Handbook of Tropical Foods

edited by

Harvey T. Chan, Jr.

HANDBOOK OF TROPICAL FOODS

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HANDBOOK OF TROPICAL FOODS

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Preface

The tropics contain some of the most starvation-stricken and nutrient-deficient regions in the world, including many of the developing countries. Postharvest food losses in these countries have been estimated to range as high as 14 to 32%. A great deal of these food losses can be prevented through the application of appropriate food handling and preservation methods. These methods are known about but not used because documentation is not widely disseminated. Only within the past decade have the major scientific journals published to any extent articles on noncash tropical foods. The rejection of many of these articles on tropical foods was justified on the "restricted regional interest of tropical foods." As a result, many tropical food researchers were forced to publish in regional journals, experiment station bulletins, in-house publications, and conference proceedings, all of which have not only a limited distribution, but also in some cases a limited readership due to publication in languages not readily understood by the general scientific community. As a result, there remains a wealth of information lying secluded, scattered, and buried, waiting to be unearthed.

Currently, the most highly developed knowledge of tropical crops concerns the export items of commerce involved in the colonial merchantile-plantation system. Attention to indigenous tropical food systems has been severely neglected; only in recent times have the hunger problems of these areas been recognized and addressed on a worldwide basis. It was not until 1967, at the First International Symposium on Tropical Root Crops, that the role of root crops and their yield potential in comparison to other crops was recognized.

This book contains chapters on two major tropical root crops, cassava and yam, and includes a chapter on the neglected aroids and arrowroots. Other chapters discuss fermented fish products, which are important to the tropical diet but have been virtually ignored due to nonacceptance in occidental fare; amaranth, which has been described by the National Academy of Sciences as an underexploited tropical plant with promising value; palm oil, a cash crop of the tropics whose by-products are an important part of the region's diet; rice, the major staple of the tropics; ginger, an important flavorant, condiment, and confection; tropical fruit wine, a relatively new product with potential economic value; mangoes, papayas, and guavas, which are widely distributed throughout the tropics and whose products have potential value; macadamia nuts, sold at gourmet prices but with tremendous potential as a cash crop for underdeveloped countries; and bananas and citrus, two important cash crops of the tropics.

This book is an attempt to unearth and collect the most recent and available knowledge on selected tropical foods. It was not this editor's intent to develop an exhaustive treatise on tropical foods, as this would be impossible because of the diversity of the subject matter; rather it was this editor's intent to develop a seminal resource book espousing the need for further research in the area of tropical foods.

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Amaranth

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I. INTRODUCTION

A. Botanical Description and Varieties

One of the most difficult groups in taxonomy is the genus *Amaranthus L.* In this genus, which is native to the tropical and temperate regions of the world, over 50 species have been recognized. According to Singh (1961) the grain amaranth species belong to the section *Amaranthotypus* of the genus *Amaranthus* and are characterized by monoecious compound inflorescences and five-merous flowers with circumscissile utricles. The basic units of inflorescence are little dichasial cymes, usually called glomerules, each ordinarily consisting of an initial staminate flower and an indefinite number of female flowers. There are in all four grain *Amaranthus* species, namely, *A. hypochondriacus*, *A. cruentus*, *A. caudatus*, and *A. edulis*. They are all annual herbs.

A. hypochondriacus is the most common one which dominates the great center of Mexico where it was probably first domesticated, and is also the species found in Asia. It is characterized by a single, erect, large flower head which is composed of thick fingerlike projections (spekes). These spikes are sometimes very thick, measuring over a foot long or else are shorter, forming a dense flower head. The color of the flowers varies from green to red, with elliptical leaves. The plant can attain a height of 1.2 to 2.4 m.

A. caudatus derived its name from the long drooping taillike inflorescence which is characteristic of the species. The spikes are loosely arranged to form the flower head. Usually the individual flowers are extremely crowded on the spikes, causing the drooping at advanced stage of flowering. The color of the flower is normally red but occasionally it can be green. The leaves are elliptical, tapering towards both ends. The seeds are sometimes light or dark colored. The plant can attain a height of 1.5 to 2.1 m.

A. cruentus has a flower head which is composed of loosely arranged spikes on which the flower clusters on the spike, but they are smaller than *A. hypochondriacus* and so given an impression of an open flower head. The flowers are generally yellow-green but occasionally they can be red. The leaves are thinly elliptical and on a relatively long petiole. The plant can attain a length of 1.2 to 2.1 m.

The distinctive aspect of *A. edulis* is the inflorescence with the branches terminating in a peculiar seven- to nine-merous staminate flower instead of the indertiminate thyrse commone to the other species. Apart from the fact that the flowers are generally rust colored, the size. habit, and leaf shape are similar to *A. caudatus*.

B. Origin and Distribution

There is enough archaeological evidence to indicate that grain amaranth originated from the New World, and that it was one of the most important staples in Mexico at the time of the Spanish conquest. Other opposing theories about the origin might have been due to the fact that the cultivation was then concentrated on the highlands which were too remote for the early oriental writers and European travelers. Furthermore, it has been estimated that the grains were domesticated over 2000 years ago since some amaranth seeds were found placed in tombs as food for the dead. The Aztecs made their idols from a mixture of human sacrificial blood and amaranth seed dough. Also before the conquest the Mexicans prepared a cermonial paste called zoale with amaranth seeds formed into idols that were known to appear in at least seven regularly scheduled ceremonies. Zoale was also fed to slaves who were about to be sacrificed to the gods, and hence it is not suprising that the tradition was eventually suppressed by the Catholic church after the conquest. *A. candatus*, for example, was first encountered by the Spanish in the Inca empire and thus was called Inca wheat, but it is believed to be much more ancient than the Incas. It appears that the Spanish introduced the seeds to Europe where it became established as an ornamental plant; and by the nineteenth century it had reached Africa and Asia where it is now cultivated as grain in the mountainous areas of Ethiopia, southern India, Nepal, and the Himalayas. In other places, such as west Africa, it is cultivated mainly for the leaves which are relished as pot herbs. In general it is now grown over a large part of the world extending from Argentina up through the Andes, from Guatemala up through Mexico the the southwestern parts of the United States, from Iran and Ceylon through India and the Himalayas, and through inner China to Mongolia and in east and west Africa.

C. Economic and Nutritional Significance

Amaranth is one of the rare plants in which the leaves are edible and treated as a delicacy, and the seeds are also used as cereals. Very few plants have this double advantage. A member of the Amaranthacene that is very similar to amaranth in many respects is *Celosia argentea*, so similar that farmers believe it is a variety of amaranth. Most of the characteristics, and conditions, and so forth are actually similar except for a few minor variations like sensitivity to attack by pest and fungus. It is very rich in protein, 12 to 16%, increasing with increased nitrogen fertilizer and is exceptionally high in lysine (6.2 g/100 g), about 25 to 30% higher than the high-lysine maize, and similar to milk. This has been attributed to the fact that this species of plant is photosynthesized by the recently discovered C_4 pathway (Hatch and Slack, 1970), yielding asparagine as the major initial product, which is a key intermediate in the biosynthesis leading to lysine (Deuton, 1973). This process, as opposed to the classic C_3 route, could be expected to be exceptionally productive in view of the fact that the C_4 process is characteristic of such plants as millet, sorghum, sugar cane, and other fast-growing plants, and it is very efficient especially under high temperatures, brilliant sunshine, and moisture stress. The fact that most of the seed volume is occupied by the embryo may account for the high-lysine content rather than the C_4 route. Amaranth is therefore an economically fast-growing plant which (as a cereal crop) has helped to sustain untold generations of American Indians in one of the most difficult agricultural regions. This is due to the plant's high resistance to drought, having less than half the water requirement of the major cereals, lack of any serious toxic problems, and production of reasonable yields on poor soils. Although it is now considered overshadowed by the conventional cereals (maize, rice, wheat), it is still cultivated in several countries in the Americas, Asia, and in some parts of Africa Although it is now used as a subsidiary food in India, in some places like the western Himalayas it is still grown at elevations of about 1800 m as a regular crop in infertile and stony soils, and it has continued as the staple cereal in place of wheat (Pal and Khoshoo, 1974). Furthermore, the seeds are hardy and suitable for growing in areas with a short season and deficient soils where the conventional cereals cannot be grown with ease. Thus, they have potentiality as a subsidiary food and could play a major role in feeding the hungry world.

Although the seeds are very small, they are comparable to the improved cereals in minerals, carbohydrate, and protein (Misra et al., 1971). The carbohydrate is easily digestible, and the growth-promoting value is about three to four times that of rice (Singh, 1961). A comparison of the composition of amaranth grain is with various other grains is given in Table 1. On the dry basis the starch content is 62.8%, it is waxy, and it forms a "long" paste that does not gel on standing, thereby resembling the waxy type of starch in cereal grains, which can be of commercial importance. MacMasters et al. (1955) have described a method for the preparation of starch from *A. cruentus*. The plant can be harvested as a whole plant with most of the parts above the ground edible within 20 to 40 days or else the tips of the branches may be picked repeatedly when the plants are older.

II. HORTICULTURAL ASPECTS

A. Cultivation Practices

1. Climatological and Soil Requirements

Amaranth adapts very well to high temperatures and high altitudes, and thus is often found in the hills of the Himalayas and the highlands of Mexico. It is a short-day plant and hence when planted in the winter may bolt early. It is best sown during the rainy season. Trials have been conducted in Ethiopia between 8° and 9° north latitude and 38° and 39° east longitude and at elevations ranging from 1600 to 2000 m above sea level (Schmidt, 1977). The soil type varies from medium-course texture, gray-brown soils with good surface and internal drainage to black and dark-gray cracking clays with slow internal drainage

Table 1 Comparison of Nutritive Value of Amaranth Grains with Some Other Food Grains (Values/Ounce)

Name of food grain	Moisture (g)	Protein (g)	Fat (g)	Mineral (g)	Fiber (g)	Carbohy-drate (g)	Ca (mg)	P (mg)	Fe (mg)	Caloric value
Rajgira, sil, or chaulai	2.2	4.4	1.5	0.8	0.6	18.7	63	185	—	106
Wheat	3.6	3.4	0.4	0.4	0.3	20.2	14	91	1.5	98
Rice (raw, milled)	4.1	1.9	0.2	0.2	—	22.0	3	45	0.5	97
Sorghum	3.3	3.0	0.5	0.5	—	21.0	8	79	1.8	101
Rajra (pearl millet)	3.5	3.3	1.4	0.6	0.3	19.1	14	99	3.1	102
Ragi (finger millet)	3.7	2.0	0.4	0.6	—	21.7	94	77	1.5	98
Maize	4.2	3.2	1.0	0.4	0.8	18.8	3	93	0.6	97

after wetting and swelling. The pH can range from 5.0 to 6.6, with reasonably adequate or high supplies of potassium (K), calcium (Ca), and magnesium (Mg) in the soils. In general, the soil should be especially rich for maximum performance. Temperature could range from 10 to 25°C and relative humidity 50 to 90%. Martin and Ruberte (1977) used a mixture consisting of 25% composted sugar cane filter press cake, 25% sand, and 50% loam in pots. The well-mixed soil was thoroughly wetted a day before planting the seeds. Dry sand is placed over the sown seeds to a depth of not more than 3.2 mm. The pots were then watered. The pots should be in a warm place, but not exposed to direct sun or strong breezes.

2. Planting Characteristics

Presently the cultivation of amaranth is on the decline in Mexico, but a few stands can be seen among maize fields. The same situation exists in Guatemala, Peru, Bolivia, and Argentina where it can no longer be seen as pure stands. In India, especially in the Gujarat state, it can be seen mixed with vegetables like chilies, and so forth; and in Afghanistan and Iran, scattered through melon and tobacco fields.

In Mexico amaranth seedlings are still grown on floating gardens, or *Chanapas*, which provided much of the food base for the Aztec civilization. This ingenious system has been estensively discussed by Early (1977), who found that some of the plots have been producing continuously for over 2000 years. The chinampas are built by scooping mud from the canals and piling it up between posts and vine walls. The upper section, which consists mainly of water weeds (serving as compost), is covered with a layer of fresh mud that provides a fertile medium for planting. The bed is cut into small squares and planted with six seeds, with dried cow manure tossed over the top. Watering is done every 2 days with the algae-rich canal water. Weeding is not required. Transplanting takes place 15 to 20 days later to nonirrigated fields, followed by fertilizer application using mineral fertilizer or manure. Harvesting is done by cutting very close to the ground and leaving in the field for 2 to 3 days to dry. The seeds are then separated by beating and sieving. The stubs are plowed under and the field is left to fallow. Usually the soil is depleted after harvesting and so the plot is never used for more than two plantings. There are canals surrounding the chinampa plots, and they contain carp and other fish that are eaten. The canals also provide a rich source of green algae that is skimmed off and used as fertilizer. This system thereby combines agriculture and intensive horticulture and is a system that could usefully be adapted in other parts of the world where traditional systems of agriculture with few labor-saving devices are still practiced.

B. Propagation

In general, there are two main methods of sowing. The seeds are drilled in by hand and mixed with about two to three times its weight