Bulletin 222 August 1925

UNIVERSITY OF MINNESOTA
AGRICULTURAL EXPERIMENT STATION

BLANCHING CELERY

BY R. B. HARVEY
DIVISION OF PLANT PATHOLOGY AND BOTANY

UNIVERSITY FARM, ST. PAUL

ADMINISTRATIVE OFFICERS

W. C. COFFEY, M.S., Director
ANDREW BOSS, Vice-Director
F. W. PECK, M.S., Director of Agricultural Extension and Farmers' Institutes
C. G. SELVIG, M.A., Superintendent, Northwest Substation, Crookston
P. E. MILLER, M.Agr., Superintendent, West Central Substation, Morris
O. I. BERGH, B.S.Agr., Superintendent, North Central Substation, Grand Rapids
M. J. THOMPSON, M.S., Superintendent, Northeast Substation, Duluth
R. E. HODGSON, B.S. in Agr., Superintendent, Southeast Substation, Waseca
RAPHAEL ZON, F.E., Director, Forest Experiment Station, Cloquet
F. E. HARALSON, Assistant Superintendent, Fruit Breeding Farm, Zumbra Heights, (P. O. Excelsior)
W. P. KIRKWOOD, M.A., Editor, and Chief, Division of Publications
[1]ALICE MCFEELY, Assistant Editor of Bulletins
HARRIET W. SEWALL, B.A., Librarian
T. J. HORTON, Photographer
R. A. GORTNER, Ph.D., Chief, Division of Agricultural Biochemistry
J. D. BLACK, Ph.D., Chief, Division of Agricultural Economics
WILLIAM BOSS, Chief, Division of Agricultural Engineering
ANDREW BOSS, Chief, Division of Agronomy and Farm Management
W. H. PETERS, M.Agr., Chief, Division of Animal Husbandry
FRANCIS JAGER, Chief, Division of Bee Culture
C. H. ECKLES, M.S., D.Sc., Chief, Division of Dairy Husbandry
R. N. CHAPMAN, Ph.D., Chief, Division of Entomology and Economic Zoology
HENRY SCHMITZ, Ph.D., Chief, Division of Forestry
W. H. ALDERMAN, B.S.A., Chief, Division of Horticulture
E. M. FREEMAN, Ph.D., Chief, Division of Plant Pathology and Botany
A. C. SMITH, B.S., Chief, Division of Poultry Husbandry
F. J. ALWAY, Ph.D., Chief, Division of Soils
C. P. FITCH, M.S., D.V.M., Chief, Division of Veterinary Medicine

DIVISION OF PLANT PATHOLOGY AND BOTANY

E. M. FREEMAN, Ph.D., Plant Pathologist and Botanist

Section of Plant Pathology

*E. C. STAKMAN, Ph.D., Plant Pathologist
J. G. LEACH, Ph.D., Assistant Plant Pathologist
*J. J. CHRISTENSEN, Ph.D., Assistant Plant Pathologist
*A. W. HENRY, Ph.D., Assistant Plant Pathologist
*HELEN HART, M.A., Assistant Plant Pathologist
LOUISE DOSDALL, Ph.D., Mycologist
P. D. PETERSON, B.S., Assistant Plant Pathologist
H. A. RODENHISER, M.S., Assistant in Plant Pathology
R. M. NELSON, M.S., Assistant in Plant Pathology
T. JOHNSON, M.S., Assistant in Plant Pathology
*J. H. CRAIGIE, M.S., Assistant in Plant Pathology
G. B. SANFORD, M.S., Assistant in Plant Pathology
WM. BROADFOOT, B.S., Assistant in Plant Pathology
H. H. FLOR, M.S., Assistant in Plant Pathology

Section of Plant Physiology

R. B. HARVEY, Ph.D., Associate Plant Physiologist
L. O. REGEIMBAL, M.S., Assistant in Plant Physiology

Section of Seed Laboratory

A. H. LARSON, B.S., Seed Analyst
RUBY URE CROULEY, Assistant Seed Analyst

[1] Absent on leave, July 1, 1925 to January 1, 1926.

* Co-operating with the Office of Cereal Investigations, Bureau of Plant Industry, U. S. Department of Agriculture.

BLANCHING CELERY

By R. B. HARVEY[1]

Origin of Celery and History of Its Cultivation

Celery in its wild state has a widespread distribution, being found in North and South America and New Zealand, as well as in nearly all parts of Europe and Asia. The first varieties grown seem to have been selected from the wild celeries found in marshy places from Sweden southward to Algeria, Egypt, and Abyssinia; and in Asia to the Caucasus Mountains and northern India. By cultivation the strongly flavored wild celery plant used in medicines principally, has been transformed into the crisp, sweet, wholesome, cultivated vegetable, which when properly blanched has a most agreeable flavor. In the southern European countries the strong flavored varieties are still used in soups, not always being blanched in the manner common in England and America.

According to Sturtevant's *Notes on Edible Plants,* celery is supposed to be the *selinon* mentioned in Homer's *Odyssey;* the *selinon heleion* of Hippocrates, the ancient Greek physician; the *eleioselinon* of the later Greek physicians, Theophrastus and Dioscoroides; and the *helio selinon* mentioned by the Roman naturalist, Pliny. The use of celery in ancient times is undoubted, but it was used almost entirely as a medicine. Strabo in the ninth century and Fuchsius in 1542 mention its use only in medicine. Dodonaeus in 1616 speaks of the wild plant being transferred to gardens but distinctly says it was not used for food. The first mention of the cultivation of celery for food is by Oliver de Serres in 1623, who called it "ache," a term used by the French which later gave way to the names *petit celeri* and *celeri a' couper.* Ray in 1686 says that the wild celery "when transferred to culture becomes milder and less ungrateful, whence in Italy and France the leaves and stalks are esteemed as delicacies, eaten with oil and pepper." Celery culture probably was begun in Italy and extended to France and England. The prevalance of a name derived from one word stem, indicates that the dispersion of the cultivated celery was comparatively recent. The common synonyms for the English celery are French, Celeri; German, Selleree; Flemish, Selderij; Danish, Selleri; Italian, Sedano; Spanish, Apio; Portuguese, Aipo. The first mention of the word celery seems to be in the ninth century in Walafridus Strabo's poem entitled *Hortulus,* where he gives the medicinal uses of Apium and uses the word as follows: "Passio tum celeri cedit

[1] The author is indebted to the Department of Horticulture for the use of material and for valuable aid.

devicta medelae." "The disease then to celery yields, conquered by the remedy." The word "celeri" may be translated quick acting and this suggests that our word celery was derived from the Latin word Celeritas, meaning speed or quickness due to the reputed quick action of the plant as a medicine.

The probable origin of cultivated celery seems then to have begun with the ancient drug gatherers who discovered the medicinal virtues of the wild plant which is rather widespread in Europe. No doubt this plant was grown in herb gardens principally for medicinal purposes; but, by the beginning of the seventeenth century, evidently cultivation and selection had yielded a plant sufficiently mild to be of some use as a flavor for soups and salads. These came rather quickly into use in most European countries under modifications of the Latin or French name, *celeri.* It is of interest to observe that the wild celery grown in herbalist's gardens with many other drug plants might have been converted into a blanched form with milder flavor through infection with the mosaic diseases which are now known to be carried by the common nightshades, and other plants commonly used by these old herbalists. Ray, in 1686, mentions that in English gardens the cultivated celery often "degenerates" into smallage, the wild form, which Townsend in 1726 says "is very hot" and evidently difficult to blanch. Possibly the infection of these garden grown plants with mosaic disease was imperfect and consequently they were not sufficiently blanched; or a few plants may have been resistant to the disease such as we now find in some of our self-blanching varieties which produce a small percentage of dark green plants that are difficult to blanch.

Methods of Blanching

The greater part of the celery crop is blanched before cutting, either by hilling the stalks with soil, which was the method first practiced, or by partly shading the stalks with boards or paper placed close against the sides of the rows. From the standpoint of texture and flavor the first method is preferred. The plants may be set out slightly below the level of the field and the soil gradually pulled up around the bunches when cultivated, or the soil may be thrown up around the plants when they are nearly full-grown. However, this is rather expensive as it involves a great amount of labor and if the soil contains a considerable amount of clay, it is difficult or impossible to wash out all the dirt until after the stalks are broken apart. In marketing, this mud is unsightly to the housewife and nearly always harbors angleworms, insects, and fungi from which rots may develop. Also in such bunches an "earthy" flavor is noticed which probably comes from decaying substances in

the mud or from organisms such as the strong smelling algae growing in it.

Hilling with earth no doubt produces a tender stalk since the plants are well supplied with moisture and thus become succulent. Covering the stalks also results in rapid growth up through the soil, producing very tall bunches. After the rows are hilled up every crevice around the celery is filled with soil by the first rainfall, thus effectively cutting off all light from the stalks which become well blanched in three to six weeks depending upon the variety of celery, the weather, and the age of the plants.

Hilling celery with boards staked on each side of the trenches is a fairly successful method for blanching especially if the plants are set out close together.

Staking building paper over both sides of the rows involves less labor and expense than the use of boards. The paper can be quickly applied by staking it against the plants with laths. At the end of the season the paper may be rolled up for use during the next season. The use of either paper or boards will cause the celery to grow up considerably, but it will not be as perfectly blanched as when soil is used for hilling. The growth occurs mostly in the young stalks at the heart of the bunch. It is impossible to exclude all of the sunlight by the use of paper or boards, and as diffused light will prevent the removal of the green color, it requires a longer time for blanching and the stalks do not have as good a flavor as those hilled with soil. The covering which is ordinarily left on from three to six weeks usually cannot be put in place until the plants are nearly full grown. Hence, in regions with a short growing season in which frosts are liable to occur early, the tendency is to remove the larger bunches before blanching is complete which, of course, gives a lower grade of celery. The market demand is frequently decreased by this imperfectly blanched celery, for once the housewife has tasted a bitter green bunch she decides to use it for soup and wait for a better quality for table use.

Fungous diseases sometimes cause considerable losses in the plants which are hilled up with boards or paper. This is especially the case in cloudy, wet weather with high temperature.

Because of the disadvantages and the long time required to blanch celery by the methods now in use, the author undertook to discover a new method. This method has now been perfected to the point where it is evident that it may be used commercially.

Use of Ethylene Gas for Blanching Celery

It was discovered that the green color of the stalks and leaves of celery could be removed by blanching the plants in ethylene gas, taking

for this new method six days for the self-blanching celery and from ten to twelve days for the green varieties. An excellent flavor, texture, and keeping qualities are obtained as a result. The stalks are as brittle and sweet as celery which has been blanched by hilling with soil, and the old leaves are as free from bitter acrid taste as the young heart leaves of ordinary celery.

The green coloring matter of leaves is called chlorophyll and it is necessary for the formation of the sugars and starches which are produced by plants. Owing to the presence of this green pigment, the leaves absorb certain parts of the sunlight, and the light energy so absorbed may be stored as chemical energy in the starch or sugars of the plant. In celery the sugars are partly responsible for its flavor and value as food so if the chlorophyll is lacking or deficient in amount, the leaves are unable to function properly for the formation of sugars and other substances. Also, plants which are deficient in chlorophyll and accordingly have light green leaves, are usually not as vigorous as those which are dark green. As leaves that are completely blanched are no longer capable of forming sugars and all growth except the stretching from water absorption ceases, it is easily seen that the self-blanching varieties of celery will be less efficient in sugar formation and in growth than the dark green. The self-blanching varieties have light green leaves even from the seedling stage, and when the plants are half grown the blanching has proceeded so far that the starch-forming efficiency of the leaves is very greatly decreased. At the time of maturity, comparatively little sugar formation can take place in the blanched leaves. From the standpoint of producing vigorous plants which are well supplied with sugars, one should select celery plants with dark green leaves; yet the bitter, acrid green flavor of such varieties make them undesirable for table use, and furthermore such a long time in storage is required to blanch them properly. A happy solution to the difficulties here presented by these vigorous green plants has been found by blanching with ethylene gas. When treated with ethylene, they are of a better texture and flavor than are the self-blanching varieties and as the time required to blanch the green varieties is from ten to twelve days not much of the original sugar content is lost. There may even be formed additional quantities of sugars by the digestion of starch and other carbohydrates of the stalks. The action of the enzymes concerned in the digestion of starch seems to be increased by the ethylene treatment and the fibrous materials of the stalk also seem to undergo partial digestion so that the stalks are more brittle and less stringy. Some pithiness of the stalk may occur, but it may be caused by dryness and wilting of the stalks rather than from the ethylene treatment. Slight freezing is also likely to produce pithiness and splitting of the stalks.

Celery varieties which will be used in the future will probably be those which are sufficiently dark green in color to permit of vigorous growth and for the production of succulent stalks of high sugar content rather than the light green, self-blanching varieties which are likely to show comparatively weak growth. The application of this method of blanching by ethylene gas will also make it possible to grow celery for a longer time before blanching is begun, a factor of importance in the northern regions of Minnesota. Frequently the celery in the Duluth region does not have time to reach maturity in the field before the first frost. Using this new method celery may be allowed to grow until the latest possible date and then may be blanched in storage cellars, or in transit in tight refrigerator cars.

The blanching of celery with ethylene offers still another advantage. The larger bunches may be pulled from the trenches as soon as they are of marketable size, and then may be quickly blanched with ethylene in tight boxes or railway cars, and marketed at a time when the price is high. Since the self-blanching varieties can be blanched in six days, the preparation for market is not seriously delayed. Furthermore, it has been found that after the celery has been exposed to the ethylene in proper concentration for three days, it can be put in transit and will continue to blanch after the exposure to the gas has been discontinued. If the time from field to market requires six days, the entire blanching can be accomplished in the railway car. If the time in transit from field to market is only three days, it may be best to treat the celery with ethylene in a storage room or tight cellar for three days before shipping so as to insure a well-blanched celery which will grade high at the market.

The photograph (Fig. 1) shows two crates of celery which were packed at the Fens Station, St. Louis County, Minnesota. The crate on the right was placed in a log cellar which was covered with peat and was not at all gas tight. A dose of ethylene which was roughly estimated to be sufficient was liberated into the cellar and two days later a second treatment was given. The crate on the left was kept in storage without ethylene. Six days after the bunches were pulled from the field, the crates were shipped to St. Paul by express and they arrived at University Farm seven and one half days after the first treatment with ethylene. The green color is shown in black in contrast to the white of the blanched parts in the photograph. The improvement in appearance and flavor shown by the celery which was treated with ethylene was marked and sufficient to make a great difference in its sale on the market. The bunches which had been treated with the gas were thoroly blanched and of good flavor showing that the gas

penetration is sufficient to cause proper blanching even in the center of the crate. These crates were then held in cold storage at University Farm for observation on keeping qualities of the blanched and unblanched material. Both crates showed some soft rot of the outer stalks after two weeks in storage, but no deleterious effect of the ethylene treatment on keeping quality could be detected even after three weeks in storage. Experiments up to the present time indicate that material treated by this new method is no more liable to rot than celery blanched in the hill.

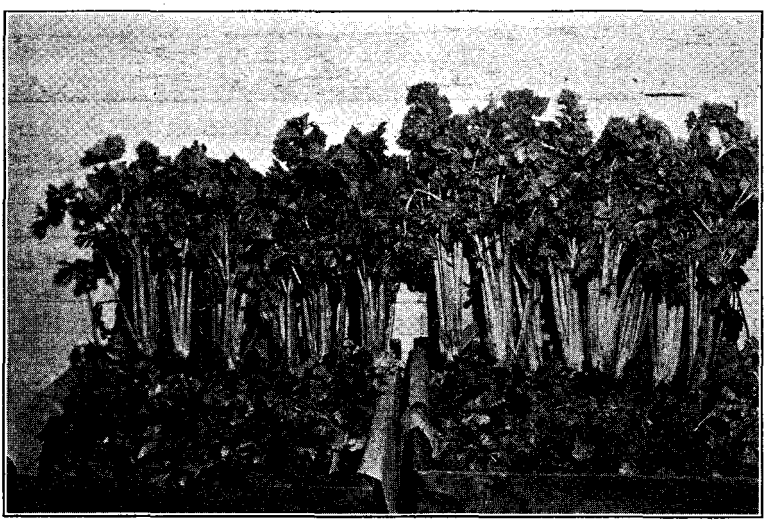

Fig. 1. Celery Blanched in Crate

Blanched celery (right), compared with unblanched (left).

In some of the experiments an overdose of ethylene was given which tended to cause browning, especially of the outer leaves which wilted more quickly than normal untreated leaves. But by proper control of the amount of gas used, this burning of the foliage can be avoided easily since the concentration of gas required for proper blanching lies much below that which will cause serious browning. Figure 2 shows from left to right the relative colors of celery (1) unblanched, (2) partly blanched by hilling with soil for one month, (3) blanched perfectly with ethylene in six days, and finally a sample showing (4) browning of the outer leaves from over-exposure to the gas.

For use in blanching celery with ethylene almost any kind of tight container can be used. The celery should be packed loosely in an upright position so that the stalks will not become crooked. Galvanized iron tanks, tight boxes, cellars that can be sealed, or railway refrigerator cars may be used; in fact almost anything that will hold the gas for

three days will serve the purpose. A heavy canvas or an oiled cloth held above the rows by a framework has been used successfully in the field (Fig. 3). Dirt should be banked around the edges of the cloth to stop loss of gas. These cloth coverings will not be as successful in windy weather as on still days since they are rather permeable to gas and the pressure of a wind helps to force out the gas from the enclosed space. A warm temperature will cause blanching more quickly than a low one, but the temperature preferably should not go above 80° F. Near the freezing point, a much longer treatment is required for blanching than at an optimum of about 65° F.

Fig. 2. Golden Self-blanching Celery
Left to right. (1) unblanched, (2) hilled with soil for one month, (3) blanched with ethylene in six days, (4) browning of leaves from an overdose of ethylene.

There is little need to provide for distribution of the gas in the container, for it is rather light and quickly diffuses throughout all of the air space. It seems to penetrate well even when the bunches are crated before being treated.

The self-blanching varieties of celery can be blanched in about six days at the optimum temperature of 65° F. at a concentration of ethylene varying between one part in one thousand (1:1000) to one part in ten thousand (1:10000) of air. If the room used for blanching is very dry, it is advisable to provide moisture by placing the roots in water to prevent wilting. If this is done or if the air space is already humid, there will be no wilting produced by the treatment as wilting is not caused by the gas itself. For the dark green varieties a longer time (ten to twelve days) is required, but the concentration of gas must not be increased above one part in one thousand of air because burning

and browning may be produced by higher concentrations. The blanching of these green varieties must not be speeded up too much by raising the concentration of ethylene. The very fine quality of the celery produced from these varieties will amply justify the use of a longer time. If the containers are not tight, it is advisable to administer a second dose of the same concentration after the first six days. Oxygen gas as found in ordinary free air is necessary for the blanching process as well as for the normal respiration processes of the live plants during the time which they are in the closed space. For this reason it is desirable to allow more space in the room or container than that actually occupied by the celery. If the bunches are too closely packed, they will use up the oxygen in the air space and they are also more liable to be injured by fungous rots. The normal rate of respiration in the plants seems to be considerably increased by the ethylene treatment.

Fig. 3. Celery Blanched with Ethylene under Canvas
Ground of same row, unblanched bunches of the same variety.

The ethylene gas recommended for blanching celery is the same gas as that now used extensively by hospitals to produce anaesthesia. It can be obtained in almost any large city in steel tanks under pressure. The tanks weigh about 15 pounds total and contain about 200 gallons of gas or 25 cu. ft. (Fig. 4). The cost of the gas alone per tank is about $4. If the gas should be used in the standard size refrigerator car, from one to three cubic feet should be liberated in the car. This will give a concentration of from one third to one part of ethylene in 1000 parts of air, (actually 1 cu. ft. of ethylene to 2800 cu. ft. of air). A small tank costing $4 then should contain enough gas for treating

ten or more carloads of celery. This does not provide for gas leakage from careless handling. It has been found that the gas loss from the standard refrigerator car is very slow, so that a concentration originally established within the car will be sufficient to blanch the common varieties of celery.

Fig. 4. Experimental Treatment of Celery in the Field with Ethylene
Ethylene from the small tank in front of the operator is being measured through a gas meter and rubber tube into a box. The large tank contains acetylene.

The space in which it is intended to blanch should be carefully measured and its cubic contents calculated. Into this space there should be liberated the necessary amount of gas to establish a concentration of not more than one part in one thousand of air. As the gas is light it diffuses quickly to all parts of the confined space.

Measurement of the gas from the tank may be made by any kind of gas meter, such as is used in measuring illuminating gas, or it may be measured by displacement of water in bottles or cans. A special measuring apparatus was devised and constructed by Mr. D. Crowther of the University of Minnesota for this purpose. It consists of an expansion valve which may be set to deliver ethylene at a constant low pressure from the high pressure tank through an orifice. Since the gas is forced through the orifice by a steady pressure, a constant quantity of ethylene will be delivered in a given time. All the meter that is needed then for obtaining a required dose of ethylene is a watch provided with a second hand. With this device the valve on the high

pressure tank may be opened to any amount sufficient to give the maximum flow from the orifice without affecting the amount of gas delivered per minute, and also the pressure in the tank has no effect on the rate of flow until the supply of gas is exhausted. The device shown in Figure 5 is of rugged construction and in our trials has given reliable measurements. The error of measurement is usually less than 10 per cent, and this is insignificant in measuring a required dose of ethylene for blanching. It is not advisable to attempt to blanch celery with ethylene without controlling the concentration with some accuracy.

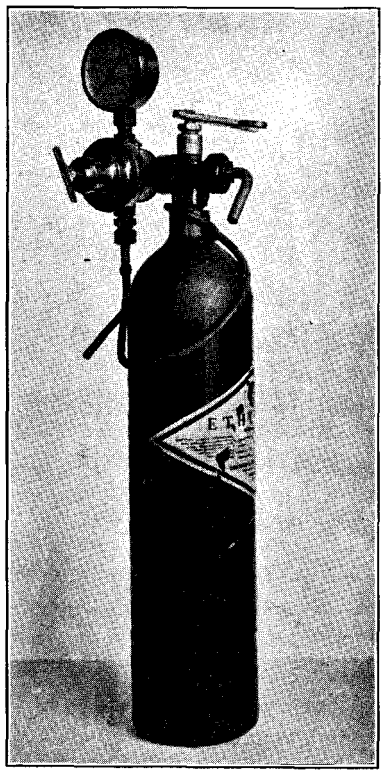

Fig. 5. Ethylene Tank with Expansion Valve and Nozzle
This outfit will deliver a known quantity of gas in a given number of seconds.

Ethylene has a faint, pleasant, sweetish odor on liberation from the tank, but when distributed throughout the air space at the maximum concentration recommended it can be detected by its odor only by persons accustomed to it. In fact, the odor of celery in the storage room is usually more pronounced than the odor of the ethylene.

With ordinary care there is no danger of persons becoming anaesthetized by the gas in cellars or storage rooms, because concentrations hundreds of times greater than those required for blanching are neces-

sary to produce anaesthesia. A number of persons have worked during these experiments in rooms containing the gas in proper concentrations without noticing any ill effects. Also there is no danger from explosions of the ethylene mixture with air when used in a proper concentration for blanching celery because the explosive mixture of ethylene and air is many times more concentrated than the strongest mixture needed for blanching; about 3 per cent of ethylene being the lowest concentration which is explosive. A whole tank of ethylene (25 cu. ft.) could be liberated into a railway car without reaching the explosive mixture. However, ethylene is inflammable, and if liberated carelessly in high concentration into a confined space will form an explosive mixture with air. Therefore light or fire should never be allowed within or adjacent to a room during the time at which the gas is being liberated from the tank, for a high concentration will be produced around the exit tube and this will ignite and burn if it comes in contact with a flame or spark. Directions and precautions for handling the gas are printed upon each tank and these rules should be strictly obeyed.

Use of Acetylene Gas

Acetylene gas also has a blanching effect upon celery, but it has an unpleasant odor and is liable also to produce headaches in persons who are exposed to it for a long time. It is, moreover, somewhat more poisonous to the plants and more liable to produce burning of the leaves in high concentrations.

The main reason for not using acetylene for blanching celery is its unpleasant odor; however, at the concentrations (1-1000 to 1-10000) needed for blanching it has little odor and the celery blanched by its use will have no detectable odor of acetylene after removal from the containers and exposure to the air for two hours.

Acetylene has one advantage in its use for blanching celery in that it can be easily generated from calcium carbide such as is ordinarily used for automobile lighting. It can be obtained in cylinders of the compressed gas for about $1.85 per hundred cubic feet. These cylinders are regularly obtainable from garages where acetylene welding is in use.

While ethylene and acetylene are able to blanch celery, they have no bleaching effect and it is improper to use this word in describing the action of these gases. Ethylene and acetylene do not bleach celery in the manner, for instance, that sulfur dioxide or other chemicals are used to bleach dried apples. The action of the ethylene and acetylene seems only to be to speed up the natural ripening process which would require a longer time without them. They seem to bring into play or to stimulate the action of the enzymes normally present in the plant by

which the transformation is brought about. Plants put into a dark room will lose their green color without the use of any gas. This is essentially what is done when celery is blanched by hilling up the stalks with soil, boards, or paper. The action of ethylene and acetylene seems merely to speed up the normal process of decomposing the green pigment, thereby shortening the time required for blanching without producing any bleaching effect. These gases have no effect on pigments in the celery other than the green pigments, known as chlorophyll. The yellow pigments of celery are unaffected by the treatment, and varieties of celery which contain yellow pigments such as Golden Plume will be a rich golden yellow after being blanched with ethylene. Varieties such as White Plume which have little or no yellow pigment normally will be pure white after blanching. Neither are red pigments found in the rose colored varieties such as Rose Rib Selb-blanching (Fig. 6) changed in any way by ethylene and acetylene. Stalks of these varieties still retain their normal pink color after blanching with ethylene. These varieties when properly blanched with ethylene have a very attractive appearance. Such varieties regularly produce vigorous succulent plants of fine texture and flavor since their leaves are well supplied with chlorophyll. The pink stemmed varieties are preferred by many Europeans, particularly by the English, but they have not met with such widespread favor in this country on account of the difficulty in blanching. Now that a means of blanching them has been discovered, they should gain in popular favor.

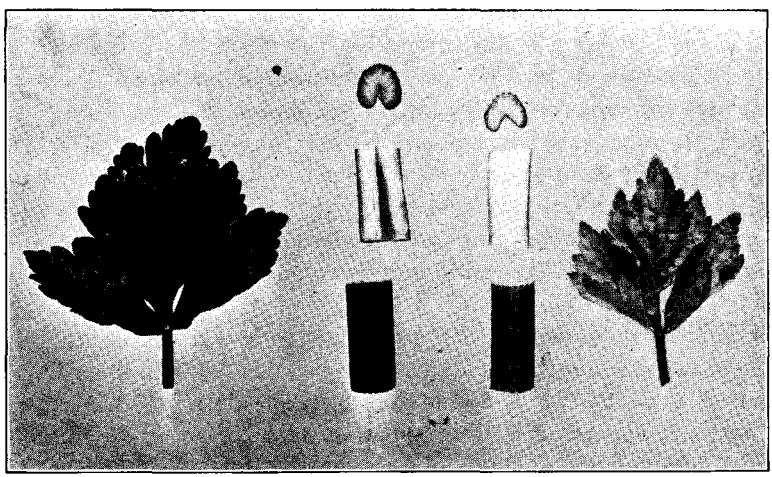

Fig. 6. Right. Leaf and section of the stalk of Rose Rib Self-blanching Celery, a very green variety perfectly blanched with ethylene. Left. Check unblanched. The difference in green color is shown in the proportion of black.

When celery plants have been exposed to ethylene or acetylene gas, the decomposition reactions of the chlorophyll are initiated and the decomposition will continue in darkness even after the plants are removed from the gas. It is evidently more effective to liberate the required concentration of gas into the space at once rather than to introduce it in low concentrations over a longer time. Apparently the optimum concentration of the gas is required to initiate the process, and this will not be accomplished by low concentrations for a longer time. Once the leaves are thoroly blanched and all of the chlorophyll is destroyed, the leaves may be exposed to sunlight for three weeks without the older leaves showing any green color altho they are succulent and healthy. The young leaves at the center of the bunches will grow out in a couple of weeks and they are the first to become green. Bunches which have been blanched may be put in store windows or on the market for a time sufficient for their sale without the stalks turning green again.

The self-blanching varieties such as Golden Self-blanching, White Plume, Golden Plume, etc., have been most popular in the past because they can be blanched much more easily than the green varieties such as Rose Rib Self-blanching or the green English sorts such as Sutton's Pink, or Rose Stemmed celery. In fact, it requires so long a time to blanch some of the green varieties that they are little grown except for chop suey, or for soups, or for winter use. The self-blanching celeries have leaves which are very light in color even in the seedling stage and as the plants grow older the whitening of leaves and stalks becomes more pronounced. Some varieties are almost perfectly blanched late in the season without hilling.

The leaves are frequently mottled with a mosaic pattern of dark green and yellow patches over the blades (Fig. 7). The green varieties mostly maintain a dark green foliage throughout the season and may be blanched only with difficulty, and then only imperfectly, by all of the common means used for the self-blanching varieties.

Among the self-blanching plants in the seed beds one will find some 10 per cent of the plants which are of a dark green color. Many gardeners reject these seedlings for they know that plants produced from them cannot be blanched for market. When these green plants are set out in the rows along with the lighter colored plants, they are found usually to grow more vigorously than their lighter colored fellows. They grow to great size and produce fine bunches of celery except that the stalks and leaves are very green and they show no tendency to blanch long after all of the other bunches have been removed for market. These bunches have been observed to grow to three and one-half feet tall and four inches in diameter; they are very

brittle and of excellent quality except for the acrid, bitter green taste caused apparently by the green pigment, the chlorophyll.

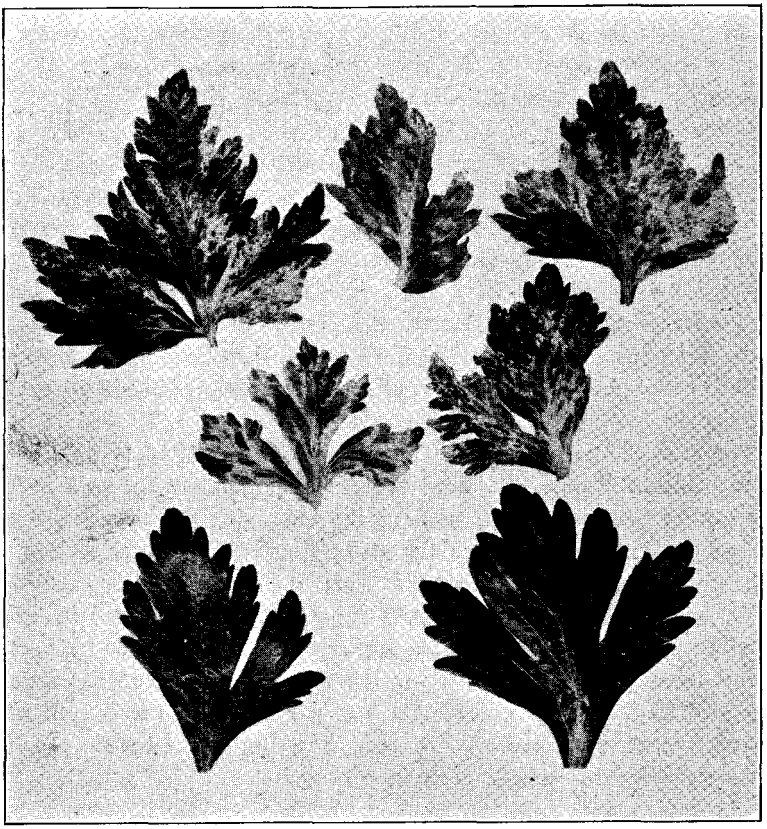

Fig. 7. Diseased Golden Self-blanching Celery
Upper leaflets showing mottled appearance, lower leaflets, from dark green plants.

The varieties of celery which are light green in color or which have mottled green and white leaves are more easily blanched with ethylene than the dark green varieties. Very frequently the self-blanching kinds show all of the symptoms of having the disease commonly recognized in other families of plants as mosaic. A mosaic disease of celery has been reported from the Florida and New Jersey experiment stations but it has been insufficiently studied to know the conditions of its development or its mode of dissemination. Such work as has been completed upon it suggests that it may be disseminated by plant lice and that it may come from other families of plants such as tomatoes on which the mosaic disease is well known. Late in the season the ordinary self-blanching varieties of celery frequently show many symptoms which are characteristic of mosaic

disease; the leaves are mottled in appearance (Fig. 8), the plants are stunted in growth, and there is a great tendency to produce suckers from the main bunch. The leaves are brittle and distorted into "shoe string" types (Fig. 9). The self-blanching varieties seem more susceptible to the mosaic or show stronger symptoms of the disease than the green winter varieties. The leaves of the winter varieties show some crinkling and curling but evidently their photosynthetic ability is

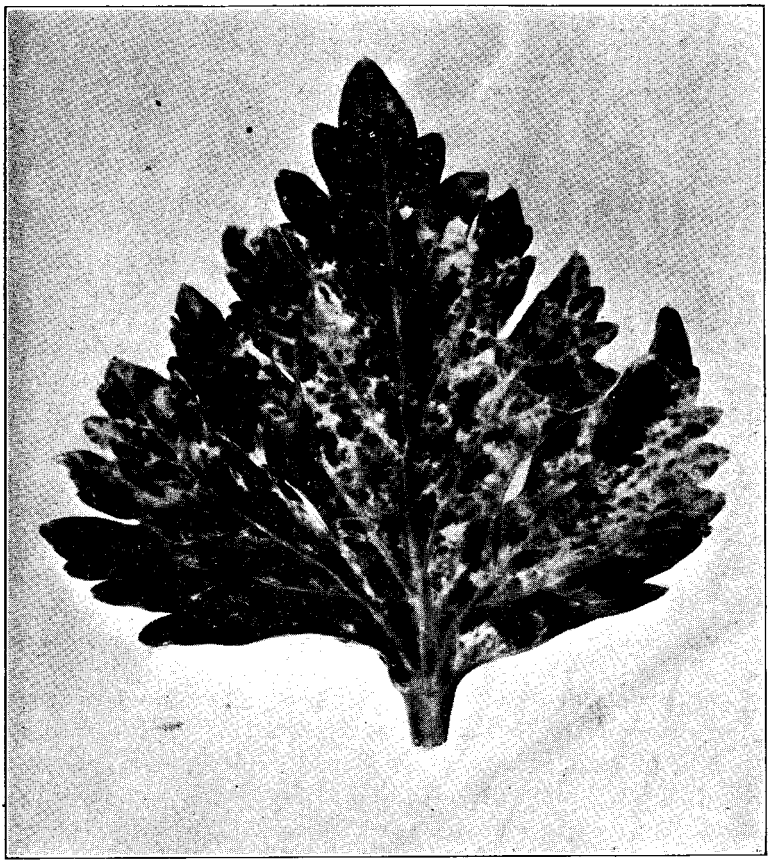

Fig. 8. Diseased Golden Self-blanching Celery
The mottling in spots over the leaf due to lack of chlorophyll. Late in the season the leaves become almost devoid of green color.

not disturbed. In the commercial green varieties one will usually find about 10 per cent of the plants which are stunted in growth, light in color, and evidently infected with mosaic disease. These plants (Fig. 10) more closely resemble the self-blanching varieties and they are more easily blanched either by hilling or by treating with ethylene

than the normal green plants. In the self-blanching varieties, over 90 per cent of the plants at University Farm in 1924 showed the symptoms of mosaic disease and less than 10 per cent of the green-leafed varieties showed evidences of this infection.

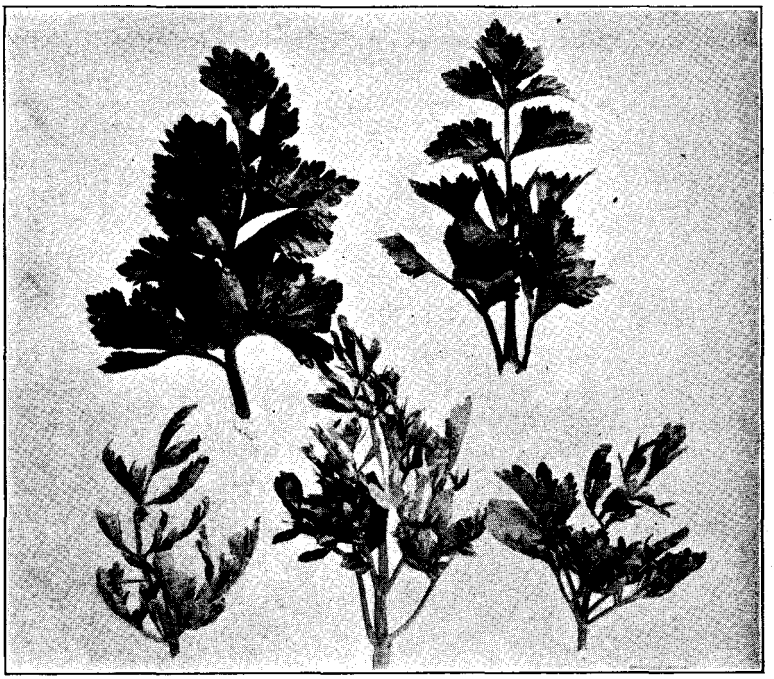

Fig. 9. Healthy and Diseased Leaves of Celery

Upper, leaflets from healthy plants. Lower, leaflets showing "shoe string" types of leaves.

It seems probable then that the self-blanching condition in celery is aided by mosaic infection and possibly in breeding, varieties which are highly susceptible to mosaic disease have been selected. This characteristic would tend to be increased in breeding by the practice of selecting those plants which were most perfectly self-blanching. The young seedlings of the self-blanching varieties are very light in color altho no opportunity is given for their infection with the mosaic disease except through the seed. This condition is generally referred to as a physiological chlorosis and seems to be inherited. From the standpoint of production, a mosaic disease would be just as effective in decreasing the yield as a physiological chlorosis which was inherited, for the ability of the plant to form carbohydrates is decreased by either condition.

In breeding for better varieties of celery it will be desirable then to select plants which are free both from mosaic disease and from physiological seed-borne chlorosis, since neither condition is now neces-

sary for the production of well-blanched celery and since any celery, however green, can be quickly blanched with ethylene. If the new process for blanching celery comes into general use and is commercially successful, it should transform the celery industry and lead to the introduction of healthy strains of plants free from mosaic disease and from any other chlorotic condition which may decrease the vigor of the plants. The already existing green-leafed varieties offer good material for the breeding of these healthy varieties of celery.

Fig. 10. Rose Rib Self-blanching Celery
Right, a plant with dark green leaves. Left, plant with very light colored leaves. Neither bunch was blanched.

Summary

Celery can be blanched by ethylene or acetylene in concentrations of one part of gas to one thousand of air, or lower concentrations within six days for the self-blanching or within twelve days for the green winter varieties. The use of acetylene for blanching, however, is not as desirable.

Celery when treated with ethylene does not turn green again in sunlight within the usual time required for sale.

The quality, texture, flavor, and color of celery blanched with ethylene is equal, if not superior, to that blanched by other methods and the keeping qualities are not impaired by the treatment.

This new method of blanching celery seems to offer commercial application, since the gas is inexpensive and can be applied in almost any gas tight container.

It is indicated that the blanching of some varieties is hastened by the infection of the plants by mosaic disease. Chlorotic varieties are more easily blanched than dark leafed plants.