Loofah—*The Sponge Gourd*

The sponge gourd has a long history of cultivation in most tropical countries of the world. Its principal uses are based on the closed fiber network that forms a resilient mesh in the walls and core of the fruit, similar in structure to that of a sponge. As oil and water filters in marine engines it was an important item in wartime supplies of the navy. Its early service as food and medicine is almost negligible in contrast to the many more recently found civilian uses ranging from bath sponges to shock absorbers and soundproof linings.

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The subject of this account is a sprawling vine bearing the scientific name, *Luffa cylindrica* Roem., and producing a cucumber-like fruit which owes its current rating of importance to an internal fibrous skeleton in the form of a spongy network. Varieties and forms of this species in times past have been cultivated as garden plants and occur naturalized in most tropical countries. Where the fruit has long been used for food, it is often associated with another species, *L. acutangula* Roxb. For example, in India both *L. acutangula* and the edible or sweet "variety" of *L. cylindrica* are extensively cultivated in the province of Bengal and eaten as food. As a source of vegetable sponges, however, the former of these two species is relatively unimportant, and since it is this aspect of the latter plant that interests us most and was the principal reason for its promotion to the forefront of wartime strategic materials, the following pages will be devoted primarily to *L. cylindrica*.

Nomenclature

The term "sponge gourd", connoting its structure and use, is a common name by which the fruit of *L. cylindrica* is widely known. However, the one most often appearing in trade literature is "loofah". The Chinese, by use of their characters which phonetically read "Szu (Ssu) Kua", call it "snake gourd". "Po Kua" is also listed as a Chinese name. Other English names are "dishcloth gourd", "towel gourd" and "vegetable sponge". Variations of "loofah", such as "loofa", "loufa", "loopha" or "lufa", have appeared from time to time. The Japanese name has been given as "Naga ito-uri", but it is also referred to as "Hechima" (Hetchima). To illustrate the high esteem in which this gourd has been held in Japan, the poet Masaoka Shiki (10), with his dying breath, was said to have addressed the spirit of "Hechima". Up to 1937 at least, the anniversary of his death was observed as Hechima-ki or "loofah day".

In the Philippine Islands it is called "Patolang bilog" or "Patóla". Other Tagalog names of local use are "Patulang-uak", "Salag-salag" and "Tabubok" (13). In Malaysia the name in Malay is "Blustru" (Bloostroo); in Sundanese it is "Lopang" and "Oyong". In Siam it is called "Būap kom"; in Sumatra, "Kětola" which is sanskritic, and "Timput". The Spanish name used in Latin American countries is "El Estropajo". The Mexican Indians, who have long cultivated it, call it "Sonayote" or "Cuazacamecate" (16). These

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Photos by courtesy of The New York Botanical Garden.

names have their origin in the Aztec tongue. For example, "Sonayote" in the Aztec was "Tzon-ayotli" which is a combination of "Tzontli" (hairy in the sense of hair- or fiber-producing) and "Ayotli" (gourd). In Hungary, where it has been introduced and was first successfully cultivated by John Szabo (1), the name is "Hálós tök".

The botanical name of the sponge gourd most widely accepted is *Luffa cylindrica* Roem., although in the past the plant has been described under other names, and authors have used these synonyms in their writings. Many of these synonyms are contained in the following list, but it is in no way complete: *Momordica cylindrica* L., *M. operculata* Blanco, *Luffa aegyptiaca* Mill. (sometimes appearing as *L. egyptica*), *L. arabus* Vesl., *L. Fabiana* L., *L. foetida* Hort. (not Cav.), *L. japonica* L., *L. mexicana* (?), *L. petola* Ser., *L. striata* Schrad., and *L. Veitchii* Naud.

Origin, Discovery, Distribution

Cultivation of the sponge gourd is of such ancient origin that it is impossible to determine whether the original home was in Africa or Asia. An inhabitant of the tropics and of the warm countries, it is claimed by many to have sprung from the eastern hemisphere, though those who know its historic background in Mexico might be inclined to contest this assertion. Some authorities think that its original home was in tropical Asia and that it still can be found wild there, one even specifying that as many as three or four varieties grow wild in India. Bretschneider, however, who included the sponge gourd in his list of Chinese plants first introduced by him into cultivation in Europe and North America, never saw it in the wild state. On the other hand, because the name "luffa" is of Arabic origin, and because the sponge characteristic of loofah was described in writings concerning Egypt over three centuries ago, it is quite easy to reason that this plant might have come originally from northern Africa.

The evidence well establishes the fact that, irrespective of origin, cultivation of the loofah plant has persisted in China, Japan, Malaysia, India and the Middle East since early times, and that it was grown primarily for food, medicine and ornament. In Chinese literature it is stated that the sponge gourd was not known before the T'ang dynasty (600 A.D.). This may be taken to mean that it had not been introduced before that time, or that its use had not become known until then. In this connection it is interesting to note that early Portuguese explorers, not Chinese, in Asia were the first to discover the practical value of the fibrous tissue contained in the gourd. One may read about the "loufah" sponge in the writings of Vesling in Egypt back in 1638. But even before that, Hernandez, physician to Philipp II of Spain (1536–1598), in his monumental natural history of Mexico described the "Tzonayotli" or "Estropajo" among the cucurbits of "New Spain" (16).

The modern era in the history of its cultivation began in Japan where, between 1890 and 1895, the sponge gourd was first grown commercially. The initial justification for the culture of sponge gourds on a commercial scale is based on the particular fitness of their skeletal network for many practical uses, and the special emphasis on their increased production is due to their successful employment as filters in marine steam engines and also in diesel engines. This special use had made them important to the United States Navy. Since the time Japan started growing and exporting sponge gourds, almost the entire commercial supply of the United States has come from Japan. After Pearl Harbor this supply was suddenly cut off. The same catastrophe which stopped their

importation enormously increased the need for them, constituting at the same time the greatest single stimulus to their wider distribution and cultivation.

Official recognition of the great importance of the sponge gourds was given on April 8, 1942, when the War Production Board, in order to conserve the country's stockpile, issued an order forbidding delivery, sale or use of loofah sponges except on the highest priority (19). Not only was the worth of sponge gourds thus officially established, but under a program of encouragement, the U. S. Government by this one official act gave considerable impetus to its spread to fresh regions where new sources of supply might eventually be established. Attempts to grow loofahs on a commercial scale in the States of California, Alabama and Florida were not successful, but the tropical countries to the south (Mexico, Haiti, Cuba, Dominican Republic, El Salvador, Guatemala) in a year's time were cultivating and exporting " el estropajo " to the United States.

The United Kingdom similarly inaugurated a series of tests in various colonial countries, and after a year sample luffa sponges were received by the Colonial Products Advisory Bureau from Jamaica, Cyprus, Gambia, Nigeria, Nyasaland, Southern Rhodesia, Sierra Leone, Tanganyika, British Guiana, Uganda, St. Kitts, British Honduras, Gold Coast and Antigua. Although some good sponges came from the test plots of Antigua, British Honduras and Nyasaland, the samples from the colonial countries in most instances were not up to the standard Japanese " loofahs ".

With the end of the war and with the recession of the shipbuilding program, the demand for sponge gourds fell off, and since again ample quantities of sponges began coming from Japan, and at a price which the colonial products could not equal, the incentive for their worldwide cultivation to establish independent sources of supply no longer existed.

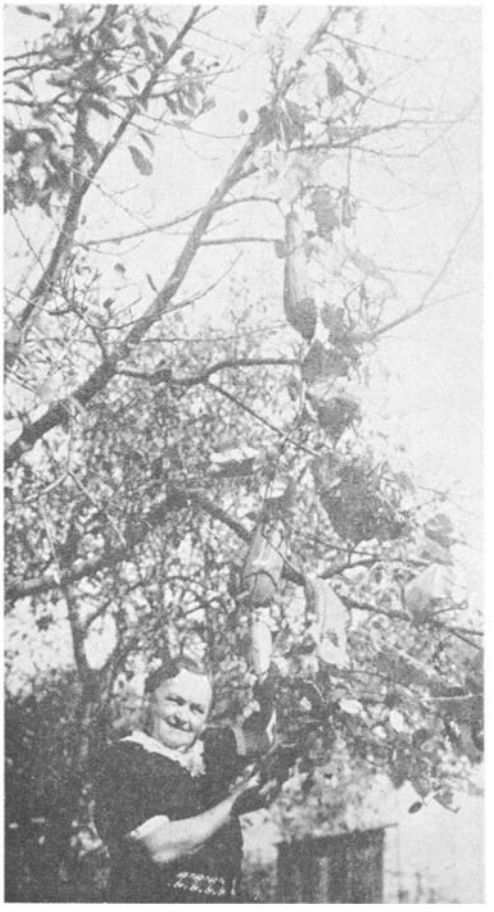

FIG. 1. Cultivated loofah in New Jersey.

Uses

Before World II 60% of the imported loofah sponges were employed as filters, which indicated their usefulness to the U. S. Navy, and 40% of them were applied to civilian uses. However, it can be said that, besides filters for the Navy and for steam engines in general, the military uses of sponge gourds range all the way from surgical operations to cleaning windshields of jeeps. Much industrial equipment requires the cleaning that only the loofah sponge can give. In more detail the special use of loofah

sponges in steam vessels consists in the fact that water condensed after expansion in the engine is passed through several layers of closely packed loofah sponges to rid it of oil and dirt before it enters the boiler to be used a second time. Substitutes were tried when the supply of vegetable sponges was suddenly cut off, but all of them proved unsuitable. Cellulose sponges, turkish toweling, coke and Spanish moss were tried, but for different reasons these would not suffice. It is interesting to note that loofah sponges have a similar use in internal combustion engines, such as diesels, except that the filtering function here is to remove carbon and metal dust from the oil.

Sponge gourds are also made into bath sponges—more acceptable in Europe since the slightly scouring effect is a little harsh for American complexions—and in Hungary are part of the equipment of the masseurs in therapeutic baths. Other products are pot holders, table mats for hot plates, door mats, bathroom rugs, insoles, sandals and gloves. To make gloves or insoles, it is necessary first with a sharp knife to slit down one side of the sponge, remove the central core, and open it out flat, after which it is passed between heated rollers. From the sheet form thus produced patterns for gloves can be cut. Also in this form combined with crude rubber excellent rubber soles for sport shoes can be made. Combined with plaster and varnished over it makes soundproof and heat-proof wall boarding.

Besides being useful for cleaning motor cars, loofahs are also good for cleaning glassware and kitchen utensils. When combined with other materials, toys, matting and hats may be made. Because of their scouring property, they can be used very effectively to rub down painted surfaces. Because of their peculiar structure, loofahs make fair shock absorbers. This useful aspect, as well as their capacity for absorbing sound, has been exploited in steel helmets and armored vehicles of the U. S. Army. Loofahs make good packing material and stuffing for pillows, matresses and saddles; also shoulder pads and stiffening material. Baskets are made of them and, in Mexico, bottle covers. Because they provide good insulation against heat, they are used in Japan in the manufacture of sun helmets.

The use of sponge gourds for food is limited to the cultivated "sweet" variety and is restricted to young fruits before the internal fibers have started to harden and before the purging substance which develops as the fruits ripen has had time to appear (6). At this stage they may be eaten sliced like cucumbers, or in soups like okra, or cooked like squash. By comparison, however, they are inferior to the common variety of squash. In India they are eaten boiled or in curry. In Japan the young fruits are sliced and dried and are thus prepared for future use. Young leaves are eaten in Malaysia but are rather insipid. Annamites eat the male flowers and flower buds.

If an incision is made in the stem of a young vine before time to harvest the fruits about one inch above the ground, a clear liquid may be extracted which the Japanese say has medical value in respiratory complaints. It also makes good toilet water, and preparations from the juice have been marketed as Eau de Hechima, Creme de Hechima, and Dentifrice de Hechima. It is a custom in Japan to cut the stems of the loofah plant about five feet from the ground after all the fruits have been harvested. The top of each stem is then bent round so the cut ends lead into a receptacle. Into this the sap flows and is collected. As much as half a liter of sap may be obtained from one plant. This is used by the Japanese women for rubbing on the face, hands and body, and is re-

garded as an excellent substance for softening the skin and for giving it a fine fresh appearance.

Wilson (24) stated that the fiber is esteemed as a medicine in China. Furthermore, the ripe fruit if burned and pulverized is said in old Chinese medical literature to have healing properties. According to Stuart, it is " carminative, pectoral, cooling to the blood, antiseptic, anthelmintic, emmenagogue, quickening to the circulation, galactagogue, and is also used in the treatment of hemorrhage from bowels or bladder, hemorrhoids, menorrhagia, joundice, hernia, and scarlet fever. Mixed with vermilion it is used to dry up smallpox pustules. Fresh fruit is considered to be cooling and beneficial to the intestines, warming to the stomach, and tonic to the genital organs ". Leaves are used in skin diseases and orchitis, the vine and root in decayed teeth, ozena and parasitic affections. Juice from the leaves is given in amenorrhea.

The pure seed oil extracted in Brazil is suggested as a possible substitute for olive oil. While the oil cake, because of bitterness and probable toxicity, cannot be used for feeding animals, it could serve as a useful manure on account of its wealth of protein and phosphates.

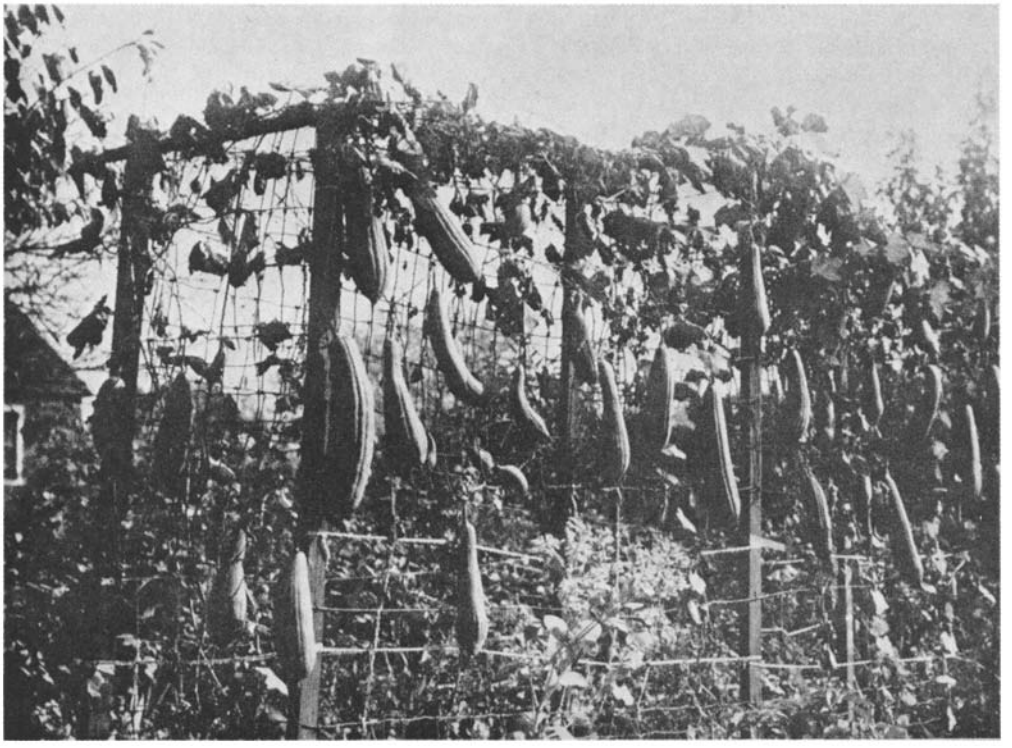

FIG. 2. Cultivated loofahs in New Jersey.

Physical Characteristics of the Plant

Luffa cylindrica Roem. is one of about eight species of the genus *Luffa,* all of which are annual tendril-climbing herbs of the family Cucurbitaceae.

The stem grows long and branches, and is capable of climbing over tall trees. The leaves are roundish in out-

line, mostly five-lobed, coarsely toothed, scabrous above and below. The flowers are large—sometimes as much as four inches in diameter—yellow, attractive, with five-petalled corolla. Stamens and pistils are in separate flowers, and staminate flowers usually two to three inches across, clustered in the axils of the leaves. In the pistillate flowers the ovary is cylindrical or club-shaped, pubescent, destitute of distinct ridges, and ripening into a slender cylindrical curved fruit, one to nearly five feet in length (6½ feet have been reported). The fruit is green, smooth, without longitudinal ridges such as identify the fruit of *L. acutangula* Roxb. The seeds are black, rarely whitish, are about the size of watermelon seeds, and are narrow winged.

The fruit is made up of a smooth outer wall forming a thin rind, marked by ten longitudinal lines, dark green and somewhat degressed. Through the wall and throughout the pulpy interior is a closed network of fibers which harden and become woody as the fruit ripens. The seeds are contained in the core of the network whose principal value as far as the plant is concerned seems to be, according to one interpretation, that it provides for a gradual liberation of seeds over a long period of time as the fruit hangs on the vine. When ripe the rind can be readily removed, and because the soft internal material has mostly disappeared, only the compact fibrous network remains, which is the sponge of commerce.

One variety of *Luffa cylindrica* in India is considered edible in the young stages and is intensively cultivated in Bengal for food, but another is bitter and grows wild. The bitter form is toxic, but except for its bitterness and slightly darker color, it is scarcely distinguishable from the edible variety. This calls to mind the species growing in Mexico, *L. purgans* Mart. (*L. operculata* Cogn.), which has been cultivated by Mexican Indians in Guerrero and Michoacan as a household remedy because of its purgative properties (16). Investigation has shown that, in this species at least, the bitter principle is contained in the rind. This species is valued also because it produces a sponge with fine and soft fibers, although it is small.

Bose (8) undertook to investigate the cause of poisoning by the bitter variety of *L. cylindrica* in India. Two glucosides were isolated from the fruit. One of these was found to act as a severe emetic, the other as a brisk cathartic, causing much irritation and giving rise to dysenteric symptoms. The edible varieties are believed to owe their freedom from toxic substances to cultivation.

The fruit contains saponin and mucus besides the glucosides. This accounts for the soapy feel of the pulp and juice. A food analysis of the fruit yields the usual components in the following proportions:

	Original material	Water-free material
Water	94.66	....
Protein	0.51	9.57
Fat	0.19	3.72
Carbohydrate ...	3.31	61.99
Crude fiber	0.46	8.58
Ash	0.41	7.65
Undetermined ...	0.45	8.49

The results of a mineral analysis conducted in the Philippine Islands are set forth in the following tabulation:

	Fresh samples		Water-free samples		Ash	
	A	B	A	B	A	B
Water ...	95.99	95.36	....	....	....	....
Ash	0.60	0.63	14.89	13.50	....	....
P_2O_5	0.12	0.11	2.96	2.39	19.90	17.71
CaO	0.03	0.04	0.64	0.81	4.32	6.01
Fe_2O_3 ...	0.004	0.003	0.09	0.06	0.62	0.41

The calcium-phosphorus ratio for sample A is 1 : 4.6 and for B it is 1 : 2.9.

By feeding tests young loofah fruits have been found to be low in vitamin B. The vitamin C content is only fair. The

results of tests (25) to show the amount of vitamin C in mg./g. of pulp is tabulated as follows:

mg./g.	Method
0.039	Harris
0.092	Iodine
0.110	After H_2S

There is more vitamin C present than is indicated by the values obtained with Harris' method. It was thought that the vitamin might be present in a reduced form, a conclusion which was borne out by treatment of the fruit extract with hydrogen sulfide. The caloric value was 103 calories/lb. (about 23 calories/100 g.).

The seeds are about 49% testa and 51% kernel, and give a green oil with a high acid value. This oil is of the semi-drying type and remains liquid at ordinary temperatures. The seeds also contain colocynthin which is the basis of their medicinal use, quite independent of the oil (6). Extraction of the oil by solvents gives a pale green oil; extracted by pressure the oil is yellowish. If it can be drawn so that it is pure, it can be used for food or cooking, the bitter purgative properties remaining in the residual oilcake. In the pure state the oil is colorless, odorless and tasteless. The acid components of the seed oil are grouped as follows:

Saturated acids:		
Palmitic acid	56.45%	Constituting 16.93% of the total mixed fatty acids.
Stearic acid	43.85%	
Unsaturated acids:		
Oleic acid	48.73%	Constituting 83.07% of the total mixed fatty acids.
Linoleic acid	51.27%	

Aside from the fatty oil, the kernel contains 6.13% water. In the water-free material the oil content is 45.72%, nitrogen 6.55%, pentosan 2.31%, reducing sugar 3.11%, crude fiber 2.89%, glucosides none, P_2O_5 1.83%, and ash 4.75% (of which 38.54% is P_2O_5). The testa of the seed contains 11.3% water, 0.45% nitrogen, 0.056% P_2O_5, and 0.96% ash (of which 5.38% is P_2O_5) (22).

Propagation and Cultivation

Propagation is by seed. The seeds resemble those of watermelon and are ranged in three lengthwise groups along a central core through the length of the fruit. In the skeletal stage each seed is contained in a pocket. After ripening, the tip of the fruit drops off, and as the pulp dries the seeds gradually loosen. One by one the seeds are shaken free of their pockets by wind and rain, and drop to the ground through the hole at the lower end of the gourd. The average number of seeds produced by a single gourd is not known, but the quantity has been observed to vary directly with the length of the fruit. Information concerning the relation of fruit size to seed size and its possible influence on size of fruit in the next generation is not yet available.

The methods used in cultivating loofah plants depend on the region of operations. Although native to the tropics and warm-temperature climates, good results have been obtained in temperate regions as far north as Connecticut, but a somewhat modified technique must be employed. Because the summers are shorter and frosts come early, growing loofahs in the northern latitudes involves the use of indoor or hot-bed planting in early spring. In New Haven, by starting plants indoors, fruits with good fibers were obtained before frost (19). In Rahway, New Jersey (11), seeds were planted in April in a hot bed, fertilized with chicken manure, and the seedlings were set out after May 15. Some of the fruits obtained measured as much as 26 inches in length. Moreover, seeds produced by these gourds were used to plant the next year's crop.

According to an old custom in China, seeds are planted in the second moon, and the flowers bloom in the sixth or seventh moon. In Japan seeds are sown

in outdoor beds in March or April. As soon as the first two leaves have developed, the young plants are set out in ridges three to four feet apart with the same distances between the plants in the rows. The explanation of the apparent paradox that the best loofah fruits, which normally would be expected from naturalized tropical plants, are obtained from temperate Japan is thought to be connected possibly not only with the volcanic nature of the soil but also with proper attention to fruit pruning, careful processing and strict observation of soil needs.

According to experience in Central America, the soil should be moderately rich; a slight clay loam gives best results, but manuring may be necessary if the soil is not rich enough. Moreover, it should be well drained but located near enough to water to ensure a cool moist atmosphere and watering when necessary. The plant is not truly drought-resistant, though dry season planting is more successful than wet season planting. In Nyasaland (9) an entire crop suffered badly during a drought. On the other hand, rain damages the flowers and creates conditions favorable to invasion by insects and fungal spores. The dampness of tropical Java (Tijpemeuh) was thought to be the reason why out of an estimated yield of 80,000 gourds from a plot, only 3,000 were actually harvested, and these were of inferior length and color. Finally, like all cucurbits, the loofah plant is tender and is, therefore, sensitive to frost. Because of this fact care must be taken not to plant seed or set out seedlings before the danger of frost has passed.

At Tengeru in Tanganyika (9) Japanese loofahs planted in February on a bench terrace at an altitude of 4,000 feet, where the soil was a volcanic loamy type with good drainage and rainfall averaging 45 inches, showed 100% germination, and after two months had completely covered the ground and started to set fruit. Under Tengeru conditions the plant appeared to be drought-resistant. Stones were used to support the fruits off the ground and to reduce damage caused by rot of the fruits. There was no incidence of pests or diseases on cultivated plants or on a local strain which was growing wild. The largest fruit was 15 inches long and had a girth of 12 inches. The results showed that the loofah plant was easy to establish from seed and would grow well under ideal conditions, and furthermore might also be useful as a cover crop. The experiment was not pursued, since Japanese loofah sponges had again become available.

The best gourds are obtained by training the vines over trellises, thus assuring maximum exposure to the sun and preventing the fruits from coming into contact with the ground with resultant discoloration and distortion of shape. In selecting the site for a trellis, protection from wind is an important consideration. Since some fruits weigh as much as five pounds—and there are as many as 25 gourds on a vine—the frame and supports of the trellis must be strong. Heavy posts seven feet tall, or two posts placed like an inverted " V ", are planted every 12 feet, with slender supports at three-foot intervals between them. Horizontal members are then fastened to these, spaced three, five and seven feet from the ground. Chicken wire has been used to support the lower part of the plants, or the young plants were tied to the uprights. Without support the vines will climb over the ground and up over the neighboring trees.

In Central America it has been the practice to plant two seeds at the base of each vertical post, to be thinned to one plant after germination. The vines should be tied to the horizontals of the trellis with vegetable fiber like raffia. Some advise at this point that as the plants grow the side branches should be pruned to encourage growth of the main

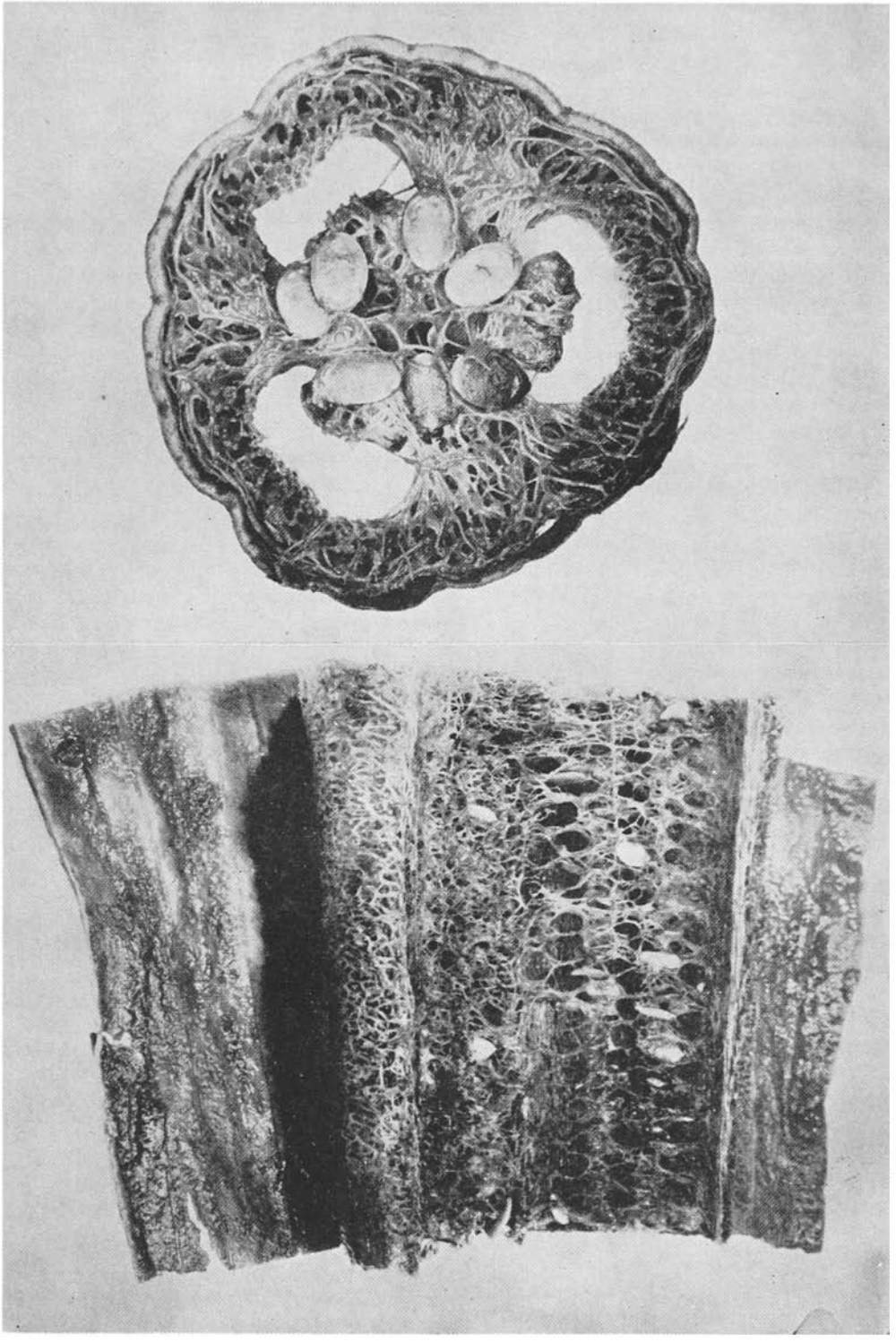

FIG. 3. Longitudinal section (lower) and cross section (upper) through loofah gourd.

stem. It is the custom also to remove all male flowers until the vines have covered all the horizontals. Some growers remove early female flowers, as these are said to produce smaller fruits. Newly formed gourds should be examined and pruned during the first week if they are deformed, pear-shaped or coarse. It is good to limit the number of fruits per vine because by doing so fruits of good length can be produced. The optimum production per vine in the opinion of many growers should be limited to 20 fruits. Harvesting normally commences four or five months after planting.

Maturity of the fruit is indicated by yellowing of the base and apex. Ripe fruits are lighter in weight than unripe ones. When cut, a length of stem should be left on the fruit for convenience in handling.

Diseases and Insects

Although no extensive study of diseases or pests harmful to the loofah plant has been made, experience has shown that it is subject to attack by both insects and disease. In an experimental plot at New Haven, Connecticut, in the summer of 1942, though north of its natural range, no difficulty with attacking insects or diseases was encountered (19). Neither cucumber beetles, squash bugs nor borers were found on the plants. This in itself was not considered conclusive inasmuch as frequent spraying had been employed and it had been a favorable growing season. Also, no cases of mosaic disease were noted, and the leaf-spot disease harmful to lagenaria gourds did not appear. The record elsewhere, however, has been less satisfactory. Insects were thought to be one cause of the poor results obtained from attempted large-scale commercial cultivation in India.

Cultivation and growth of sponge gourds came under close observation in the experimental gardens set up by agencies of the United Kingdom in Africa and in Central America after the outbreak of hostilities in the Far East. On Morogoro Farm in Tanganyika (9) fruits set in May were attacked by a fly which proved to be a fruit fly (*Dacus* sp.). In Nyasaland also, 70% of the fruits set during one particularly dry season were destroyed by the fruit fly. Again, insects were a significant factor in a 25% to 30% loss of a 1942 commercial crop in Cuba where the gourds have long been grown for local use.

It seems that when a fly punctures a ripening gourd, the flesh of the fruit eventually becomes a mass of worms and is badly discolored. Besides the fruit fly the plants were also found to be susceptible to eel worm and wire worm. To combat the latter Gammexane powder was used. Against fruit flies Agrocide 3 was used with some success. DDT was not tried. Other attempts to destroy the fly during the feeding period were made by using poison dust of lead arsenate and sugar. Three forms of fungus attack, not identified, were found on plants, and for this, Perenox, a copper dust, gave fair success. In general dusts were more effective than wet spraying.

Yield

As already shown, production of sponge gourds, assuming that the best seed is used, may be seriously affected by a variety of factors—soil, climate, frost, disease and insect attack. The disappointing crop in Java reported by Howes (1931), of which only 3,000 gourds were actually harvested of an estimated yield of 80,000 because of excessive dampness, illustrates this point (8). On the other hand, the partial loss of the 1942 crop in Cuba cited above was the result of insect attack and insufficient rainfall during the growing season, which limited production to only four or five fruits per vine where normally 20 would be expected. In Japan, at one experimental station, 10,773 plants produced 160,000 ripe gourds, or

about 15 per plant. Under experienced management and optimum conditions, however, the yield can be expected to be 20 to 25 per vine, with a total of 24,000 per acre. In New Jersey, 140 ripe sponges were harvested from a 40-foot row of loofah vines (1942), about half of them being as large as the 26-inch specimen sent to the New York Botanical Garden for exhibit.

Processing

Before the fruits are ready for commercial use, they must be processed, i.e., the "skin" removed, the pulp washed out and the seeds extracted. To avoid injury or discoloration of the skeletal fibers, ripening fruits must be handled with care. If left on the vines to ripen and dry, the "skin" can be peeled off quite readily, thus revealing the residual skeletal network which constitutes the sponge. After this the seeds must be removed. This is done either by shaking or by beating the fruit against a stone.

Another method of preparing the "sponge" is to cut off ripe fruits at the stem, then immerse them in tanks of running water for five to ten days until the outer wall disintegrates and can easily be removed. Further retting and washing will remove not only most of the seeds but also a small amount of soapy pulp left clinging to the fibers. The latter process is accelerated in some areas by pounding with a mallet to drive out the remaining substances. When washed, the sponge takes on a clean white color. If allowed to lie around too long unwashed, the sponges discolor and depreciate in value. By exposing the cleaned sponges to the sun and air, preferably by stringing them on wire, they dry and bleach. To attain the whiteness demanded by the trade, further bleaching may be done with hydrogen peroxide. The sponges are then graded and packed for shipment.

Still another method of processing is to hang freshly cut fruits in an airy draughty shed for two or three days, after which the outer skin becomes soft and pliable. The tip of the gourd is cut off at the lower end, leaving a small hole through which water may drip. The internal "sponge" is then extracted from the fleshy rind by running the fingers down the skin of the fruit on one side and splitting it open. They are then thrown into a washing vat of lime water. From there they are transferred to a drying shed. The lime water should be shaken from each sponge before drying. To avoid brittleness, the sponges should be dried slowly.

Trade

For commercial purposes the preferred type of sponge is of a light uniform color, well cleaned and free from seeds. Furthermore, the sponge should have a good shape, a firm strong fibrous network, neither too closely nor too widely meshed. One report states that the sponges which sell the best are those with a length of over 14 inches. Many commercial specimens reach 18 or 20 inches in length. It is obvious that the size and grade of mesh will vary according to the different requirements of the trade; hence the necessity for grading them. When the sponges have been dried, they are sorted by length, those in any one group ranging no more than two inches from the shortest in the group to the longest. According to the Hechima Export Guild in Japan, there are five grades, of which the first four are disposed of to foreign markets (10). These grades are identified as follows:

Grades	Minimum length	Minimum weight
Special	1.5 shaku	14 momme
First	1.4 "	12 "
Second	1.2 "	9 "
Third	1.0 "	7 "
Fourth	1.0 "	1 "

1 shaku = 0.9942 feet.
1 momme = 0.1323 ounces.

The main faults of the sponges received by the Colonial Products Advisory Bureau from the various experimental gardens throughout the British Colonial Empire were their short length, narrow girth, bad color, dirty condition and inferior fiber texture, although there were some very good ones, particularly those from Antigua, British Honduras and Nyasaland (9). In regard to the last named area, it may be stated that in general the color, mesh and softness of the fiber of sponges from Japanese seed were better than those of the sponges from local seed. The superiority of the Japanese sponges results from their being firm in texture yet yielding to ordinary pressure of the hand, and from their having sufficient resiliency to withstand being bent and twisted without causing a breakdown of the fibers after several foldings. The U. S. naval specifications as of 1943 stipulated that sponges must be at least eight inches long and two inches wide, free from pulp, and must contain no more than ten seeds. Under pressure of shortages a length of six inches was being accepted.

For shipping the best method is to pack the sponges as flat as possible, i.e., in press-packed bales. In such bales measuring 3 feet × 2 feet × 18 inches the number of sponges contained, depending on their length, is figured as follows:

Sponge length (inches)	Number of sponges in bale
8–10	5,000
10–12	4,500
12–14	3,500
14–16	2,500
16–18	1,800
18–20	1,200

Until World War II about 60% of the imported sponges were used as filters on naval vessels; 40% were reserved for civilian local needs. After the WPB order of April 1942, all loofah sponges were reserved for military use.

Japan's biggest customer for loofah sponges up to World War II was Germany which bought more sponges than all other countries. Great Britain ranked second. The following tabulation briefly compares the export of loofah sponges in pounds from Japan to Germany, the United Kingdom and the United States for the years 1936, 1937 and 1938:

	1936	1937	1938
Germany	146,302	402,131	299,879
United Kingdom	118,920	146,566	65,743
United States	73,151	95,903	42,330
Total countries	529,121	847,120	703,596

Imports through the port of New York from Brazil in 1937 totaled 1,056,800 sponges; and in 1940, 1,146,000. The total U. S. imports through all ports for the first half of 1941 amounted to 1,851,-500 sponges valued at $49,202.00 (2).

Trends in Breeding

The purpose of loofah cultivation is to produce sponge gourds in numbers, size and quality of skeletal network adequate for the special uses to which they are to be applied. The fact that a wide diversity in size, shape, texture of fiber and mesh of network does exist indicates that in order more fully to fill the special needs in dependable quantities there is need of some standardization of type.

In this connection investigation has shown that the width of the two outer zones of fibers which form the bulk of the sponge and help form the wall of the fruit, in addition to the compactness of the net, the diameter of the strands and the length of the fiber cells, varies greatly in different races, and experimental work has demonstrated that these traits are inherited and thus capable of breeding and selection.

Breeding the plants for uniformity and superior traits is a project of some magnitude but one with distinct possibilities of success. Because the staminate and pistillate flowers are separate, controlled pollination is simple. If the

tips of pistillate flower buds advanced enough to be opening the following morning are tied, the flowers cannot open and be pollinated. Artificial pollination can then be performed and the flowers bagged until the stigmas dry. Both cross- and self-pollinations have been successful, but whether or not the strain deteriorates and a loss of vigor will result from continued self-pollinations is not known. The tests of Sinnott and Bloch at New Haven (19) in the summer of 1942 disclosed that seeds were produced in all races grown by self-pollination.

It is interesting to note with reference to the practice of removing the early female flowers because of the probability that they will produce smaller fruits, that not all experience has supported this procedure. Sinnott and Bloch report successful application of growth substances, especially indole-acetic acid, on the stigmas or the tips of young ovaries before pollination and the production therefrom of fine fruits entirely free of seeds. The fruits otherwise appeared to be exactly like those of normal seeded fruits. Because removal of seeds from dried gourds is a time-consuming process, it would be worth the labor involved to employ the hormone technique to produce such a seedless type.

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