ninetynine were compared to those of several other conventional clones both before and after cooking by boiling, conventional baking, and microwave baking (Martin and Deshpandey, 1985). The content of non-reducing sugars varied among the cultivars, and that of Ninetynine was low, but not extremely low. The percentages did not vary due to cooking or according to cooking technique, except that some sucrose was lost in boiling the sweet potatoes. On the other hand, in the conventional cultivars the amount of reducing sugars increased from 300 to 1200 percent during cooking, but the method of cooking did not affect the degree of change. This is

precisely what was expected, and is in agreement with previous results as I have summarized above. However, in the clone Ninetynine the amount of reducing sugars stayed the same, that is, what not affected by cooking. Therefore, the lack of sweetness in Ninetynine was due to the fact that reducing sugars stayed the same during cooking, and that the total amount of sugars after cooking was less than the threshold for tasting sweetness, about 10 percent.

In the same studdy measurements were made of the starch of the sweet potato to see if the lack of starch degradation could be explained by differences in the starch itself. Starch size, starch reducing power, and starch intrinsic viacosity were measured. Some minor differences were found, but these differences in subsequent studies were found not to be associated with sweetness or its absence.

Through a series of simple, detective-like tests it was possible to identify the physiological causes of non-sweetness, which is the lack of activity of beta amylase. But, before I review that evidence, let me remind you that sweet potato is a hexaploid. Thus, with six sets of chromosomes it is possible for a sweet potato to have up to 6 alleles of any gene. In such a plant there can be a dosage effect depending on the number of dominant alleles present. We might expect that the control of beta amylase, an enzyme, is genetic, and therefore, there may be several levels of activity corresponding to the number of alleles and thus to the amount of the enzyme present.

Now, identification of beta amylase is done by its activity. This can be done in a standardized cooking test with a standard starch, or by gel electrophoresis, separating the various proteins in a sample, and staining with starch and an indicator the spot which corresponds to the enzyme. Even then, the proof of the presence of the enzyme is its activity.

When I used gel electrophoresis I found that all normal sweet potatoes had one kind only of beta amylase. If there are isozymes of this enzyme, our techniques did not separate them. In all tests with non-sweet sweet potatoes, no beta amylase activity was detected. From these results we concluded also that it was not necessary to separate the proteins by electrophoresis, and we developed a simple spot test to rapidly identify the presence of beta amylase activity in a simple saline extraction. It was tempting to conclude that no beta amylase was present, but at that moment we could not rue out the possibility of an

inhibitor.

The most difficult to interpret were some low-sweet lines where beta amylase activity was present, but appeared to be weak. In trying to understand these materials we had to remember that sweetness in the sweet potato is not just the result of maltose, but the result of the combined contributions of maltose, sucrose and some very minor sugars. If the sucrose quantity is very high, as indeed it is in some cultivars, then the cooked product wil be sweet regardless of the beta amylase activity. That's why, in analysing sweet potatoes, it is desirable to distinguish between the presence of beta amylase activity, and sweetness itself, the latter by taste tests.

In perhaps the most definitive study made of the cause of non-sweetness, starch samples were isolated from both sweet and non-sweet cultivars. These were cooked in a standardized cooking technique in various combinations alone or with the fresh sweet potato, and afterwards the reducing sugars were measured.

The following observations were made:

The sweet potatoes, when cooked by themselves, yielded reducing sugars or not according to their nature, sweet or non-sweet.

The starches, when cooked alone or mixed together, did not yield reducing sugars in any case, which indicated absence of beta amylase activity.

The starch from the non-sweet sweet potato, when cooked with a small amount of the flesh of the sweet, yielded reducing sugars normally, indicating that the starch itself was a influenced by beta amylase as that of the sweet variety.

The starch from the sweet type when cooked with the flesh of the non-sweet type, did not yield reducing sugars, suggesting the complete lack of beta amylase activity.

Now, here is the crucial test. When the flesh of the two sweet potatoes was mixed and cooked together, the amount of reducing sugars released indicated that the starch of both had been degraded. This clearly demonstrated that the lack of beta amylase activity is not due to the presence of an enzyme inhibitor.

A name is needed to replace the expression non-sweet sweet potato, something related to current names in English or Spanish, potato, sweet potato, kumara, camote, and boniato. I have proposed that the name be camiota.

In conclusion of this part, the evidence suggests that non-sweetness resulte after cooking when sucrose content is normal or low, and when beta amylase is absent. This type of sweet potato is now called camiota.

THE USES OF CAMIOTA

Camiotas, non-sweet potatoes, must be thought of as something different. When one plans to use a conventional root or tuber crop such as sweet potato, yam, cassava, tannier, or others, from previous experience one knows what kinds of dishes might be made from the particulaar crop, and the techniques that will be useful.
Experience tells one that these roots and tubers have much in common but also that they have their own peculiarities. With respect to the camiota, techniques of production are just the same as in the case of conventional sweet potato varieties, but the techniques of usage, as well as the flavors and textures differ.

The camiota is likely to have a dry mouthfeel as well as little or no sweetness, and these characteristics affect its usage. In the laboratory in Puerto Rico we tested the uses extensively, and have published the results, as quoted in the bibliography of this paper. Here I wish to offer informal summaries of the principal uses.

Boiled. After boiling for 20 minutes, mash and add something to increase the feel of moisture, such as butter, milk, or meat sauce, or serve with gravy. This makes an excellent Irish potato substitute and most people will not even know that they are eating sweet potato. Some camiota clones do not need this treatment.

In soups and stews. Dice and cook in soops and stews as if it were an Irish potato, and indeed it will seem the same.

Baked. Bake as if the camiota were a potato, and serve in the same way.

Fried as chips. Cuts into thin slices and fry as potato chips. Add salts or seasoning as desired. Color, taste, texture, and storability will be about the same as chips of Irish potato.

Fried as strips (French fries). Cut into strips and fry as for French fries. The product will be something dryer and will stay firm longer.

Preparation as pulp. Boil the camiota normally and mash. Store

in airtight plastic bags, and use as instant mashed potato at your convenience.

Pancakes. Mix in pulp of camiota as a substitue for about 1/3 the wheat flour (note, because of the moisture added on making pulp, 3 parts pulp equal about one part flour).

Bread. Mix in pulp of camiota as a substitute for about 1/4 the wheat flour used in making bread.

Flour. I do not recommend making flour from sweet potato at the level of the home. If the flour is not well made, using an antoxidant, the flour will suffer the Mallard reaction on cooking, that is, discolorattion, bad oder, and bad taste. This reaction is due to the combination of reducing sugars with protein, and is subdued but not entirely absent on making flour frrom camiota.

RECEPTION OF CAMIOTA BY THE PUBLIC

The success of any new product requires first that it be good. Then, it must be distributed to those who can use it, the potential users must try it, and they must decide that it is good and that they should purchase it regularly. In addition, it is necessary that producers, middlemen, and consumers are satisfied by a net work of circumstances, including the financial aspects of the product. It has been said that one can produce in the laboratory the best possible product, or for that matter, the best possible variety of a particular crop, ant it wont make any difference in the Caribbean. With respect to the sweet potato as well as the camiota, there can be no doubt of the difficulty of bringing new cultivars into general use.

Of the four requirements that I have mentioned, as a scientist my responsibility would be that the new sweet potato is good. In the case of the camiota, this was done in Puerto Rico by an extensive series of informal and formal tests. The most pertinent data have been published and are included in the bibliography. I shall now mention both informal and formal evidence of the worth of the camiota.

Personal evoluation. Because literally thousands of seedlings of sweet potato passed through my hands each year, I have considerable confidence that what I and my former assistants identified as high quality is indeed high quality. Initial identification of high quality was

verified by many subsequent tests, and much that was only superficially good was discarded during the process. I am convinced by experience of the value of camiota.

Evaluation in the family. My family has had to test many sweet potatos as a consequence of my professional interest. The family does not suffer from professional aspirations and readily rejects what is not liked. The family is spoiled and expects high quality with every serving. I have lived for six years in Florida, and grown the camiota clone Ivoire, and the family has convinced me of its high quality.

Haitian agronomos. I taught a course in sweet potato production in three locations in Haiti to agronomos, and, as part of the course, we tested twelve of my sweet potato clones. The sweet potatoes were boiled, without further treatment. The reactions required of the participants were simple, good, bad, or between good and bad. The agronomos cooperated with great interest, for they were very much concerned with sweet potatoes. All ratings were high, for, after all, these were all highly selected clones. The camiota clone Margarita was the highest rated among the clones tested. The camiota clone Ninetynine received intermediate ratings.

Senior citizens. About ten clones of my sweet potatoee were tested in a Catholic home for old persons in Puerto Rico. Each night one clone was presented, only boiled. Participants were asked several questions about the clone of the night. Again, the camiota clone Margarita rated the highest of all clonea tested. The clone Ninetynine received only intermediate ratings. Many persons commented that these two clones were not sweet potatoes.

Small farmers, USA. The camiota clone Ninetynine was obtained by university in Northern Alabama, USA, along with other clones of mine. According to reports, when small farmers became acquainted with this clone, they liked it, and a small industry has been established around it.

Small farmers, Haiti. In northern Haiti, where a collection of my been established, the clone Tapato, which is high yielding, mild flavored, not too dry, and very slightly sweet, has been accepted by the local people, end is replacing all other locel varieties.

Fries and chips. French fries and potato chips from the camiota clone Ivoire have been served on numerous occassions to many people of diverse origens and interests, always with a high degree of reception.

This informal evidence, which cannot be evaluated statiatically, suggests that the camiota clones in question are indeed recognized, when presented, as valuable.

In more formal trials camiota selection were compared to normally sweer, sweet potatoes. Thirteen selections including 4 selections of camiota were evoluated for appearance, mouthfeel, taste, sweetness, and overall acceptability in three tests, in part with the University of Puerto Rico (Martin and Beauchamp de Caloni, 1988). Not all trials included every selection. In the first trial boiled pieces of nine selections of sweet potato were evaluated by a trained panel. The highest rated clone was Tapato, a very low sweet camiota. This was rated very low for sweetness, but of accepteble mouthfeel. The lowest rated clone was Ninetynine, rated the same for sweetness but of unacceptable mouthfeel.

In the second trial boiled cubes of 8 selections were rated by 5 to 27 untrained coworkers at the rate of one selection each dry. The highest rated clone, a camiota, Margarita, was judged even lower than the lowest, Ninetynine, in sweetness. Again, Ninetynine was too dry for most palates.

In the third trial five famillies rated 10 selections, one a day, in their own homes. Each was asked to cook the sweet potato or camiota according to the family habits. Again, Margarita was Judged to be the best, with excellent mouthfeel, and very low sweetness.

In these trials what stands out ia that camiota varieties differ in mouthfeel, and very dry mouthfeel was rejected by most people. The correlation between mouthfeel and overall acceptance was significant at 0.73. There was no correlation between sweetness and acceptability.

I think the results are clear. Some camiotas are just fine as they are when cooked and presented with no special treatment. Others are quite dry and are acceptable to most people only when something is added to improve mouthfeel. A little butter or cooking oil does a good job of this.

PROSPECTS FOR THE CAMIOTA IN THE CARIBBEAN

With respect to the future of the camiota in the Caribbean it is possible now only to speculate. But, in speculation we cannot forget

what we are, numerous islands representing diverse political entities, each with its own program and priorities, problema of communication in spite of the presence of the most modern technology, problems in transportation and distribution, problems of economy, problems of finding a way to pay for what we perceive to be necessary, and the perennial problem of the hot, humid tropics, that it's nice not to push too hard. Yet, in spite of obstacles, changes do occur, and what we do influences such changes.

The first and minimal impact of the camiota could be varietal substitution. There is some evidence that this is already accurring on a very small scale. It is likely to be a slow and frustating process, and depends on numerous formal and informal trials and decisions. To facilitate this process individual islands need small but long term programs of introduction and testing of sweet potatos and camiotas. It may be possible to begin with camiota clones now developped and still available in Puerto Rico. Over time, a breeding program for the Caribbean will be necessary. Clones that are identified as superior need trial in the hands of the penultimate judges of quality, the farmers, and the final judges, the consumers. The complex relationship of farmer, middleman, marketer, and consumer needs to be resolved, not once but thousands of times. Advertising has been adopted as a medium for training and for swindling the populace in the so-called advanced economies, but this propaganda is purchased very dearly, backed with megabucks.

The second potential impact is import substitution. This is probably still more difficult to achieve, for it requires more complex arrangements and changes. As a prerequisite camiotas must be produced in market quantity and quality. The next step would be the use of camiotas in a wide variety of home dishes and processed products. While the research so far has suggested some of these products, much more must be done until extension people are well aware of the value of the camiota. Many, many persons must be convinced. With time, one might expect that it will not be necessary to import potatoes on those islands that cannot produce them. I visualize the possibility of camiota breads; and of sweet potato breads, and since bread is a big item in the diet it might be possible to reduce the importation of wheat. With time the hotel industry might want to serve camiota products, not only because it is economical to do so, but because it is fashionable, and

because they taste good.

Yet these economic benefits might be small compared to the tremendous current of money that leaves the Weat Indies constantly to import the junk of other cultures, and to change to foreign values not compatible with what these islands are, or their long term needs. I do not know how to stop this economic loss, for I am not an economist, nor do I know how to preserve the best of local cultural values, for I am not an anthropologist. I am just a sweet potato breeder, and I do know a good sweet potato when I see one, and I know that the camiota is something good for the Caribbean. It will be people like yourselves that will make it come about.

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DONNÉES SUR LA REPRODUCTION SEXUÉE ET LES POSSIBILITÉS DE SÉLECTION CRÉATRICE CHEZ *D. ALATA* et D. *CAYENENSIS-ROTUNDATA*.

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avec la collaboration technique de C.SUARD et J. GELABALE

RÉSUMÉ : Après une brève description des inflorescences, nous passerons en revue les différentes limites que nous avons pu recenser à la recombinaison sexuée. Enfin, nous envisagerons les solutions et les perspectives en matière de sélection créatrice.

ABSTRACT

Authors : F. PIERRE -GAMIETTE et L. DEGRAS
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TITLE : DATA ON THE SEXUAL REPRODUCTION AND THE POSSIBILITIES OF BREEDING NEW VARIETIES IN *D.ALATA* AND D.
CAYENENSIS-ROTUNDATA.

ABSTRACT : After a brief description of the inflorescence, the different limitations found in sexual recombination will be reviewed. Finally, the solutions and prospects in the field of breeding will be considered.