STARCHY ROOTS IN THE DIETARIES OF DEVELOPING TROPICAL COUNTRIES

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The Food and Agricultural Organization of the United Nations regularly publishes food balance sheets for about 65 countries. In 38 of these, starchy roots and tubers and starchy fruits provided more than 100 calories per person per day in 1964/65 ; in Poland and Colombia they provided more than 400 calories, in Paraguay more than 700, and in Uganda almost 1,000 calories. Not included in the set of food balance sheets are many of the countries of Africa and southeast Asia, for the very good reason that statistics of production and disposition (even statistics of populations for some countries) are so poor that the FAO statisticians have been unwilling to attempt to construct food balance sheets from them. The United States Department of Agriculture, which does not operate under the same proscription from adjusting official estimates that FAO must observe, has published estimated food balances for 90 countries. In 65 of these more than 100 calories per person per day are believed to come from the starchy roots and fruits, and in 18 countries of tropical Africa and the tropical Americas, more than 400 calories.[1] The Department estimates that in 6 of the 14 countries of tropical Africa for which it has published food balances, starchy roots, tubers, and fruits contribute more than 1,000 calories per day. Food balance sheets for geographically large countries with a wide range of climates may obscure the importance of the starchy roots over extensive areas if they include in one national total such different climatological areas as southern and northern Nigeria, or north eastern and south eastern Brazil.

In Western Europe the starchy roots are more clearly supplementary foods than staples, although they are an essential item in most menus. In Ireland, where potatoes were once the preeminent staple, they now contribute only 265 calories to the daily diet and records of the past three decades show consumption declining there, as it has been in all of the western countries except Spain and Portugal.

M. K. Bennett has demonstrated that declining consumption of the cereals, starchy roots and tubers, and starchy fruits — the starchy staples — typically accompanies an increase in per capita income, and that the starchy staple ratio may be used as an indirect measure of relative income levels. Declining con-

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Countries for which the Department finds values of 400 or more calories per person per day are : Angola, 661 ; Cameroun, 1,094 ; Congo (Kinshasha), 1,506 ; Ghana, 1,297; Guinea, 646; Ivory Coast, 1,537; Liberia, 756; Malagasy Republic, 506; Nigeria, 1,219 ; Sierra Leone 583 ; Tanganyika, 1,389 ; Togo 1,063 ; Brazil 568 ; Dominican Republic, 555 ; Ecuador, 553 ; Haiti, 439 ; Panama, 447 ; Paraguay, 704. Estimates were not published for Uganda. The very tentative character of many of these estimates is illustrated by the figure for Nigeria, which implies that 50 per cent of all food calories come from yams and manioc. This figure seems reasonable, or even a little low, for the Southern Regions, but more than half of the country's population lives in the Northern Region, where the roots are a minor element in the diet.

sumption of starchy roots appears to be an aspect of the declining starchy staple ratio. Records for the United States, however, show the rate of decline in potato consumption to have been less than for the cereals over the period 1880 to 1960. Perhaps this is not surprising given the much greater importance of cereals at the beginning of the period when wheat flour contributed 1,000 calories a day and cornmeal 652 calories against 168 from white and sweet potatoes. By 1910 wheat flour consumption was unchanged, but maize products and potatoes were about equal at 229 and 189 calories. By 1959, consumption of wheat flour had declined nearly 50 per cent from this level, as had potatoes, but maize products were off 85 per cent and provided only about one-third as many calories for human consumption as did potatoes.[2]

II

The great prominence of root crops in tropical diets results essentially from the large amount of food calories they yield per unit of cleared land, in agricultures where a major cost of food production is the physical effort of claiming land for cultivation. Long-fallow agriculture — shifting cultivation — today is most widespread in tropical Africa of all the continents, and estimates of yields there clearly demonstrate this superiority. For West Africa, B. F. Johnston reports yields of sweet potatoes, cocoyams, yams, and manioc of from 1.25 to 4.20 times those of the millets and sorghums in net food calories per hectare, or from slightly more than (cocoyams) to 3.5 times (manioc) those of maize and rice. In Congo (Kinshasha) manioc yields are approximately 4 times, and yields of sweet potatoes and plaintains about double, those of rice and maize.[3] Comparison of yields of manioc and other staples province by province in Congo shows manioc to outproduce maize and rice in all provinces except the high country of North Kivu, with an advantage ranging from about 10 per cent in Maniema to nearly 400 per cent in Lac Leopold II.[4] Similar comparisons for Nigeria show manioc and yam yields about the same as the cereals in the drier northern provinces but exceeding cereal yields in the south by 100 to 250 per cent. Statistics of crop yields elsewhere in the tropics reveal this same superiority of the roots, particularly of manioc, over the cereals when growing conditions are similar, a superiority frequently enjoyed also by the plantain. The high yields of manioc are less impressive where seasonal rainfall distribution permits two growing seasons. Then yield per acre per year may be little more than can be obtained by double-cropping maize or rice because of the long period the manioc crop must occupy the field. Manioc's yield advantage is most dramatic on soils so poor as to make other crops uneconomic, or in areas subject to frequent drought that may periodically make seasonal cultures a total failure.

There is something of a paradox here. The roots, and especially manioc, are highly productive of food calories in terms of natural resources utilized. But they enjoy their greatest popularity in tropical Africa where land, in the sense of

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2 M. K. Bennett and Rosamond H. Peirce, "Change in the American National Diet, 1879 – 1959", **Food Research Institute Studies,** II, 2, 1961.

3 B. F. Johnston, **Staple Food Economies of Western Tropical Africa,** 1958, pp. 126–27

4 W. O. Jones, **Manioc in Africa,** 1959, p. 259.

unoccupied geographical space, was until recent years essentially a free good and even today the space available for cultivation is still relatively plentiful in most places. If the popularity of manioc — and let us speak only of this root crop for a bit — is to be explained by the cheapness of the calories it provides, it is not enough to say that it gives high yields per acre on relatively costless land. How cheap is it in terms of the limiting factor, the amount of labour that can be employed? How many calories does manioc yield per man-day?

Statistics of labour costs of growing and harvesting the tropical starchy staples under comparable conditions are fragmentary and confusing. In general, however, they suggest that the time required to plant and to cultivate an acre of maize and an acre of manioc are roughly the same, varying with how the field is prepared for planting and how many times the growing crop is weeded. If more careful preparation of the soil is thought to be necessary for maize, this cost may be offset by the longer time required to prepare the manioc stakes for planting. Although manioc occupies the land much longer than does maize, it may be necessary to weed it no more or even less often than maize if the leafy tops establish a good canopy early. The major difference is the labour required for harvesting, but it is so because of the difference in yields, and is probably not as great as that difference even when yields are measured in calories. Moreover, because timing of the manioc harvest is not as critical as for most other crops, the opportunity cost of labour used in harvesting may be much less, an advantage enjoyed in part by maize only in colder regions. The productivity of labour up to harvest is therefore greater for the crop that yields more per acre, and the advantage may be increased when harvesting costs are added. Increased yield per acre may be taken to imply increased yield per man-day.

That this must be true — that both land and labour costs of growing manioc are low — is confirmed for Africa at least by comparison with market prices of the starchy staples. At nearly every place where manioc is available in significant quantities, some one of its products costs the consumer substantially less in calorie terms than any of its competitors. This can only be so if total production costs are less.

In comparison with starchy staple prices, the qualification that manioc *in one of its forms* will be cheapest, is necessary. In urban markets, fresh roots are frequently much more expensive than dried ones ; and manioc meal (gari or farinha) may sell for quite a bit more than less highly processed forms of the dried root. That the price of a prepared foodstuff like manioc meal should reflect the additional labour costs involved in its manufacture is not surprising, nor is it unreasonable that the high perishable and bulky fresh roots should command a price sufficient to repay the transport costs and the risk of sending them into urban markets some distance from the farms where they are grown. It is a bit surprising, however, to find urban consumers willing to pay the high fresh root prices asked for what is generally regarded as an inferior good. The answer here may be that fresh manioc roots enter the diet more as vegetable than as starchy staple in the pure sense, that is, they occupy a place in the dietaries of tropical cities similar to that of potatoes in European cities. That dual character of potatoes, too, may explain their persistence in European and American diets at a low but significant level. (It is not uncommon in American restaurants to be offered a choice of two out of three "vegetables", one of which is potatoes.) In European-type diets the potato's position in menu planning reinforces its place in consumption. For manioc,

the use in Brazil of farinha as a general dressing for other dishes is the nearest analogy.

It is not, however, because they are preferred as vegetables that potatoes, yams, manioc and taro have served as major providers of food calories, but rather because they have been the cheapest sources of these calories, just as in other places and in other circumstances the great cereals have supplied the cheapest food calories. That cost, not taste, is the primary determinant of the dominant position of the starchy staples is confirmed by the negative correlation between starchy-staple ratio and income. In general, we may expect that as the low income countries succeed in efforts to raise consumer incomes, effective demand for the roots and tubers, as for the cereals, should fall. As between these two major groups, we might expect that rising incomes would be accompanied by a shift from roots to cereals, followed by a decline in consumption of the cereals themselves, for there is evidence of a general preference for cereal products over root products as staple foods. But this evidence is not conclusive, and the tendency it implies may take decades to manifest itself. For useful prediction of the future position of the roots, more detailed examination of the development process and of its implications for the root crops is required.

III

The long-run goal of economic development is to increase net output per capita. Most often this means to increase consumer income, although occasionally this objective may be subordinated to that of increasing the economic power of the state. The principal means to achieve this objective is through increased specialization in production, made possible by improving productive skills and expanding the nation's resources through saving and investment.[5] Specialization and increased use of productive capital result in transfer to urban industrial centres of a large number of economic functions previously performed in the rural area; economic growth is accompanied by a relative growth in manufacturing and in services provided by transport and communication agencies, by public utilities, and by government. An increasing proportion of the population comes to live in cities, and eventually, even though total population may continue to grow, the number of people living in the countryside declines. The essential characteristics of developing countries that may be expected to affect demand for the starchy root crops are rising consumer incomes and increasing urbanization. Independently of these consequences of development, however, demand will also be influenced by continuing growth of total population, and by continuing growth of the rural population in the early period of development, a period that may extend over a number of decades. The quantitative information needed in order to make firm predictions of the effect of each of these influences on the competitive position of the root crops is lacking, but a considerable body of evidence supports the reasonableness of speculations about their direction and sequence, even though estimation of the magnitude of the changes they may induce is beyond our grasp.

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5 Specialization in itself, of course, tends to improve productive skills, and increased reliance on the market for allocation of resources and products tends to bring the members of the society who are potentially most productive into control of the productive and distributive process. Over and beyond this, however, is the contribution made by new knowledge and new skills to specialization and to productivity.

Where uncultivated lands still remain, as they do in some parts of the tropical world, larger rural populations can be fed simply by bringing more land under cultivation with the increased labour force they provide. But this cannot go on for long without forcing farmers to alter their cultivation practices. As open land becomes less available, fallows will shorten and yields decline. If there is no other change in technology,[6] the decline in nutrient content of the soils may be expected to bias production in the direction of the crops yielding more calories per acre, even though their labour costs may be relatively high. This would seem to favour the entire set of starchy roots. In fact, as land becomes dearer the relative cost advantage of manioc over yams may decline, despite, or rather because of, the greater amount of labour required in yam production. Manioc would continue to be cheaper to grow, in terms of labour and land, but the difference would be relatively less than when the cost of land was less, i.e., when the ratio of wages to economic rent was higher. Possibly the response to increasing population in Southern Nigeria was something like this in the early decades of this century. The evidence is not clear, and other changes in the economic environment were taking place at the same time. Various observers have reported, however, that southern farmers were producing yams for sale to the cities and growing manioc to feed to their families, and it may be that this represented a more rapid expansion of yam than of manioc production. If the only change is growth of population such a tendency cannot go on for long.

Increasing land scarcity must inevitably lead to declining rural incomes until farmers can no longer employ land in ways that contribute less than they might to the supply of food calories. Absolute yield advantage now takes over from relative advantage, and just as yams may have displaced competing maize, now manioc replaces yams. This shift to a less preferred staple represents a decline in consumer satisfaction, that is to say, in consumer income. It need not, however, result in nutritional deterioration of the diet if advantage is taken of the superior productivity of manioc to grow food crops with high protein content on some of the land once devoted to yams. If economic growth has progressed far enough so that farmers have market outlets for their products, some of the increased production of food calories in the form of manioc may be sold and the proceeds used to buy supplementary foods.

When the commercial economy is still more highly developed, and farmers can rely on the market for their basic food supply, relative yields may again become important, with the consequences that yam or even cereal production takes over where these crops yield best, even though manioc might yield well too, and manioc production is concentrated in areas where its competitors do very poorly. Overall, the relative contribution of manioc to rural food supply should still be expected to increase because of declining wage income in farming and rising land values. This change has in fact been observed in various parts of tropical Africa and in Indonesia, perhaps elsewhere.

Eventually, if development is carried through successfully, the time will come when rural population begins to decline. Greatly increased productivity of labour in the industrialized sector will long since have influenced wages in the farming sector too, and this, combined with the shrinking agricultural labour supply,

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6 A shortening of the fallow period is itself a technical change.

will reverse the relative importance of wages and rent in determining comparative costs of the staples. If capital can be substituted for labour equally well in the production of all starchy staples, their comparative costs will be altered less by this change in factor costs, but experience to date has been that mechanization of cereal culture is much easier to achieve than mechanization of root culture. Here the potatoes appear to fare best, the yams least well. Mechanization of manioc culture lacks only the solution of the problem of harvesting and even here appreciable reductions in labour cost can be achieved by mechanical topping and by cross-ploughing before lifting. But digging of the roots continues to require a major labour input.[7] Even when mechanical harvesting of root crops is possible, however, the cereals, because of their lesser weight per thousand calories, will tend to benefit more than the bulky roots. Mechanization achieves large savings in labour costs in the processing of the cereals and of manioc flour and meal; it is of little importance for the other roots. Mechanization of field operations and mechanization of processing have somewhat different implications, depending upon the stage of economic growth. (These are explored tentatively in the last section of this paper.)

Economic development, however, implies that consumer incomes are rising; for those parts of the population enjoying an increase in income, cost considerations may be expected to play a lesser part, and taste considerations a greater, in the composition of food consumption. It will probably be the city dwellers who enjoy these first fruits of increasing national productivity. Building the specialized manufacturing and processing industries to take over the functions once performed by rural populations requires that a greater part of the nation's capital stock and labour force be placed at the disposal of the manufacturing sector. Whether in a socialistic or a capitalistic state this implies relatively higher economic rewards for those engaged in the favoured urban industries than for those still employed in rural occupations. It is a persistent characteristic of the developing countries, however, that although average incomes may be higher in the city, greater poverty may be found there too. The chance for better wages in the town serves to lure the countryman in greater numbers than the new industries can absorb. As a consequence, a certain number of the migrants find themselves less well off than before.[8] On the whole, however, the urban population may be expected to enjoy a relatively higher income, and a rising one.

The revolution in effective demand for staple foodstuffs that comes with a move from country to town is fairly complex. Income, food costs and availability, and tastes as well are likely to alter. Those who experience rising income may be expected to buy more of the higher priced foodstuffs previously denied to them and total expenditure on food should increase. Engel's law says that it will increase less than income; availability of a wide range of non-food commodities not to be found in the country will make the increase in food expenditures even less. Nevertheless, relatively high income elasticities of demand are likely to prevail in these populations for which expenditure on food accounts for such a large part of total

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7 A. Krochmal, "Labour Input and Mechanization of Cassava," **World Crops**, September, 1966.

8 Increasing population alone may produce a similar migration to the cities where poverty-stricken rural workers seek some relief from government and wealthy townsmen. The movement to the cities is a familiar aspect of the great famines.

income. This implies a decline in consumption, or at least in upgrading, of the starchy staples in terms of consumer perference.[9] Typically, upgrading takes the form of substituting rice or wheat flour for manioc and sweet potatoes, probably for taro and yams. The income effect alone for this part of the population should reduce consumption of the starchy roots as staples, although they may continue to occupy a position as vegetables at a much lower level of consumption. For the poorer city dwellers the effect might be expected to be the reverse.

Other forces alter the effect of changing incomes. Growing city populations draw their supplies from ever-widening areas, and as the supply hinterland increases, so does the cost of transport. Because of their higher moisture content, the urban prices of fresh root crops, in terms of food calories, rise much more rapidly than prices of cereals, and prices of highly perishable fresh manioc roots rise more rapidly still. The end result may be that the root crops are no longer the cheapest sources of food calories in the cities, despite their lower costs of production. But here we must again single out manioc for special attention, for it alone yields a widely accepted product in the form of manioc meal or flour which enjoys the low cost of transport of the cereals and approximates their keeping quality. Increased transportability and storability are not achieved without cost, and manioc meal is more expensive in rural markets, in calorie terms, than are fresh roots, although the relationship is typically reversed in town. At the same time, the cost embodied in the processed product yields a service to the consumer in the form of much greater ease of preparation for the plate, a matter apt to be of more significance to the townsman than to the rural householder. Higher wages mean higher opportunity cost of labour, and more rigid work schedules plus the distractions of city life mean less time for the kitchen. In much the same way that ready-baked bread and rolls make wheat flour more attractive, so does gari or farinha increase the appeal of manioc. [10]

In general, then, the competitive position of most root crops in urban diets may be expected to decline, both because of higher cost of marketing and because of higher incomes. Demand for manioc in the form of meal, however — although affected adversely by income — may be heightened by consideration of cost and convenience. For that part of the city population that is unable to find regular remunerative employment it will have an additional appeal.

IV

Let us consider what might be expected to happen in a country with a growing population and rising per capita income. Let us assume that the increase in population has already created a sufficient shortage of land so that it is being brought into higher uses and the demand for food calories is provoking a shift

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9 Household expenditure studies in tropical Africa show more evidence of upgrading than of decline in the starchy-staple ratio (cf. Poleman, Kaneda and Johnston, Jones, 1960).

10 In many African cities, where men without families make up a large part of the working force, the ease of preparation of manioc meal is of even greater importance.

toward staple foods with higher calorie yield, but without other changes in farming practices.

In the early stages of development farm population will continue to rise and the pressure for food calories will intensify. In those parts of the rural sector with few and unremunerative market outlets, the drive to higher calorie yielding crops will intensify and the kinds of shifts in cropping patterns that have been reported in many parts of tropical Africa may be expected to occur. To other farming areas, however, economic development will bring improved market opportunities, and acreage formerly devoted to subsistence crops will be planted to those bringing a higher cash return per acre and per hour. If the density of rural populations is very high and labour costs low, the shift may be in the direction of more labour-intensive crops including double-cropping when rainfall or irrigation makes this possible. In either event the area available for staples may be expected to decline. The consequent shortfall in supplies of food calories can be made good by substituting crops with higher calorie yields for those with lower yields, e.g., by growing manioc instead of yams, or it can be met by purchasing part or all of the staple food supply with proceeds from the cash crops.

Urban population rises more rapidly. Recent migrants are compelled by low incomes, changed relative prices of foodstuffs, and the opportunity for new kinds of expenditures to save on maintenance cost by consuming the cheapest staple. Earlier migrants who have found the economic advancement they sought will consume increasing quantities of the dearer, preferred staples — rice and wheat flour when they are available. For the country as a whole demand for the high-yielding roots and their products will continue to increase until development has progressed far enough so that increased purchasing power of the cities begins to offset the income-depressing effects of rising rural population. This may be a very long time indeed.[11]

If significant increases in consumer income are to be achieved, sole reliance cannot be placed on expanding the urban population and raising its productivity. In a country where city employments occupy 20 per cent of the working populations, for example, and, with urban and rural incomes equal, to increase income 2 per cent per capita per annum assuming no change in total population would require a 10 per cent annual increase in urban productivity. If town workers are already twice as productive as rural workers, it would nevertheless require a 6 per cent annual rise in urban productivity or a 12 per cent increase in urban employment. If rural productivity can be increased at a rate of only 1 per cent per year, required increases in urban productivity become 6 per cent, and 4 per cent without migration.

Increased productivity in agriculture comes about first because expansion of market economy permits specialized production of crops for which comparative advantage is high. In these early stages the export market tends to dominate all

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[11] B. F. Johnston has calculated how long it would take, at varying growth rates, for populations one-fifth urban and four-fifths rural at the outset to reach the point where urban and rural populations are equal and the point where rural population begins to decline. If total population grows at 2 per cent per annum, and the non-farm labour force at the very high rate of 4.5 per cent per annum, the farm labour force would begin to decline after about 35 years and would equal the non-farm labour force after 40 years. (Johnston, 1966.)

farming investment and research. As commercial activities in the producing country expand, however, the local market for food, and later for feed, becomes increasingly important, and specialization in production of food crops for market profitable. Many parts of the tropical world are in this stage now, and are far from exhausting the rewards that specialization can bring. As they do, new investments in food crop production become necessary if agricultural productivity is to continue to increase, investments that may take four principal forms — alteration of production methods without increased inputs of the productive factors ; improvement in planting material ; expanded use of purchased inputs such as fertilizer, pesticides, and herbicides ; and capital investment either in machines or in the farm itself. The major need for fixed capital in the industrial sector argues against similar investment in agriculture except when capital can be formed primarily by labour, as in ditching, building and levelling. The large working population in the rural areas argues against labour-saving mechanization. The indicated strategy appears to call for improving farming practices, improving varieties, and increasing the use of purchased inputs.

Productivity of the tropical starchy roots can undoubtedly be raised significantly by the use of improved varieties, as it has been for potatoes. It is not clear that changes in farm practices can significantly alter return per acre or per man day ; at least the large amount of agronomic research on manioc culture seems not to have resulted in economically important advances. It seems unlikely that economic returns from the roots will justify extensive use of scarce and costly fertilizers on a crop like manioc, although it may be profitable for roots that enter the diet as vegetables.

For manioc, but not for the other roots, there may eventually be great advantages in mechanization, especially because of the market open to this crop in its dried form. If it is to become a staple foodstuff for low income city populations, regular and large supplies of a standardized product must be obtained. It is extremely difficult to assure such supplies from a multitude of small processors. It is being done in some of the cities of West Africa, but the low returns per man hour afforded by this production suggest that output will decline as labour productivity elsewhere rises, and the highly differentiated product results in high and increasing market costs as volume of sales rises.[12] Regularity of supply is a strong argument for mechanized processing ; it is reinforced by the large labour savings that can be effected. Manioc processing by hand methods requires as much or more labour than growing and harvesting the crop, labour performed usually by women. Labour saved by mechanization cannot make much of a contribution to field operations, but it will permit the women of the household to devote more time to domestic duties and care of their children and may enable the girls in the household to obtain more formal education.

Fully mechanized processing plants have nearly always had difficulty in obtaining a regular supply of fresh roots and have most often found it necessary or desirable to establish their own plantations. On manioc plantations of any size the arguments for as complete mechanization as possible are again compelling if costs are at all comparable, for mechanical ploughing, stake preparation, planting, cultivating, cutting, and lifting could greatly reduce reliance on less dependable

12 R. Galletti, K.D.S. Baldwin, and I.O. Dina, **Nigerian Cocoa Farmers: An Economic Survey of Yoruba Cocoa Farming Families,** Nigeria Cocoa Marketing Board, 1956.

labour supplies. For the long-term development of manioc as an economic crop, efforts should continue to achieve complete mechanization of the harvest. This will probably require the development of new varieties with roots more amenable in shape, size and number to machine-harvesting as well as research on the machines themselves.

The market for manioc products in the immediate future is probably to be found in supplying calorie requirements of lower income populations of growing cities. Its longer-term market is undoubtedly as a feedstuff. Rising incomes will both increase the demand for meat and the demand for cereal foods. If manioc producers can devise ways of reducing their requirements for labour, which will become increasingly costly in this final stage of economic development, manioc should be able to realize a continuing competitive position as principal element in animal rations.

Dried manioc roots are presently imported in quantity for animal feeding in Western Germany, but there must be some skepticism about potential growth of this market so long as manioc products are widely consumed as human food in the producing countries. One of the problems in the international market for cassava starch has been the way in which exportable supplies have been reduced when economic reversals or shortage of other foodstuffs caused roots to be diverted to human consumption in the producing countries. Steadily rising incomes should eventually reduce the possibility of such diversion, while the improved marketing system accompanying economic progress eases the flow of roots to the processor.

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