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DIVISION OF BOTANY.

CHICORY GROWING

AS AN ADDITION TO THE RESOURCES OF THE AMERICAN FARMER.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Botany,
Washington, D. C., November 11, 1897.

Sir: I have the honor to submit herewith, for publication as a Bulletin of the Division of Botany, a manuscript entitled "Chicory Growing as an Addition to the Resources of the American Farmer," prepared under my direction by Mr. Maurice G. Kains. As the report contains chapters on the adulteration and chemical analysis of chicory, it has been submitted to the Chemist of the Department, Dr. H. W. Wiley, who has revised those portions of it.

In the year 1896 the United States imported 16,306,474 pounds of chicory, having a wholesale value of $225,228.31. Most of this chicory was grown in Belgium. In the belief that chicory could be made a profitable crop in the United States, we began an investigation the results of which are embodied in this report. The Department of Agriculture may confidently recommend the cultivation of chicory in the mid-northern belt of our country. Its cultivation, however, as a market product on a farm should be undertaken only when a chicory mill, where the crop can be disposed of, is close at hand, or when the farmer can grow the root on a sufficiently large scale to own and work his own mill. As a home product, however, its cultivation may be much more general. There is no reason why the individual farmer should not grow, dry, and roast the chicory used upon his own table, if he desires to pursue this course, instead of purchasing the pure manufactured product. He is certainly entitled to exemption from its purchase at an exorbitant price in the form of supposed ground coffee. It should be considered, however, by those who propose to take up the cultivation of chicory as an agricultural industry, that a very limited area will produce all the chicory we customarily import, and that overproduction of this crop would be easy.

Respectfully,

Frederick V. Coville,
Botanist.

Hon. James Wilson,
Secretary of Agriculture.

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CHICORY GROWING AS AN ADDITION TO THE RESOURCES OF THE AMERICAN FARMER.

DESCRIPTION OF PLANT.

Chicory (fig. 1) (*Cichorium intybus* L.)[1] or succory, as it is often called, is a native of Europe, which, like the oxeye daisy, the burdock, and the wild carrot, has become naturalized in this country, and, in many sections, is classed as a weed. It belongs to the same natural family of plants as the hawkweeds, the prickly, garden, and other lettuces, and the dandelion, which last it resembles in having an opaque, bitter, milky juice, which owes its opacity, and much of its bitterness, to the presence of an inert vegetable compound called inulin. The brilliant blue (sometimes pink or almost white) flowers are crowded together in little groups of two, three, or four, and sometimes more, which stud the straggling, rigid, nearly leafless branches, to which they are attached by very short stalks. The plants, which rise to a height of 1 to 6 feet, are familiar along roadsides, in fence rows, and even in fields. In sunny weather the blossoms seldom last longer than a few hours in the morning, but they may continue later upon cloudy days. The perennial, spindle-shaped tap-root, with its single or double head, is of a whitish-yellow, or grayish-yellow color, and but for its white juice might

[1] TECHNICAL DESCRIPTION—*Cichorium intybus* L. Root thick, perennial, fusiform, 30 to 60 cm. (11 to 23 inches) long, with smooth white surface and bitter, white, thin, milky juice. Stem herbaceous, erect, branching, glabrous, sparsely hispidulous or thinly strigose, sometimes purplish, 0.5 to 2 m. (1½ to 6 feet) in height, leafy below, but usually bearing only reduced bract-like leaves, with the flowers, on the long, upwardly curving branches. Leaves softly pubescent on the midrib and veins below, glabrous or thinly puberulent above; those at the base oblong or somewhat spatulate, usually obtuse, irregularly dentate, runcinate or nearly entire, 15 to 30 cm. (6 to 12 inches) long, 6 to 12 cm. (2⅓ to 6⅔ inches) wide; stem leaves smaller, oblong or ovate, acute, sessile, cordately clasping, dentate or nearly entire. Flowers (fig. 2) sky-blue or sometimes white, ligulate, in flat, sessile heads about 4 cm. (1⅔ inches) in diameter; these racemosely disposed along the slender branches in clusters of two to four in the axil of each of the reduced upper leaves. Involucre of two series of scales, all herbaceous and bearing slender, gland-tipped hairs along the margins, and sometimes upon the back; the outer series of five to seven ovate, acute, recurved bracts 8 to 12 mm. (one-third to one-half inch) long; the inner series of about 10 lance-linear bracts one-third longer than the outer ones, erect before and after flowering. Ligules (fig. 2, c.) spreading about 20 mm. (four-fifths of an inch) long, and 5 mm. (one-fifth of an inch) wide, 5-toothed at the apex. Akenes (fig. 2, d, e.) 2.5 to 3 mm. long, varying from very light brown to nearly black, often mottled, granular-roughened, slightly curved, irregularly angled, thickest at the truncate apex; pappus, a single row of minute, erose, obtuse paleæ.

easily be mistaken for the root of a parsnip. The lower leaves resemble those of the dandelion more or less closely, but are generally larger. They usually lie upon the ground until the stem commences to grow. The leaves of the upper stem and branches are much smaller, and are more or less pointed and lance-shaped.

USES.

Although chicory is in many sections of the country a troublesome weed, due in most cases to carelessness on the part of someone who has grown it for the table, for fodder, or for its roots, it has held a place in the list of culinary plants for ages. The Romans, according to Horace, who notices it under the name of *cicorea*, used the plant, probably as a salad or pot herb. Girarde relates that "the leaves of chicory are boiled in potage or broths for sicke and feeble persons that have hot, weak, and feeble stomachs, to strengthen the same." At the present day its young leaves, when well blanched, are considered equal as a salad to those of the endive (*C. endivia* L.), to which it is closely related. In this form it is known as *barbe de capucin*. Under special cultural processes, accidentally discovered and long kept secret by the discoverer, M. Bresiers, the famous "witloof,[1]" or "witloef," of the Dutch is produced.

FIG. 1.—Chicory plant (one-tenth natural size).

The tender young roots, when boiled and served with butter and pepper, in the same way as young carrots, are considered a great deli-

[1] To produce *barbe de capucin* and *witloof*, vegetables almost unknown in America, the well-grown chicory roots when taken up in the autumn are trimmed of their leaves and superfluous rootlets. For the former vegetable about one-half an inch of the top is left. The roots so trimmed are laid horizontally in sloping heaps with

cacy by many Europeans, especially the Belgians. The young green leaves, when cooked in the same manner as spinach, except that two waters are used, rival the justly popular dandelion greens. To produce these greens the seed is sown thickly in drills in early spring, and when the leaves are a few inches tall they are cut with a sickle or a knife. Several cuttings may be made in a season. Governor Bowdoin, of Massachusetts, is said to have introduced the plant from Holland in 1785–86 for this purpose.

In some parts of Europe a blue dye is made from the leaves by much the same process as that followed in the manufacture of the still extant woad dye, with which the ancient Britons stained their bodies in time of war. This manufacture is, however, somewhat limited. Recently it has been proposed to utilize the roots in the manufacture of alcohol, since they contain a large quantity of inulin and sugars, which may be readily converted by much the same processes as the constituents of sweet potatoes and other roots in the production of this spirit.

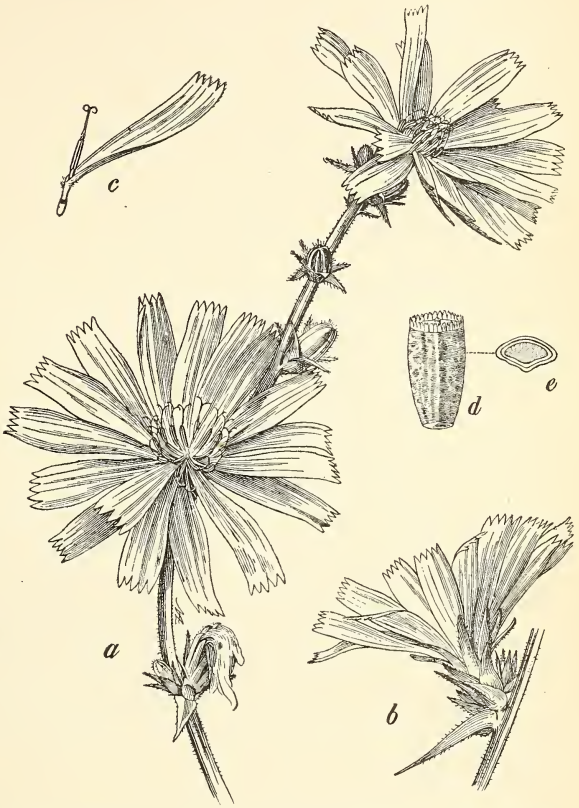

FIG. 2.—Chicory flowers and seed: *a*, heads of flowers, front view, with buds on twig; *b*, head of flowers, side view; *c*, single flower; *d*, seed (akene); *e*, section of same.

As a fodder plant for sheep, swine, and beef cattle, chicory was extensively planted in the latter part of the last century and the earlier

alternate layers of moist sand or earth upon the floor or upon the shelves of a root cellar, or other dark warm place. The large ends of the roots extend an inch or so beyond the earth. In about three or four weeks fine white leaves, 6 or more inches long, may be gathered. If undisturbed, the roots will continue productive for some weeks. This vegetable is used as a salad, or boiled like kale, or is cut like cabbage for slaw and mixed with oil and vinegar as a seasoning for boiled beef.

For witloof, the tops are trimmed to 1½ inches and the roots, preferably those which have produced the largest leaves, are planted upright at least an inch apart in the rows, which are in trenches 15 to 18 inches deep. The roots are then covered with

years of this, and it is even at the present time more or less used in Europe for this purpose, although alfalfa has been steadily replacing it in general favor. This use of the plant will be further treated in the concluding section of this bulletin.

When dried the roots have been used by druggists as a substitute for dandelion root, which it so closely resembles in officinal qualities that at one time the question of adopting it in preference to the latter in medicine was discussed by the American Pharmaceutical Association. It was claimed for chicory as a drug that it produces the same physiological effect as dandelion root; that it retains its medicinal qualities longer; that it is stronger than nine-tenths of the dandelion root sold in the markets; that it is always obtainable, and that it is cheaper and of better quality as a root. Upon the other hand, the Pharmacopœia of the United States, in speaking of dandelion root, remarks: "It should be free from the root of *Cichorium intybus* Linné (nat. ord. Compositæ), which closely resembles it, but is usually paler and has the milk vessels in radiating lines." A prominent wholesale drug firm writes that its use as an adulterant of taraxacum has, they believe, been discontinued; but according to another drug company it is still largely used by manufacturing druggists in making the extract of taraxacum, in which form it can not be distinguished from the genuine product. The roasted root is used to give a darker color to and to increase the bitter qualities of certain liquors, such as porter, for which purpose it is probably less harmful than quassia, which is also used extensively as a substitute for hops in many beers, ales, and porters. When pulverized the roasted root is used to adulterate snuff and coffee. It is also used in many parts of Europe in this roasted and pulverized form as a substitute for coffee. In America it is but little used for this purpose, except where the population is largely composed of European immigrants.

Chicory appears to have been first used as a beverage in Holland more than one hundred and fifty years ago, and, according to Mr. Charles N. Lachman, of Bethlehem, Pa., it "was cultivated by the Moravians at Bethlehem * * * as early as the latter part of the last century" for this purpose. Its use in Holland as an adulterant of

6 or 8 inches of soil, above which manure is placed to the depth of 2 or 3 feet. Deep covering is essential, since if not so buried the heads may not form at all. In about a month the crop will be ready. The manure and earth coverings are removed and the roots dug up. The witloof heads, which resemble those of cos lettuce, are usually cut off with a part of the root attached. Witloof is used as a salad or is boiled like cabbage, or, more properly, like Brussels sprouts, since the heads are not chopped or cut up, but are carefully boiled whole and so served.

A more rapid method of forcing the heads consists in plunging the roots, trimmed to 5 inches, in spent tan bark and covering, as before, with manure. The bed is made under a greenhouse bench or in some other dark warm place. The heads will be larger and finer after two weeks' growth than those usually produced by the previous method in twice the time. After the first forcing, the roots if again planted will produce from adventitious buds leaves which resemble the *barbe de capucin*, but are more or less in the form of loose witloof.

coffee was kept secret until the early years of the present century, when the adulteration became known to the public. During the great blockade of Napoleonic times, when coffee, tea, and cocoa could not be easily procured, the demand for an infused beverage led to extensive adulterations and substitutions of various kinds, the principal of which in the case of coffee were made with chicory. The people having become accustomed to the use of chicory, either pure or mixed with coffee, during the continuance of the blockade, still continued to use it in the succeeding times of peace. Its use as a beverage upon the Continent is now as well established as that of tea, coffee, or cocoa, and forms a unique example of the creation of a taste by an adulteration which afterwards demanded the continuation of the adulteration or even a complete substitution. Numbers of substances, such as roasted cereals, acorns, sweet potatoes, etc., have been suggested and tried with varying success as coffee substitutes, but chicory still holds first place. These materials from time to time become more or less popular in the market, but sooner or later they are abandoned, except as domestic products, in favor of chicory, only to be retried commercially by a succeeding generation. So general has the use of chicory as a beverage become that many continental powers have been obliged to enact laws to prevent its adulteration, and have made the penalties as severe as for the adulteration of either of the three other great table beverages.

Europeans accustomed to its use maintain that a mixture consisting of two or three parts of good coffee to one of ground roasted chicory is superior to the coffee alone. The mixture is more economical than coffee, since not only does it cost less, but a smaller quantity is required to make the same volume and strength of infusion. Americans, as a rule, do not knowingly use the mixture. They are prejudiced against the root, since it is charged with being the most common adulterant of coffee, although it is probable that much of the adulteration charged to chicory is made with other substances, such as roasted grains of various kinds, acorns, and damaged flour. The simple mixture of pure chicory and good coffee, even if dishonestly sold for the latter alone, seems less objectionable than the "imitation coffee, composed of coffee, clay, and bean fecula, made into the form of coffee beans,"[1] or similar beans, the ingredients of which are pea hulls and low-grade bran, or which consist of molasses, brick dust, and flour. The mixture seems more wholesome, and is certainly more palatable, than the dried coffee grounds rearomatized by chemical methods, which are sold as fresh ground coffee in pound papers with showy labels and attractive names, and which are bought by the manufacturers from the large asylums, hospitals, and prisons of our land at $12 a ton.

Since people demand chicory, there seems little reason for the outcry against it, provided it be sold under its own name; or, if mixed with coffee by the trade, the fact that it is a mixture be so stated upon the

[1] American Journal of Pharmacy, 1893, p. 159. See also Bulletin 13, Division of Chemistry, U. S. Department of Agriculture.

package. To persons who are not aware that the true flavor of coffee is dependent upon its aromatic, volatile oil, and who measure its strength by its bitterness, the substitution or addition of chicory can bring no disappointment. During the process of roasting, the quinine-like bitter of the milky juice in the raw root in part or wholly disappears, while the pleasant bitter quality of roasted chicory seems at least to be partly acquired in the roasting process by the conversion of the sugar of the root into caramel, which is a harmless substance. "Very probably," says the National Dispensatory, "an infusion of chicory taken at meals as a substitute for coffee would be preferable to the latter on the score of health, and it is still more probable that pure water would be more wholesome than either, but such facts furnish no reason why the public should be deluded into believing that in drinking an infusion of chicory they are using a true substitute for coffee."

From the standpoint of health the case does not seem very clear against the moderate use of chicory. Much has been written and said upon the subject, but the greater part has been more or less biased and unaccompanied by data. Dr. Hassall's experiments are perhaps the most noteworthy. Three persons drank an infusion of chicory at breakfast. This infusion was bitter, and dark-colored, and lacked the agreeable, refreshing aroma characteristic of good coffee. Each of the three experienced drowsiness, heaviness, weight at the stomach, and great indisposition to exertion. Two suffered from headache, and the other from relaxation of the bowels, but whether these symptoms were due to the chicory rather than to the abrupt cessation of a customary stimulant, such as coffee, does not appear. In repeated trials with the same subjects, the feelings of drowsiness, lack of energy, and weight at the stomach were experienced, but no diarrhea or headache followed. Further trials produced practically the same results. These symptoms were produced only with the pure chicory infusion; when cheap coffees, consisting of chicory and probably other adulterants, were used the subjects were troubled with diarrhea but not headache. Similar experiments with chicory were tried recently by several persons who tested its qualities, both alone and mixed in varying proportions with different grades of coffee. None of them speak favorably of the chicory when used alone. It was found to be anything but pleasing to the palate, and, in one instance, produced headache and looseness of the bowels. With the exception of only one case, it was found that a small quantity of chicory added to good coffee improved the flavor and reduced the peculiar nervous effects of the coffee. It is supposed that in the single exception referred to an inferior grade of coffee was sold for the high grade. With the cheaper grades of coffee no improvement, but generally the reverse, followed the addition of chicory. In all these trials the purity of the chicory was undoubted, it having been sent by a prominent chicory firm for analysis and experiment.

Analyses of both the raw and the prepared product have so far failed to reveal the presence of any positively harmful substance. Neither

the National nor the United States Dispensatories condemn its use. "Chicory," says the former, "is thought to increase the appetite, promote the digestion, and stimulate the liver—in a word, to operate very nearly as dandelion is supposed to act. Its excessive use is alleged to occasion venous congestion of the abdominal organs, the brain, and the organs of the senses." Professor Beer, of Vienna, places chicory, when used in excessive quantities, in the list of causes of amaurotic blindness. In France and Germany use is made of chicory infusion as an aperient for infants and young children, mothers prefering it to ordinary medicine on account of its less disagreeable flavor and less harmful effects. Since none of the symptoms already mentioned are apparent when the mixture with coffee is used, and since equally remarkable symptoms follow the excessive use of coffee, it appears that the use of chicory in moderation is not fraught with greater evil than the use of coffee. Each beverage affects different temperaments in different ways, and it should be left to the individual himself to choose chicory, coffee, a mixture, or neither. The very general use of chicory for the last one hundred and fifty years, and the proportions which its cultivation has assumed indicate that it is beneficial and agreeable to at least some constitutions.

CHICORY GROWING FOR THE ROOT.

RAISING THE CROP.

RANGE.

The cultivation of chicory is a permanent agricultural industry in nearly every country of Europe. It is more particularly a cool climate crop. The Dutch, the Germans, the Scandinavians, and the northern French are the principal raisers, consumers, and exporters. A large quantity, too, is raised in Great Britain, most of which is consumed at home. In the United States its cultivation has been attempted in but a small way, but as a crop it has met with considerable success. It has been or is now cultivated in Massachusetts, New Jersey, New York, Pennsylvania, Michigan, Wisconsin, Indiana, Illinois, Nebraska, California, Oregon, and probably other States, to a greater or less extent. From these facts it may be inferred that its range is similar to that of the sugar beet, since the latter thrives in all the regions mentioned above.

SOIL AND MOISTURE.

As far as soil is concerned chicory is not a fastidious crop. It has been known to produce well upon clayey, sandy, and prairie soils. In general it may be stated that, except the heaviest clay and the lightest sand, any soil not too stony which will produce good crops of sugar beets, potatoes, or maize should produce paying crops of chicory. The very sandy soils are generally too dry, the very heavy clays too hard to work. The root is usually smaller and more woody in compact than upon looser soils. The stony soils, particularly if the stones are large

and deeply embedded, are generally too hard to work at the depth to which chicory land must be plowed. The surface soil should be deep and the subsoil should be open to allow ample space for the extension of the long tap root. Neither the soil nor the subsoil should ever be dense or hard or contain stones, roots, or other obstructions, since the chicory root tends more or less to branch and to subdivide at the crown into many small rootlets or to develop abnormally the small side rootlets when it comes in contact with such substances. These small roots, in addition to being more difficult to pull up and to wash clean, are also of very inferior quality. An objection to clay soils is that, although occasionally producing good-sized roots of fair quality in favorable seasons, they are too prone to bake and pack under the influence of hot suns and heavy rains, which packing renders the extraction of the root very difficult. Virgin soils freshly broken should also be avoided as a general thing, since they are likely to contain an excess of organic matter, which generally induces a woody growth of poor quality.

Professor Hilgard, in speaking of crops likely to prove available upon the alkali soils of the West, mentions chicory. It is known that the beet does well and that some of the Compositæ, notably salsify and the Jerusalem artichoke, also do well upon such soils. It is, however, unsafe to judge by analogy, double though it be in this case; and since no experiments have so far been recorded, the practicability of growing chicory upon these lands must be left in question until experiments shall have been made.

An ideal soil would be a reasonably level, deep, sandy or clayey loam, with a somewhat open, friable subsoil. In the sandy loam the roots, being slightly smaller, may stand closer together in the rows; in the clayey soil they should be farther apart. The dark loams of the Saginaw Valley, Michigan, when not too peaty, and the equally dark prairie soils of Nebraska, fill the requirements of a good soil for the cultivation of chicory. It is in these two sections that the best roots were raised in 1897.

If the soil is not naturally well drained, tile should be laid or chicory culture not attempted. The advantages of drained over undrained land for chicory are much the same as in the case of other crops. Points particularly affecting chicory are that in undrained land, especially if heavy, there is more shrinking and swelling, a process inimical to the germination and growth of such small seeds and delicate plantlets as those of chicory; and that the dangers of puddling and baking are greater, results which it is very desirable to avoid with all root crops. Further, the warm spring rain percolating the soil forces out the cold water and imparts its own heat to the soil, while the cool summer rain tends to reduce the temperature of the overheated earth. Each of these conditions is of great importance, since for its best development chicory needs ample moisture from the very start and a comparatively cool soil around the feeding portion of its roots while it is increasing in girth. This period is during July, August, and September. Finally,

drained land requires less expenditure of capital and muscle in manipulation—items which even with the best of management are always large in chicory culture—and gives a greater return in the crop.

If the distribution and supply of water be normally equal, upland is usually as good as bottom land of practically the same texture. Land which is considered too moist for the cereals will generally be found too wet for chicory; while, upon the other hand, soil too dry for profitable grain growing may, with care, still be made to produce good crops of chicory.

FERTILIZERS.

The analyses of the ash of chicory root[1] show a high percentage of phosphoric acid and magnesium, which implies that these substances must not be deficient in the soil. The tops, which also contain considerable quantities of the ash ingredients, if not fed to stock, should be plowed under.

The fertilizer most often employed for chicory is stable manure. Should the soil selected require more potash or phosphoric acid than this affords economically, commercial fertilizers which contain no nitrogen should be applied, and this may be done at any convenient time. Indeed, it is often safer, as will be seen further on, to make the application of animal excrements somewhat light, and the dressing of potash and phosphoric acid proportionately heavier. A good rule for the application of these two substances is to use from one and one-quarter to one and one-half times as much potash, and two and one-half times as much phosphoric acid as has been removed by the preceding crop. Since these fertilizers do not tend to force the plants into redundant growth, any slight additional quantity can do no harm. And since they are not lost by seepage as the nitrogenous compounds are, but are more or less completely fixed in and retained by the soil, the grower is not a loser, at least if he occupies the land with a judicious rotation in the seasons which follow. Potash and phosphoric acid are found to produce more effect upon the crop when used in conjunction than when applied separately.

It is essential that the soil for chicory be also well supplied with humus. This substance helps to keep it more open and friable and aids in retaining moisture in the surface layers, besides drawing water from the lower strata by capillarity. Soils rich in humus are less affected by drought than those in which it is deficient. Humus also, directly or indirectly, controls the nitrogen, potash, and phosphoric acid supply in the soil. It is usually most abundant in bottom lands and least plentiful in uplands. Mucky soils are composed very largely of humus, and have been found to be well adapted to the growth of chicory, especially in the vicinity of Bay City, Mich. But these mucky soils of the Saginaw Valley must not be confounded with the peaty and powdery muck beds of swamps. Although the soils of this district are commonly

[1] See page 42.

spoken of as muck beds, they contain so much clay or sand, or both clay and sand, that they properly belong in the loam class. Where easily obtained, muck may often be profitably applied an inch or so deep while the crop is growing, and allowed to remain as a mulch, although it is claimed that this proceeding is liable to make the ground cooler from the evaporation of water than it otherwise would be. Humus also tends to raise the temperature of the soil by the absorption of heat due to its dark color. This accelerates the germination of the seed and also tends to lengthen the growing season. In the absence of muck, humus may be best supplied by the method of green manuring, or in the form of stable manure.

Stable manure for chicory should be applied, at least partially decomposed, not later than the autumn previous to the seeding. It is generally better practice to apply it to the preceding crops of the rotation. It may be spread either before or after the plowing, the former preferred. Heavy applications must be carefully avoided, since excessive quantities of nitrogen induce a dense growth of the top and a woody development of the root, making the latter of very inferior quality for roasting. It is considered good practice to apply only as much nitrogen to the soil as has been removed by the previous crop. These rules for the application of fertilizers presuppose land not impoverished by injudicious cropping or neglect. If the land has been robbed of its fertility, much heavier dressings must be applied.

When fertilizers are required, especially potash and phosphoric acid in the form of commercial fertilizers, it is better to apply them in excess to the preceding crops, which should be such as do not demand large quantities of either of these foods, and will, therefore, leave considerable quantities in the soil for the chicory. This treatment will be found more satisfactory than large applications immediately before the planting, since by the latter method there is greater danger of loss by leaching, and the fertilizer is not so well distributed throughout the soil. Liberal applications will bring heavier crops of better quality than are obtained by sparing treatment.

It is probable that chicory is, like other root crops, partial to the phosphates rather than to potash or nitrogen, although it demands ordinary quantities of these; but as no specific fertilizing experiments have been tried with this crop, there is only the unsafe reasoning by analogy.

Should it be necessary to grow chicory upon heavy land, an application of lime may be found beneficial by rendering the soil more porous. But since lime tends to form a hardpan at the bottom of the furrow, plowing must be done at different depths in different years in order to loosen and break up this false subsoil. The application of lime counteracts acidity in the soil and may also be used to hasten the decay of coarse litters, such as cornstalks and straw. For this latter purpose, however, it is better to depend on the compost heap.

ROTATION.

In neither Michigan nor Nebraska is an avowed rotation practiced. What crops are grown depends largely upon the convenience of harvesting, etc. Few of the chicory growers consulted practice rotation.

In some soils, such as those fertilized by overflows, and those of the prairies and of the Saginaw Valley, chicory may be grown without change for a series of years; but unless the land receives extra attention in the way of fertilizers and cultivation, rotation must sooner or later be practiced.

Chicory should follow some cereal crop other than maize, since the small grains are all harvested early enough to admit of fall preparation of the soil, which is a prerequisite of chicory culture.

One good scheme of rotation is: Clover, one crop cut for hay, the other turned under; potatoes; a cereal (barley, wheat, or oats); chicory. The potatoes may be left out if a three-course rotation is preferred.

Another good four-course rotation scheme is corn, cereal, chicory, clover. Under this plan only two plowings are absolutely necessary, one for the corn and one for the chicory. The wheat may be sown among the corn stubble, as is customary in Nebraska, Iowa, and other parts of the West, and when the chicory is removed the land need only be harrowed to prepare it for the clover seed. In this scheme the chicory tops should be fed to stock. For a rotation in which the feeding of animals is included, oats and peas, or barley and peas, may be used as a soiling crop, in which case they may take the place of the clover of the above schemes. In this way the soil is doubly benefited, first by the legume and second by the large quantity of manure produced by the animals fed upon the green food.

PREPARATION OF THE SOIL.

The preparation of the soil for chicory will depend largely upon the crop which has preceded. As has been stated, it should not immediately follow Indian corn. If the preceding crop should happen to have been beets, potatoes, or mangels, which remain in the ground somewhat late, the land should be plowed as soon as they are off, as described in the next paragraph. If the crop be a cereal, which is always to be preferred, the land should be plowed shallow with a gang plow, say 3 inches deep, immediately after the grain is removed, since at that time it is more moist and consequently more easily worked than if allowed to stand for even a few days. This moisture would, moreover, be lost if the land were allowed to stand and bake. The plow should be followed by a spike-toothed harrow to break up the surface so fine that it may act as a mulch, and the harrow should be used every two weeks to keep the surface fine. Land so prepared loses only a small fraction of its moisture as compared with soil having the packed and cracked surface usually seen after the removal of a cereal crop, a

condition which grows worse daily. By the former practice the elaboration of plant food suffers no check; by the latter it is often wholly suspended, because there is insufficient moisture to support the micro-organic life in the soil.

Plowing as soon as the cereal crop is off prevents the ripening of the seeds of weeds otherwise left to grow among the stubble. It thus lessens the labor of weeding among the chicory plants in the following season. The extra moisture saved in the soil hastens the decay of the stubble and the weeds turned under, whereas if the weeds are left until fully grown, their tough, woody stems will not break down until after considerable time has elapsed. This preliminary plowing loosens the surface so that the rains may penetrate and air may enter the soil; thus the chemical and biological processes are hastened, and considerable plant food hitherto unavailable is elaborated. Further, it lightens the labor of the plowing to be done later in the autumn; and the finely pulverized stratum which it provides being turned under by the second plowing insures an open, friable soil of greater depth than is otherwise possible. The surface exposed by the first plowing should be kept loose and open by harrowing it lightly after each hard rain until the autumn is somewhat advanced.

When the time of fall plowing arrives the tract for chicory should be worked 10 inches deep, to increase the storage capacity of the soil. Deep plowing and underdrains also lessen the tendency of the heavier soils to puddle. If the preliminary plowing has been unavoidably omitted, the plow should carry a jointer, to disintegrate as much as possible the furrow slice, to prevent this furrow slice from falling too flat, and to bury the weeds and other rubbish, which might hinder surface tillage in the growing season. The furrows should be allowed to stand upon edge through the winter, so that the frost may act upon the upturned soil and break the clods as much as possible. This frost action is most noticeable with heavy soils, making them much lighter and easier to work. The plow may be followed by a subsoiler to loosen the lower strata 4 to 8 inches deeper, but usually, unless the soil is very deep or the subsoil fairly open, the operation of subsoiling is too costly to be justified by the results. It is practiced extensively in the West, where the rainfall is generally deficient, and is considered of prime importance not only to root crops but to grains as well. Its advantages are the deepening of the root bed, the accelerated downward flow of water in the rainy season, and the better upward passage of capillary moisture from the lower levels in the dry weather.

The special advantage to chicory of this fall preparation is that the land is mellowed by exposure to the forces of winter, and in the spring is more readily prepared for seeding by simple surface cultivation. Another advantage of autumn preparation is that it may extend over a period of several weeks if the time is needed for other work, whereas in the spring plowing comes when time is far more precious. Furthermore, the soil being heavier from the extra moisture contained in it in

the spring, the deep plowing necessary to the proper preparation of chicory land can not be done as well without the use of more powerful machinery and a far greater expenditure of labor both by horse and man. Deep plowing is essential to deep-feeding plants, such as chicory, and this deep preparation is especially necessary when the preceding crop has been a surface feeder, since the inverted surface soil has been more or less robbed of its plant food and the fertilizers spread upon the surface before plowing are thereby placed where they are needed. This deep plowing need not be practiced upon the lighter lands in which the preceding surface-feeding cereal has sent its roots fairly deep, since in that case there will be no exhausted layer of surface soil.

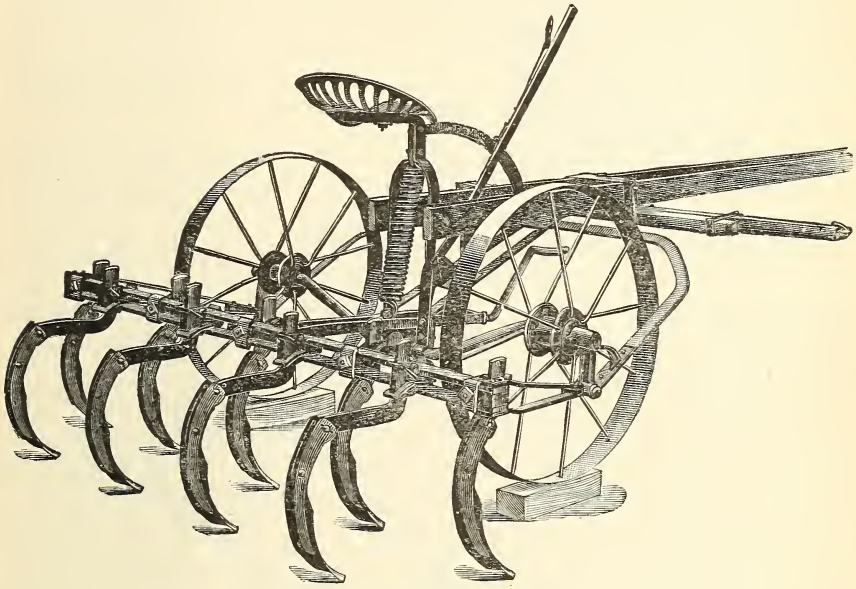

FIG. 3.—Heavy cultivator.

In the spring a gang plow or heavy cultivator (fig. 3) should be used as early as the ground can be properly worked. A harrow should be used every ten days, and after each rain hard enough to form a crust, until the weather and the ground become sufficiently warm to insure good germination of the seed. At the last harrowing prior to seeding, the harrow may, when necessary, be followed by the roller. As a rule, only the lightest soil, which is liable to drift, will need to be rolled. Since the roller tends to compact the soil and thus to induce more rapid evaporation, it should be followed by a light spike-toothed harrow to scarify the surface, form a mulch, and thus conserve the moisture in the soil. The harrow may be attached to the roller and the two operations of rolling and scarifying be done at the same time. The moisture in the soil should by cultivation be confined to the stratum in which the plants are feeding. This stratum lowers as the season advances and

as the plants grow older and send their roots deeper into the soil. At all times the supply of water should be ample, since plants suffer more from an insufficient supply of moisture than from the deficiency of the other essential elements.

Another tool used extensively in the chicory and sugar-beet fields of the West is the subsurface packer, which is a modified roller.

This machine consists essentially of a series of cast-iron wheels placed abreast upon an iron axle, so that their rims, which are about an inch thick at the base, narrowing to a sharp angle at the extreme circumference, are about 5 inches apart. The whole machine, when run over the soil, is heavily loaded. The object of the subsurface packer is, first, to further pulverize the soil, and second, to bring the newly turned soil, which is held up to a greater or less extent by the stubble, into contact with the bottom of the furrow. This packing of the furrow slice upon the bottom of the furrow renews the capillary relation between the newly turned soil and that below, a thing desirable in a dry fall, and also opens a way downward for rain, should there be any. It is well known that water does not percolate so readily into a soil that is dry and filled with air spaces as it does into one that is already moist, and, while mellow, is not filled with large openings.[1]

Much time in after cultivation may be saved if the area of land prepared for seeding at any one time be not greater than can be planted the same day, or at furthest upon the following day; for if the seeding closely follows the preparation of the soil the seed falls in ground better supplied with moisture than the same soil would be a few hours later. Two gangs of men, one preparing the ground, the other sowing the seed, could work to great advantage both in respect to time and to the better stand of the crop.

If the weather and the soil be dry at the time of seeding (a condition to be avoided if possible) the roller should be used, since it packs the soil and thus augments capillarity. The rolling of heavy soils is more or less disastrous if heavy rains follow, and more or less beneficial if dry weather succeeds it. It is hard to say just when or where it should be used in the chicory field. If the sowing of the land be but a day or so later than its preparation the chicory seed will not only be handicapped from loss of moisture in the seed bed, but the weeds will obtain a start which no system of after cultivation can economically overhaul.

SOWING.

The ground being in a high state of tilth—mellow and free from lumps—sowing may be commenced as soon as the weather is fairly settled and favorable. The conditions which favor the germination of corn are also favorable to the germination of chicory seed, although, since chicory is hardier than corn, it may often be planted with good results at times which might be fatal to maize. But upon no account should the seed be put in cold ground, because a large percentage of the seeds may decay and the plants which do appear will almost certainly be much weaker than those which sprout from seeds sown in

[1] North Dakota Bulletin, No. 29, September, 1897.

warm soil. Again, if planted too early the plants are more likely to run to seed than if planted somewhat later, say about the middle of May in Michigan and Nebraska. Sowing may be done by means of

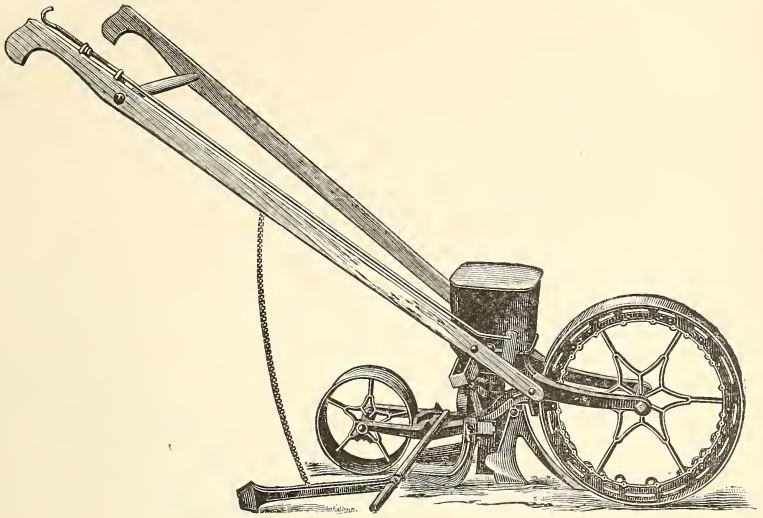

FIG. 4.—Hand seed drill.

a garden drill (fig. 4), which will not clog and which will not crack the seed. It must drop the seeds very uniformly. From 1 to 1½ pounds of good seed, testing at least 90 per cent germination and 95 per cent

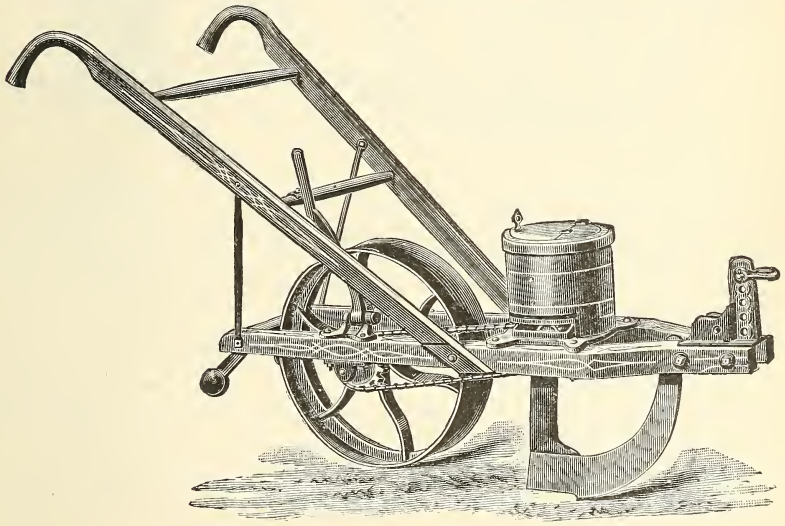

FIG. 5.—Seed drill, drawn by one horse.

purity, should be used to the acre. After setting the drill it should be tested until it is found to drop 20 or 30 seeds to the foot. At the above figures and at the distances given below, a man should be able to

plant from 2 to 2½ acres a day. Horse drills, built upon the principle of grain drills, have as yet proved unsatisfactory since they are liable to clog, and to plant at uneven depths. Small drills, such as are illustrated in figs. 5 and 6, drawn by one horse, are not included under the above criticism.

The seed may be planted about one-third of an inch deep if the soil is in favorable condition, less if it is rather moist, and more if it is dry; but in no case should it be covered deeper than three-quarters of an inch, since those plants which chance to reach the surface will have lost much of their vigor in pushing their way up to the light. The quality of the soil also influences the depth at which chicory may be planted. If light and open the seed may be planted deeper than in heavy dense soils, especially if they are liable to puddle and bake. If the preparation of the soil has been carried on as above described there should be no deep planting, as the soil will be in prime condition. It is claimed

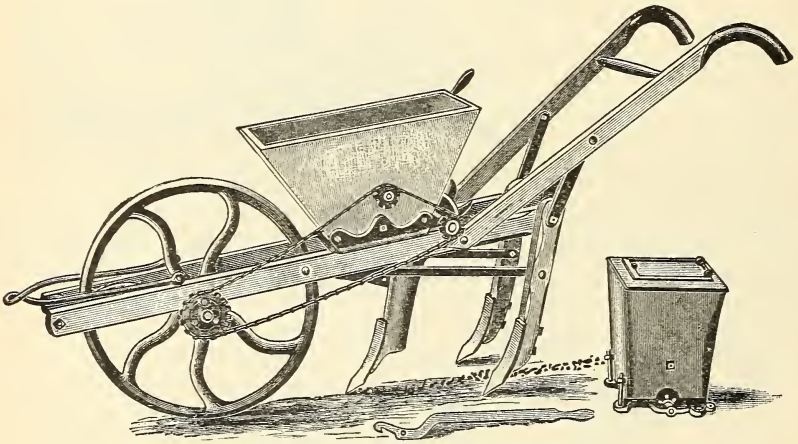

FIG. 6.—Seed drill, drawn by one horse.

by many root growers that plants will do better in north and south rows than in rows running east and west. They believe that the plants get a little more sun if planted that way, and it has been found that sugar beets are of better quality when so planted. As regards chicory this is still a subject for experiment.

If the cultivation is to be done by hand, the rows may be from a foot to 15 inches apart in order to save space and labor; but if a horse is employed, they should be 18 inches apart in order to give the animal ample space in which to walk.

In many of the American chicory fields, notably those of the Saginaw Valley and Nebraska, where the soil is of a fairly uniform texture, free from stones and other obstacles, and reasonably level, use is made of the many forms of wheel hoes and other hand cultivators. These do the work in uniform soil better than a horse, and they will permit the rows to be as close together as 12 inches. It is stated by growers who have practiced both horse and hand cultivation that the latter is to be pre-

ferred where the soil is light and easily worked, since less expenditure for seed, land, and tools is required, and the amount of time and attention necessary to the proper cultivation of a field with horses will produce a far greater tonnage upon the same area if cultivated by hand with the wheel tools.

SEED.

Chicory seed should not only be fresh and clean, but it should germinate rapidly and evenly, and should give rise to plants which throughout their whole period of growth present a uniform appearance as regards their habit. When dug their roots should be found to be evenly developed and of uniform pattern. Too often the plantation presents more uneven germination than can be charged to the conditions of moisture, etc., surrounding individual seeds. In the test plots of the Department the widest differences were noticed in the habits of growth of plants from seeds of the same packet. Some plants lay prone upon the ground, others stood erect; some were red-leaved, others green. Ideal conditions for good germination had followed the planting. A shower of rain fell immediately after the seed was sown and in only four days the first plants appeared above ground. These formed a good and fairly uniform stand and were thinned to 4 inches between the plants two weeks later. At that time many seedlings from the same sowing were just making their appearance, and four weeks later there were still others coming up. The plots had to be thinned a second time. Making due allowance for unevenness of conditions, it is still obvious that these results were largely owing to the quality of the seed. Imported seed was employed and might have been of a grade which, as a prominent chicory firm informs us, is gathered from "culls," or the plants which appear in the fence rows and in the fields where chicory has been previously grown. Such seed sells for even less than 25 cents a pound, while good chicory seed costs usually between 65 and 85 cents a pound.

The production and maintenance by selection of good types of chicory is attended with more than ordinary difficulty. The roots grown from even the most carefully selected seed are liable to revert to the old, tough, long-rooted, wild form. Again, as in case of the beet, the turnip, and other roots, it is not until the second year that seed can be obtained from a sowing of seed, and another year must elapse before the seed crop will give roots to be selected from, so that much time and patience must be expended before a quite desirable form is secured. Sometimes only one or two plants approaching the desired form can be had from even an acre. Then as with many members of the composite family of plants, the seeds ripen at different times, some early, some late, and this in part accounts for the variation in the individual seeds, the seeds from the early flowers being in general large, and those from the late blossoms generally small. This also in part accounts for the unevenness above noted both in time and percentage of germination.

The point last mentioned has been the subject of experiment in the

Department greenhouses, the results of which are here given. The figures in the table are the averages of four tests.

Differences in weight and germination of seeds from early and late chicory flowers.

Seeds sprouted in—	Large seed.		Small seed.	
	Early flowers.	Late flowers.	Early flowers.	Late flowers.
Two days	9	7	3	0
Three days	36	28	14	1
Five days	75	59	33	3
Nine days	88	70	43	10
Fifteen days	91	73	46	15
Twenty one days	92	74	47	17
Weight of 100 seeds in milligrams	182	114	81	33

In this test each lot of 100 seeds was weighed and then planted at a uniform depth in damp sand. The large seeds were the largest 100 in some four or five hundred large seeds selected singly from the early and the late flowers, respectively. But the small seeds were by no means the smallest seeds obtainable. If such had been the case, it is probable that no figures whatever would have been obtained. The small seeds were as carefully selected as the large from as large a number, but only such were picked out as would probably germinate. The ratio of good to poor seed in individual flower heads proved, in all cases examined, to be in favor of the early flowers.

The unevenness in size and germination is probably due to the struggle for existence among the different flower heads; the ovules in the first flowers which expand seize upon the plant food which should go to fill out the seed in the flowers which succeed them. But since the plant soon has as large a crop of fertilized ovules as it can mature, many of the later flower buds fail to open, and many more which do expand fail to produce seed. Thus there is a range in seed production from marked fecundity in the flowers which open first down to absolute sterility in the late blossoms. Corresponding to this decrease in the size of the seeds, there is a more or less manifest diminution in the size of the heads. Experiments with cotton have shown in a similar manner that the size of the bolls depends upon the part of the plant where they grow, and in the case of various umbelliferous plants the central stalk is supposed to produce the best seed.[1] It has been observed by a prominent chicory grower that the small seed when sown may send down an apparently strong root and yet not be able to develop even the seed leaves. This same abortion was noticed in a chicory-seed test made in the greenhouse, but at the time was thought to be due to a troublesome damping-off fungus not identified.

It is known that, with many plants, large seeds produce stronger and better plants than small seeds. To establish the truth or falsity of this statement with regard to chicory a number of tests were made with seed, both large and small. It will be noticed in the following table, which presents the averages of five tests, that the aggregates of the

[1] Yearbook, Department of Agriculture, 1896, p. 306.

large seeds weighed more than twice as much as those of the small ones, and that the large seed germinated far better, as will be seen from the percentages of germination in corresponding numbers of days. Each seed was planted in a 2-inch flowerpot filled with uniform soil.

Weight and germination of large and small seeds.

No. of experiment.	Large seed.							Small seed.						
	Weight of 100 seeds sown.	Days.						Weight of 100 seeds sown.	Days.					
		2	3	5	9	15	21		2	3	5	9	15	21
	Mgms.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*Mgms.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1....	226.14	13	28	59	75	86	91	81.20	6	11	25	39	46	51
2....	208.16	9	22	49	68	79	85	81.20	4	9	17	24	30	33
3....	207.02	11	23	50	71	83	88	80.00	3	8	18	26	31	33
4....	190.09	8	19	40	63	74	81	79.84	4	7	14	20	23	26
5....	114.00	5	13	29	49	58	63	81.05	2	5	10	15	17	19

Not only was the percentage of germination in favor of the large seeds, as was the case in the tests recorded in the first table, but the time required to get a fairly good stand was also much less. The tops almost from the start showed a slight difference in favor of the plants from the large seed. To find the effect of the large and the small seeds upon the growth of the roots, plants of uniform development were selected from the seedlings produced by samples 1 and 2 of the above table, ten plants of each. These were carefully transplanted in 5-inch draintile filled with uniform soil. The tile were sunk full depth in a greenhouse bench full of sand. The spaces between the tiles were also filled with sand. All the water the plants received was furnished by subirrigation. A difference more or less marked was noticed in the development of the tops all through the experiment, at all times being in favor of the plants produced by the large seed.

When the roots were dug, just three months from the day of planting the seed, the difference between the two sets was very marked. The smallest specimen produced by the large seed was larger than the average specimen produced by the small, although a few individual specimens of the latter were larger than the smallest of the former. The following table gives the weight in grams of the whole plant after washing off the earth.

SAMPLE NO. 1.

	From large seed.	From small seed.	Difference.
Outside row	1,017	625	392
Inside row	957	588	369
Total	1,974	1,213	761

SAMPLE NO. 2.

Outside row	903	407	496
Inside row	873	262	611
Total	1,776	669	1,107

When it is considered that the plants were only about half grown at the time the experiment was brought to a close, it may be safely concluded that the difference would have increased as the plants grew older, since the root systems of the specimens produced by the large seed were in every case superior to the root systems of the plants in the other group. The figures also show a difference between the samples of seed. No. 1 is the "schlesische" or Silesian variety, which will presently be described; No. 2 is the ordinary chicory seed of the American market. In addition to the great difference in weight in favor of No. 1, it must also be stated that the plants were of far more even size, shape, and habit than the plants of No. 2.

The difference in weight between the outside and inside rows is doubtless due in each case to the better supply of air and light which the outside row from its position was able to obtain.

From the above tables it seems probable that the careful sifting of chicory seed will pay by securing better and more uniform germination, more even growth, and increased size. Probably, also, some improvement in the quality of the root would be secured. It must be borne in mind, however, that no system of mechanical seed selection is adequate to the production of good varieties. For this purpose selection must commence with the plant itself, and only those individuals be grown for seed which most nearly approach the ideal type. An "ideal type" is one which an originator deliberately sets out to get. The quality most desirable in a chicory root intended for roasting will be discussed in the next section.

The doubtful character of the seed offered for sale in the open market has compelled the companies who make chicory-roasting a business to purchase direct from the seed growers practically all of the seed used in the commercial growing of chicory. Persons who attempt to grow the crop from seed obtained from other sources are too often disappointed with the results of their labor. At present the only guide as to the purity of the sample is the seedsman's reputation, and this is an unreliable one, because the seedsman himself may have been imposed upon by the grower. If the name of the latter were advertised, it would become at length an index to the quality of his wares. What makes the difficulty greater, the form of the leaves is at present no indication of the character of the roots, which makes it impossible to detect impurity in the seed until the crop is harvested.

VARIETIES.

While there are many varieties of chicory, distinguished principally by the form and color of their leaves, which are used exclusively as vegetables, there are comparatively few well-established ones in use for roasting, and none so used exclusively, since the leaves of the roasting varieties are as good for culinary purposes as those of the garden sorts. The following are the best known kinds used in America for roasting:

Brunswick (fig. 7*b*): Roots straight, thick, and tapering, 12 to 15 inches long, 2 to 2½ inches thick below the crown; leaves more or less spreading, spatulate, larger and less cut than the leaves of the dandelion. This variety is also known as the Belgian root.

Magdeburg (fig. 7*b*): Roots straight, thick, and tapering, 15 to 21 inches long, 2 to 2½ inches thick below the crown; leaves more or less erect, larger than the leaves of the Brunswick variety, but with an uncut and but slightly toothed margin. More productive than the former, but somewhat more difficult to dig.

Schlesische (fig. 7*a*): Roots, straight, thick, bluntly tapering, 10 to 14 inches long, 2 to 2½ inches thick below the crown; leaves more or less spreading, spatulate, larger and less cut than the dandelion leaves. Type not fully fixed.

Of these three the schlesische (Silesian) is certainly the most desirable, which in form resembles a half-long carrot. This feature makes it easier to dig and no part is left in the ground to become a weed the succeeding season. It is more uniform in size and shape, and thus easier to handle, both in the field and in the factory. It thus has great advantages over the old, long-rooted forms and should be made the basis of future effort at improvement.

FIG. 7.—Chicory roots and leaves: *a*, schlesische variety, root with leaves; *b*, Brunswick and Magdeburgh varieties, root. (Both one-sixth natural size.)

It has been observed in all the chicory fields visited that the foliage is by no means a constant character of a variety. In plantations where the seed sown was believed to be pure the form of the root was found to be more regular than that of the tops. The originators of roasting varieties have, unfortunately, directed their attention mainly to the root. The consequence is that, as already stated, leaves are no criterion of a variety, and the grower can not know whether he has been defrauded or not until the crop has been harvested. This defect should be remedied in the course of varietal selection hereafter.

CULTIVATION.

Two or three days after the seed has been sown the weeder should be run over the entire field in the direction of the rows. This operation should be repeated at least once (twice would be better) after the plants appear. It may and probably will kill some of the chicory plants, but the loss will not be noticed and will be far outweighed by the destruction of weeds just coming through the ground. Hand labor in weeding is thus greatly reduced. When the above rule for weeding is practiced the crop has a nearly equal chance with the weeds, the seeds of which, being already in the soil and moistened, are ready to germinate, and do germinate sooner than the dry chicory seeds. This is all the more noticeable if the soil is dry at the time of planting. When the weeder is used as specified, countless weeds are destroyed in their infancy, while the crop receives the additional benefit of the cultivation.

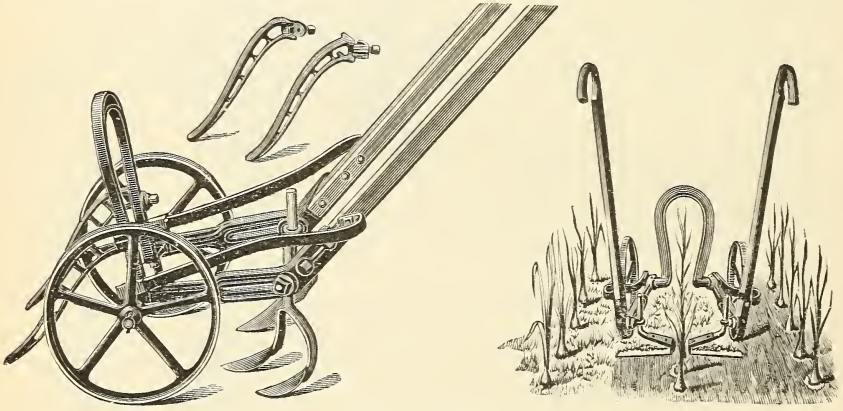

FIG. 8.—Hand hoes.

Thinning should be done as soon as the leaves of the plantlets have spread an inch or not more than 2 inches. This is usually less than two weeks after they have appeared above ground. Some growers practice thinning when the plants are much smaller and when only a very slight effort will dislodge those not needed. This is sometimes an unwise policy, since the plants left may unavoidably be injured by the tool or the foot of the worker, or may die from natural causes. It may be accepted as a general rule to thin the young plants before they commence to crowd one another in the row. An interval of at least 4 inches should be left between the plants. This may be increased to about 6 inches if desired. Two plants should not be allowed to grow very close together, since their combined weight will be less when harvested than that of either one alone if allowed to develop separately. The labor of topping is also double. If the thinning be postponed until the plants have attained any considerable size the remaining root will be likely to suffer injury by the removal of others near to it.

It is impossible to avoid stooping in thinning the plants, and as this is the most wearying and tedious operation in chicory culture, any practice which gives promise of being an improvement over the hoe and finger method should be given a thorough trial. The plan followed by many turnip raisers in the East at thinning time requires three men. The first walks between the rows ahead of the other two, and cuts the rows at right angles with a hoe made slightly narrower than the interval to be left between the plants, leaving small clumps of plants from which the other two men select the plant which is to remain. These two men, each beside a row, walking upon their knees, and with Hazeltine, Noyes, or Lang hand weeders, not only cut out the superfluous plants and the weeds, but stir the soil around the remaining plant. This stirring often takes the place of the second hoeing practiced in

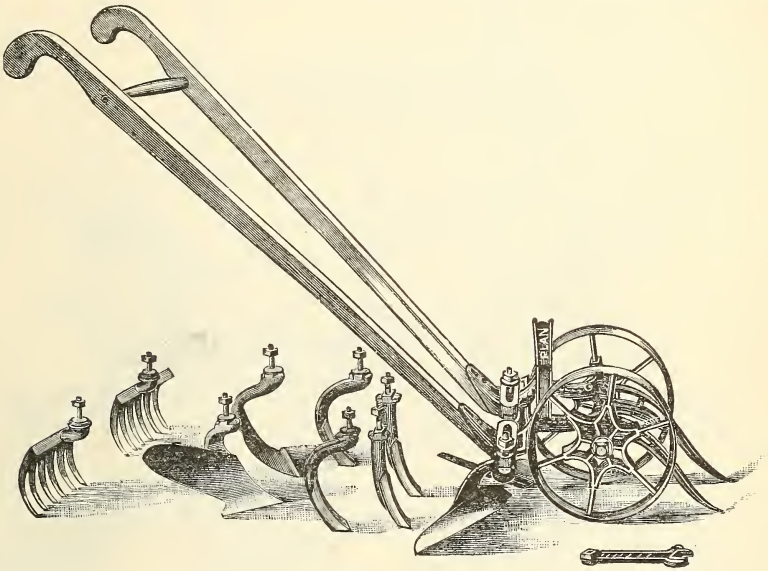

FIG. 9.—Cultivator for chicory.

many localities, especially in the West, where the only improvement is in the shape of the hoe used. This is made 1½ inches wide and from 4 to 6 inches long, and is used in the rows between the plants. Most of the thinning, according to this method, has to be done by hand, which, on account of the frequent, almost continual stooping, is very tiring. By the turnip growers' method the man who hoes should easily keep in advance of the men who weed. He should take his turn at the weeding to give his comrades a change and a rest. Thus the three should be able to thin a larger area and do it better than they could separately by the old method, and be less fatigued at the close of the day.

After the thinning and when the plants have obtained a good foothold, the regular cultivation should commence. At first the ground should be scratched to the depth of only an inch or so, but later, as the

season advances, this depth may be increased to 2 or 3 inches. Chicory is impatient of deep cultivation and never does as well as where the shallow intertillage is practiced. The primary object of this cultivation is not merely to kill the weeds, but to conserve moisture in the soil—an item of paramount importance with all root, as well as with grain and fruit crops. The hand hoe (fig. 8) or cultivator (fig. 9) should be run between the rows once in ten days or two weeks, and after every rain until the crop has obtained full possession of the ground. If horse

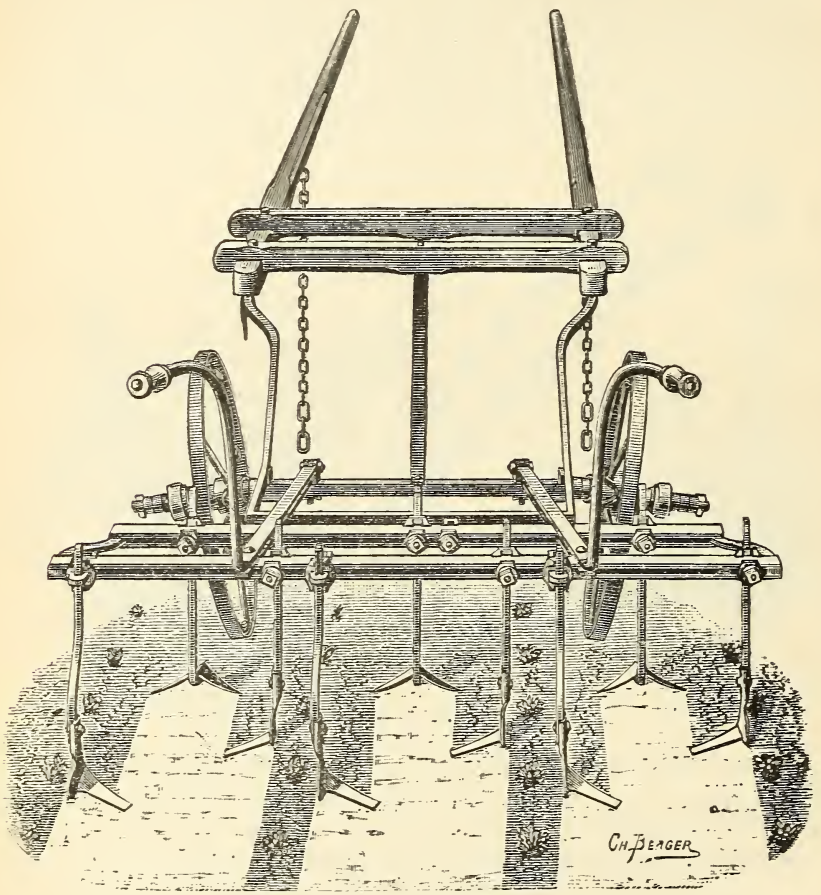

FIG. 10.—Horse hoe.

power is preferred one of the power cultivators or hoes (figs. 10 and 11) may be used. They handle several rows at a time. If the rows are straight they do fairly good work. It is a good practice to run the cultivator over the same route each time, since in this way less injury is likely to occur from the breakage of the plants. Hilling the plants should be carefully avoided, since it materially augments the evaporation of moisture from the soil, increases the difficulty of removing the roots at harvest time, and does not

improve either their size or their quality. At first the cultivator may be run to within two inches of the plants, but as the season advances and the tops spread, this distance should be increased until the crop is laid by, which is usually about the middle of August, but varies with the kind of cultivation practiced. If horse power is used this laying by will be later than if hand-wheel hoes and cultivators are used. It will also vary with the distance between the rows, the season, and the progress made by the crop. Even after it is laid by it may be necessary to give some attention to the larger weeds which appear. This weeding may be performed at the same time as the important operation of removing the "trumpeters"—that is, the plants which throw up a flower stalk. These produce roots of very woody

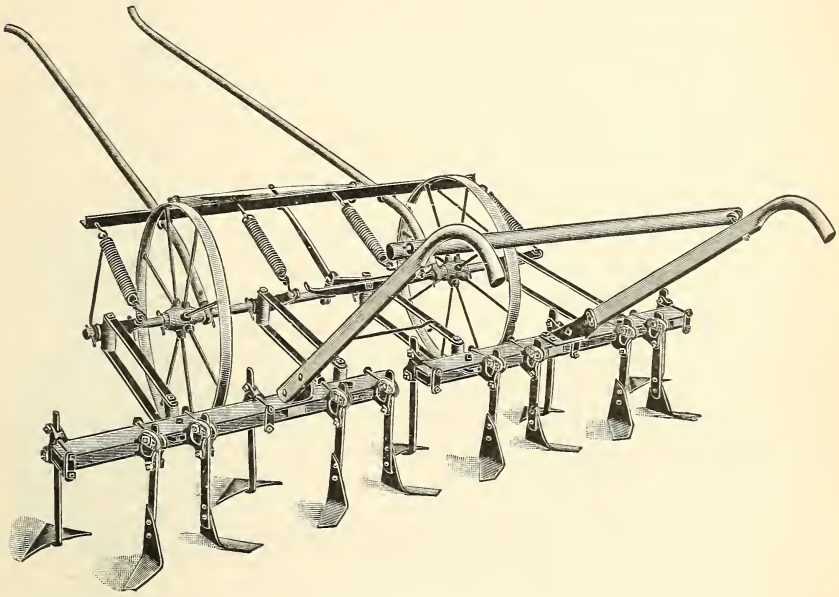

FIG. 11.—Horse cultivator.

texture, which, if harvested with the rest of the crop, will materially injure the quality of the product when roasted and ground. These woody portions look like and are as hard as roasted wood. They may be distinguished at a glance in the prepared product.

ENEMIES.

Few plants enjoy such immunity from disease and insect ravages as chicory. The European fields are visited by at least one serious pest. This is a "worm" which eats around the crown of the root and causes the tops to turn brown. The creature, which is usually slow in its operations and seldom appears in large numbers, may be discovered by the discoloration of the tops. It usually passes down the row, and the more withered tops will show its starting point. Just what this creature is—whether the larva of some insect or a true worm—is not

stated, but from the nature of its attack it seems possible that it might be only a cutworm or a wireworm. Its work has not yet been reported in the American chicory fields, and the above note is only to call attention to its mode of operation. The affected plants should be pulled, the worm found, and the plants burned to destroy any eggs or minute worms which may be present.

Cutworms have done occasional mischief in chicory plantations, but since they are not generally very troublesome except upon newly prepared sod land the proper preparation of chicory land is usually a safeguard against them. Moreover, since cutworms are common enemies of other crops and are destroyed with comparative ease by poisoned baits, they should not be considered as specific enemies of chicory or as of very great importance.

Wireworms, the larvæ of click beetles (*Elateridæ*), have been found in several plantations, but have so far not proved very troublesome. They are most abundant in soils which have been long in meadow, where they feed upon the roots of the grasses. They may most readily be destroyed by fall plowing, and those which escape may be killed by means of poisoned baits.

Up to the present time only one insect has proved itself very destructive in the American chicory fields. This has done considerable damage in Nebraska, where it appears in great numbers in June while the plants are still small. Almost before the grower is aware of it his plants have disappeared, and so have the depredators. An attempt was made early in July to obtain some of these pests for identification, but it was too late. They had eaten up everything in sight, even the weeds, and had departed. From a general description of the injury it seems probable that the culprit is one of the flea-beetles, which are very abundant in Nebraska, where they destroy corn, garden vegetables, and other plant growth. Bordeaux mixture applied thoroughly and promptly has proved effective when these insects have attacked other plants, and is, therefore, recommended for chicory.

No diseases of any kind have been observed or reported. Even in the wild state chicory seems to enjoy exemption. But, notwithstanding their comparative immunity at present, it is only a question of time when the chicory fields will be visited by some scourge in the form of an insect or plant disease. One method of delaying such inroads, and of combating the depredations of these pests when once they have obtained a foothold, is the proper rotation of farm crops. An enemy established in a certain field, when it no longer finds the material in which it is accustomed to work, will necessarily migrate or die out.

HARVESTING AND STORAGE.

It has been found that chicory roots increase in weight more rapidly during the month of September than during any previous month. The harvesting should upon this account not commence until October.

Frost should be guarded against, since a root frozen is a root spoiled, at least if allowed to thaw out in the field. If it is sliced while still frozen, however, and put into the kiln to dry out, but little damage is done. But manufacturers claim that it costs more both to cut and to dry frozen roots. It is possible that frosted chicory roots can be saved by slow thawing, but this at best can be considered only as an emergency remedy. It is better that the crop be dug and disposed of before the advent of cold weather. Roots in the ground will stand a much lower temperature than those which have been dug and are exposed to the cooling process of evaporation.

As a means of harvesting the spade in this country has been superseded by the plow, and this in turn to some extent by the chicory-root loosener, which is only a modified form of the sugar-beet loosener. One

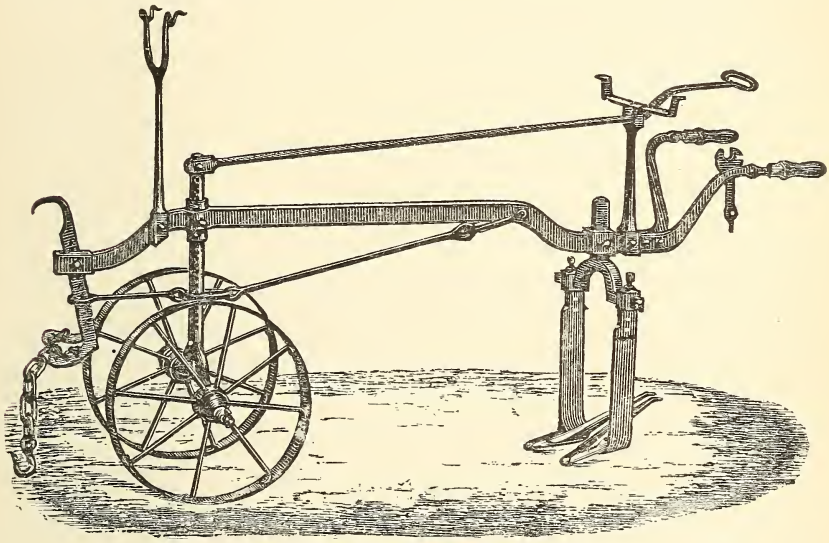

FIG. 12. Chicory-root loosener for one row.

form of this tool is shown in fig. 12. Some forms have no wheels, but are built much like plows in their forward parts. Where the plow is used it is run close to the row and a furrow turned away from the plants, which, being exposed more or less, may be pulled with comparative ease. The chicory-root loosener, where available, is a great improvement upon the plow, but it is a practicable tool only when the soil is light, of uniform texture, and free from stones and all other obstacles, and when the rows are straight and the roots are of comparatively uniform size. The working parts of this implement consist of two knife-edged plates which are carried each side of the row to loosen the soil, and two teeth, one on each plate, which together catch the root very low down and lift it loose, but do not remove it from the soil. Heavy horses are required to draw it, and in compact soils three are necessary.

When the roots are taken up the top is cut off at the crown, and the root is then ready for the factory. In France the tops are cut prior to digging and are fed to cattle. When roots must remain exposed in the field for any length of time, say two or more hours, the tops should be thrown over them as a protection from the drying influence of the sun and the wind. It is a common practice to throw the roots as pulled into a pile, to top them at once, and then spread the tops over them. After the roots have been removed the tops should either be plowed under or fed to stock. They are valuable as green manure; but since it is usually inconvenient to plow under these tops before they have suffered much loss of moisture, it would be perhaps better to promptly use them for feed. Chicory is a plant that stock do not at first like, but which they soon become very fond of.

Chicory roots lose weight very rapidly if uncovered, and for this reason it is good policy, if possible, to deliver the roots to the manufacturer at once. When this is impracticable the roots, without their tops, should be thrown into piles 4 or 5 feet wide, 2 or 3 feet high, and 7 or 8 feet long, and covered with clean, dry earth, leaving holes at the top for ventilation. These silos, if made say a foot below the level of the field, require less covering in proportion to quantity and secure a slightly higher temperature. If the roots are to remain for more than a few weeks, the earth covering should be increased in thickness as the cold weather approaches. The silo should be located in the highest part of the field, both because such spots are better drained, and consequently warmer as well as drier, and because they are subject to relatively less severe temperatures upon still nights. Chicory roots may be kept in this way with small loss for six months; but there is more or less risk, and they should not be stored unless absolutely necessary.

YIELD AND PROFITS.

The cost of raising an acre of chicory varies in different localities and with different growers to such an extent that a general estimate would need much qualifying to make it of any use in specific cases. In the table which follows the figures have been obtained from a large number of growers in Michigan, Illinois, Wisconsin, and Nebraska, in which States the industry is at present most extensively carried on. These growers have given the average figures in connection with their own chicory fields. The lowest and the highest figures as well as the final averages are given to show the range in the items of debit and credit. It will be noticed, too, that no mention has been made of fertilizers. This item was disregarded, since it is believed that by proper soil management and judicious rotation the chicory crop should not demand very heavy direct applications of fertilizers, but should feed upon the stores left by the previous heavily manured crops of the rotation. An allowance can be made for the share of the chicory in these previous applications, and for any fertilizer which may be directly

applied; but in that case increased returns must also be taken into the account.

While from 6 to 10 tons is the common range of production per acre, with good culture as much as 15 tons may be raised, and it has been found by one grower that 5 tons per acre will usually, in his case, pay all the expenses enumerated below, so that whatever is raised over and above that amount is clear profit.

Average cost per acre of raising chicory.

Items.	Range of averages.	Final average.
Land rent, wear of tools, etc	$3.50 to $7.50	$5.42
Preparation of the land for planting	2.25 to 7.50	3.96
Cost of seed	.35 to .75	.64
Pulling up the "trumpeters"	.00 to .50	.20
Planting, thinning, and cultivating	12.00 to 20.00	15.15
Harvesting and delivering	7.35 to 18.00	11.76
Total cost	30.35 to 44.50	35.95
Average crop (tons)	6 to 10	8
Average price per ton	6.00 to 8.00	7.36
Receipts for the crop	45.00 to 68.40	59.29
Net profit	3.50 to 36.75	23.05

One grower whose average crop was 8 tons per acre and cost $20.50 when delivered at the factory found, in the same year, by experiment with two acres, that by the addition of only $7 worth of labor his crop was a little over 11 tons per acre. As the price he was paid was $7.50 per ton, his investment of $7 worth of muscle brought in $22.50, of which $15.50 was clear gain.

While it is reasonably safe to count, in ordinarily favorable seasons, upon a net profit of from $15 to $30 per acre if proper attention is given to the crop and if the distance from the factory is not too great, it must not be forgotten that chicory is a special crop and that it can not be raised with the certainty that there will be a demand for it such as there always is for staple crops, such as corn, wheat, or potatoes. Although consumed in considerable quantities, as will be seen from figures given in the section upon importation, and although in 1897 American manufacturers contracted for the product of some 2,000 acres more than previously, chicory has only a limited market, which may easily be overstocked. It would therefore be unwise for the general farmer to plant the crop except for home use (see p. 38) unless a guaranteed market at a guaranteed price is assured by contract with one of the chicory manufacturing companies. Where such contracts can be made, and where the freight rates do not eat up the profits, chicory may be found a very profitable crop, and it may be found even more profitable under the present tariff than it has been in the past few years. The manufacturers can afford to pay a higher price per ton while the imported dried product is upon the taxed list. One manufacturer, who in 1897 paid $6.50 per ton, announces that he will pay $7.50 in 1898.

Another item which will influence the standing and prospects of American chicory is its quality. It is claimed by disinterested parties that the home-grown product compares very favorably with the foreign article, not only in the size of the root but in its richness and its flavor when prepared. The only criticism against it is the appearance of the kiln-dried root. The pieces are more uneven than those of the imported crude product. American manufacturers can not afford, at the present price of labor, to practice the European methods of cutting: but the virtues of the root are still retained, even if the pieces are not uniform, and it is not believed that this will prove a serious drawback.

PROCESS OF MANUFACTURE.

The process of converting the raw root into the finished product is essentially the same in the different kilns and factories.

In Europe the roots are now seldom washed, since it is thought that their qualities are more or less impaired by the process. If the washing were done after the roots had been cut up, or if there were considerable breakage of the skin, this theory might seem well founded; but since very slight breakage of the epidermis results from even comparatively rough handling in washing, the theory seems untenable. For the sake of cleanliness the roots should receive washing. In samples which have not been washed the sand and other earth can be readily detected by tasting.

Where washing is practiced the roots, after being weighed, are emptied into a long and narrow vat or tub which is kept half full of water, and in which there rotates a worm screw constructed of numerous diagonally placed paddles. This machine is built after the same pattern as the worm screw for washing the beet roots in beet-sugar factories. The paddles in turning not only move the roots from the less clean water at the lower end of the tub to the fresh water at the upper end, but wash them at the same time. Arrived at the upper end, the roots, which by this time are very clean, are thrown out by a set of parallel prongs arranged like rake teeth, attached to the lower end of the worm shaft and revolving with it.

The roots are now shoveled by hand or carried by machinery to the cutting machine, which is either upon the ground floor or at the top of the building. One or other of two styles of cutters is commonly used. In the first machine the knives are set parallel in a cylinder which revolves, the cut pieces falling inside and then dropping out at either side of the cylinder. The other machine is composed of two sets of knives set at right angles to one another and worked back and forth through a set of steel pegs or teeth by means of a piston. The former does a far greater amount of work in a given time, but the latter cuts the roots into pieces of more uniform size. This is the style of machine commonly used in Europe. When the cutter is upon the ground floor the cut roots—"cossettes"—are elevated by chain or strap buckets to the

kiln floor. When at the top of the building the whole roots are elevated in a similar manner, cut, and dropped at once into the kiln.

The kiln is built of brick and iron, and preferably has an iron roof, since there is often great danger of fire. The furnaces are placed upon the ground floor, upon either side of a passage extending from one side of the kiln to the other. They are so built that the whole of the heat from the fires, distributed by various devices, such as tubes and sheet-iron hoods, may be carried up through the mass of drying roots upon the kiln floor. The fuel used is either anthracite coal, charcoal, or coke. The last is generally preferred. The kiln floor, which is usually not less than 8 feet above the fire grates, is built of steel or sheet iron, with numerous perforations large enough to insure a good draft, but too small to allow even the smallest cossettes to pass through. Some kilns have two floors, upon the upper of which the fresh roots are spread. After remaining there until the lower floor is cleared of its load of fully dried cossettes a trapdoor is opened in the upper floor and the half-dried cossettes shoveled down. This arrangement is thought by some operators to secure a greater economy of heat, although the believers in the single-floor system claim that such is not the case in actual practice. Probably the construction of the kiln and the individual methods of management have much to do with the point under dispute. To increase the draft of hot air through the mass of roots upon the kiln floor various devices are used. In some kilns the ventilators are made very tall, while in others large rotary fans are placed. These latter are generally the most satisfactory, since they can be driven at any speed desired and the steam is forced out rapidly or slowly, as the advancement of the process may require.

The cossettes, spread upon the kiln floor to the depth of from 4 to 10 inches, remain for from twenty to twenty-four hours. They are turned frequently by hand, so as to insure the complete drying of the whole mass. Specially constructed shovels are used for this purpose. The temperature of the freshly filled kiln is usually not less than 150° F., and this is generally increased toward the completion of the process. When sufficiently dried they are cooled and stored. If placed in storage before being well cooled, they are liable to become a solid mass, since the steam which they contain tends to cement the pieces to one another. In a moist state they are more or less open to the attacks of mold if stored for any great length of time. And it is probable also that the insects (caterpillars and adult moths) which have proved a nuisance in some of the warehouses would not be troublesome if the cossettes were well dried before being stored. In the process of drying the root loses a great part of its weight, as much as from 3 to 5 tons of green roots being required to make 1 ton of the dried product. This great difference in the ratios is principally due to the season, the large watery roots grown in a wet season losing more than the smaller ones produced in a dry year.

The dried root is now ready for the roasters and is either shipped in this form to the retail trade, to be roasted by them to any shade of brown the individual may prefer, or it is put through the finishing processes by the company which operates the kiln.

The roasting is done in large coffee roasters, the drums of which are turned by steam power. Upon the interior of the drums and attached to their circumferences are two worm screws, one of which carries the cossettes to the rear, the other to the front, as the machine revolves. Some of these machines handle 300 pounds of cossettes at a roast. About a pound of butter, lard, cocoa butter, cottolene, or an equivalent volume of mustard-seed, sunflower-seed, or rape-seed oil is added to the above quantity of the cossettes. This is done partly to keep them from burning, partly to make them less hygroscopic, and to give them a "coffee gloss," but primarily "to carry the color in," and thus give the product an even tint when ground. After about an hour's roasting the cossettes are emptied upon a perforated tray, attached to which is an air-tight box, whence a tube leads to a suction air shaft. A current of air is thus drawn through the smoking mass, and not only prevents the escape of the fumes into the room, but also cools the material in a few minutes. When cooled it is ready for grinding.

The grinding, or, to speak more properly, breaking, is usually done by iron rollers, which in some mills are gauged to produce as much of the granulated grades and as little of the powder as possible, and in others in just the reverse way. It depends upon the market which the manufacturers wish to supply. To separate the grades, the ground mass is then bolted in perforated sheet-iron sieves, much like those used in flour mills.

Where chicory is prepared for package goods, only two grades are thus put up. The other four grades, which range from the size of a small pea to the whole cossettes, are sold in bulk.

Granulated chicory is of a rich dark-brown color, greatly resembling ground or pulverized coffee. It smells, and at first the grains taste, much like licorice. It soon develops a peculiar bitter flavor and becomes soft in the mouth from absorption of water. The granulated chicory is retailed in 1-pound cartons, and the powdered article sold in the American market in rolls which weigh about 4 ounces and which are wrapped with red or yellow paper. In the European market the usual red and yellow rolls are found, in addition to which cubical cakes resembling chocolate and round or square sticks, generally wrapped in waxed or oiled paper, may be obtained. In these forms they have a very attractive appearance.

HOME MANUFACTURE.

From what has been said of the drying and roasting processes it may be seen that the preparation of chicory for home use is within the bounds of possibility. Where good and pure chicory can not be

obtained in the market, it may be to the farmer's advantage to raise enough chicory for his home supply and put it through the manufacturing processes in a small way himself. Some advantages of this practice would be the certainty of the genuineness of the home-prepared article, the extra cleanliness, and the possible higher quality of the privately finished material resulting from the more careful selection of roots.

The roots, carefully washed, should be cut into pieces not more than half an inch in diameter and of irregular shape. The smaller sizes are to be preferred, since the drying and roasting will be more uniform and perfect. If cut in slices, the pieces are more likely to lie flat in the roasting pan, in which position the lower layer is hard to turn over, and, as a consequence, is likely to be overroasted while the upper layers are still raw. A good way to insure tolerably uniform size would be first to cut the roots into slices not more than half an inch in thickness and then chop them in a chopping bowl until they are of the proper size, remembering that the smaller pieces will, in both drying and roasting, be "done" first, and may be overdone if the difference between the sizes be great.

Having prepared the pieces, they may be put in shallow biscuit or pie pans in the oven at any time when there is a gentle or at least a not very hot fire. The old hand coffee roaster may be used for this purpose, as well as for the roasting to be noticed later. The time required will vary with the size of the pieces and with the strength of the fire. The process of drying will, of course, not take so long as in the kiln, because the pieces are much smaller, and also because they are not more than an inch or so deep in the pans. A good way to know when the material is dry enough is to remove some of the larger pieces from the oven and allow them to cool. If they are sufficiently dried, they should be brittle when cold, whereas, if underdone, they are more or less soft and pliable. If tested when warm, they will not be perfectly brittle, even if dry.

In roasting, an ordinary skillet, spider, or frying pan may be used over the kitchen fire if only a small quantity is to be prepared at a time. Previous to putting in the dried root, about as much butter, lard, or other fat as would be used to fry an equal amount of cold boiled potatoes should be melted in the pan, the dried root added, and the mass stirred until the fat is all taken up.

The roasting may be continued and finished in the skillet or it may be finished in the oven. If the dried roots are put into the oven without having the fat mixed with them in the frying pan, some of the pieces are likely to absorb too much fat, while others will get none. The roasting should continue until the pieces have become deep brown. The fat may be dispensed with, but the roasted roots are then more prone to absorb moisture, and if they are kept for any length of time they will need to be thoroughly dried again, if it is desired to grind

them, since the moisture they will absorb will make them more or less leathery. In fact, if it is true, as stated by one authority, that the dried root will as a rule absorb less moisture than the roasted, it would perhaps be better to roast only a small quantity at a time, especially if it is decided not to use any fat in its preparation for the table.

It is not absolutely necessary to grind the pieces of roasted root. If they are small they will yield almost as much of their strength to the water if whole as if ground, and the loss, if any, will be trifling. But where grinding is preferred, it may be done in the coffee or spice mills kept in most farmhouses.

About one part chicory to four or five parts of good home-ground coffee is a fair proportion in which to mix the two, although some tastes may prefer either more or less of the chicory. It is well to purchase only the best coffee in the form of the beans, and to do the grinding at home. In this way freshly ground coffee, which is always to be preferred, may be had at any time to mix with home-roasted chicory.

If the farmer wishes to operate upon a somewhat larger scale, he may use his fruit evaporator for drying and a hand-power coffee roaster to finish the process.

ANALYSES.

The following analyses of chicory, raw, kiln-dried, and roasted, have been selected principally from the works of authorities upon food adulteration. They show the changes in the proportion of each substance in the different forms of the product, the total absence of the substances which are characteristic of coffee—caffeine, caffeo-tannic acid, etc.—and apparent freedom from any harmful substance in the commercial product. It may be here stated that the glucoside discovered by Nietzki in the flowers has not yet been found in any other part of the plant, and that the bitter principle of the milky juice has not yet been isolated. From the absence of caffeine and kindred substances, it is evident that chicory is not a true coffee substitute.

The addition of chicory as ordinarily prepared to coffee decreases the percentage of gum in the resulting mixture, which in chicory seldom reaches 15 per cent, while in coffee it is seldom less than 22 per cent; it decreases the percentage of fatty matter, which in chicory ranges from 1 to a little over 2 per cent, while in coffee it is seldom less than 15 and is sometimes more than 20 per cent; it decreases the percentage of tannin, caffeo tannic acid, and caffeine, none of which are to be found in chicory; it increases the percentage of sugars, which in chicory is usually not less than 8 per cent, while in coffee it is seldom more than 2 per cent. Its influence upon the ash is also very pronounced, especially as regards the amounts of silica and sand, which in chicory ash, owing to imperfect methods of washing, range from 10 to 25 per cent, while in coffee they together seldom reach 2½ per cent.

The analyses have also a value when compared with the analyses of substances used to adulterate either coffee or chicory. Since the adul-

teration of coffee is not within the province of this investigation, the comparison on that side is not here carried out. The subject of chicory adulteration will be taken up under a later head.

ANALYSES OF RAW ROOT.

By Dr. Letheby.[1]

	Per cent.
Hygroscopic moisture	77.0
Gummy matter (like pectine)	7.5
Glucose, or grape sugar	1.1
Bitter extractive	4.0
Fatty matter	0.6
Cellulose, inulin, and woody matter	9.0
Ash	0.8
Total	100.0

By A. Mayer.[2]

	Per cent.
Water	72.00 to 77.3
Albuminoids	1.1
Fat	0.2
Inulin and other nonnitrogenous matters insoluble in alcohol	12.00 to 17.3
Crude fiber	1.40 to 1.8
Sugar, etc	5.60 to 6.0
Bitter extract	0.05 to 0.15
Ash	1.40 to 1.9

ANALYSIS OF KILN-DRIED ROOT.

By Dr. Letheby.[3]

	Per cent.
Hygroscopic moisture	15.0
Gummy matter (like pectine)	20.8
Glucose, or grape sugar	10.5
Bitter extractive	19.3
Fatty matter	1.9
Cellulose, inulin, and woody matter	29.5
Ash	3.0
Total	100.0

ANALYSES OF ROASTED ROOT.

By Dr. Letheby.[4]

	First specimen.	Second specimen.
	Per cent.	*Per cent.*
Hygroscopic moisture	14.5	12.8
Gummy matter	9.5	14.9
Glucose	12.2	10.4
Matter like burnt sugar	29.1	24.4
Fatty matter	2.0	2.2
Brown or burnt woody matter	28.4	28.5
Ash	4.3	6.8
Total	100.0	100.0

[1] Hassall, Food: Its Adulterations and the Methods for their Detection, p. 174 (1876).
[2] Biedermann's Centralblatt, 1885, p. 828.
[3] Hassall, loc. cit.
[4] Hassall, op. cit., p. 175.

By Beckurts & Kauder.[1]

	Per cent.
Substances soluble in water	57.40
Substances insoluble in water	41.90
Ash	7.66
Fat	0.73
Nitrogenous substances	7.12
Grape sugar	4.35
Cane sugar and dextrin	5.33
Starch	2.45
Other nonnitrogenous substances	49.13
Woody fiber	26.23

It seems probable that the samples of chicory which these chemists analyzed had been adulterated, since no starch has been found in the raw root or in samples of the prepared product known to be pure. Letheby remarks:

"Neither of these specimens exhibited the least trace of starch, but by boiling in water, filtering, and cooling they yielded a small quantity of a white powder which has all the characters of inulin."

Again:

"The absence of starch in the state in which the root is ordinarily used is also conclusively shown by means of the microscope."

By Koenig.[2]

	Per cent.
Water	12.16
Nitrogenous substances	6.09
Fat	2.05
Sugar	15.87
Other nonnitrogenous substances	46.71
Cellulose	11.00
Ash	6.12
Substances soluble in water	63.05

By A. Petermann.[3]

	Coarse grains.	Fine powder.
	Per cent.	*Per cent.*
Water (100°–105°)	16.28	16.96
Glucose	26.12	23.79
Dextrin, inulin	9.63	9.31
Albuminoids	3.23	3.66
Coloring matter and bitter extractive	16.40	17.59
Ash	2.58	2.55
Total soluble in hot water	74.24	73.83
Albuminoids	3.15	2.98
Fat	5.71	3.92
Cellulose	12.32	13.37
Ash	4.58	5.87
Total insoluble in hot water	25.76	26.14

[1] Battershall, Food Adulteration and its Detection, p. 31 (1887).
[2] Battershall, op. cit., p. 38.
[3] Biedermann's Centralblatt, 1883, pp. 843–845; analyses quoted Journal Chemical Society, vol. 46, p. 648 (1884).

It is further stated that "the ash was somewhat higher than usual, but was quite white; as the ash of pure samples varies much, owing to the imperfections of manufacture, it is quite inadmissible to judge of the purity of a sample of chicory by its ash."

A sample of roasted chicory was submitted for analysis to the Division of Chemistry of this Department and the following reply was received from the Chemist, Dr. H. W. Wiley:

The sample of roasted chicory received September 20, 1897, has been analyzed, with the following results.

The chicory as received represented several grades of fineness in grinding. Aliquot parts of each sample were taken and mixed for the composite sample. Following are the data found on analysis of the composite sample.

	Per cent.
Moisture	3.05
Ether extract	0.88
Fiber	8 36
Ash	8.90
Albuminoids	6.81
Sugar, starch, and other carbohydrates, besides fiber	72.00

ANALYSES OF THE ASH (ROASTED ROOT).

By Graham, Stenhouse, and Campbell.[1]

	Darkest English Yorkshire.	English.	Foreign.	Guernsey.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Potash	33.48	24.88	24.56	32.07
Soda	8.12	15.10	2.04	3 81
Lime	9.38	9.60	5.00	5.31
Magnesia	5.27	7.22	3.42	3.85
Sesquioxide of iron	3.81	3.13	5.32	3.52
Sulphuric acid	10.29	10.53	5.38	6.01
Chlorine	4.93	4.68	3.23	4.56
Carbonic acid	1.78	2.88	2.80	3.19
Phosphoric acid	10.66	11.27	7.06	6.65
Silica	3.81	2.61	12.75	10.52
Sand	9.32	8.08	23.10	20.19
Total	100.85	99.98	100.66	99.68

By Dr. Letheby.[2]

	First specimen.	Second specimen.
	Per cent.	*Per cent.*
Chloride of potassium	0.22	0.45
Sulphate of potash	0.97	0.98
Phosphate of potash	1.41	1.37
Phosphate of magnesia	0.90	0.53
Phosphate of lime	0.40	0.81
Carbonate of lime	0.10	0.26
Alumina and oxide of iron	0.20	0.20
Sand	0.70	2.20
Total	4.3	6.8

[1] Hassall, op. cit., p. 176.
[2] Hassall, op. cit., p. 175. The material was the ash of the two samples noticed above.

By Battershall.[1]

	Per cent.
Potassa	23.00
Soda	13.13
Lime	.40
Magnesia	5.88
Ferric oxide	5.00
Sulphuric acid	9.75
Chlorine	4.93
Carbonic acid	4.01
Phosphoric acid	8.44
Silica and sand	16.46
Total	100.00

By Dr. Wiley[2] and by James Bell.[3]

	Dr. Wiley.	James Bell.
	Per cent.	*Per cent.*
K_2O	34.76	24.88 to 33.88
Na_2O	2.95	2.04 to 15.10
CaO	4.34	5.00 to 9.60
MgO	2.56	3.42 to 7.22
Fe_2O_3	1.69	3.13 to 5.32
P_2O_5	5.91	6.65 to 11.27
SO_3	7.21	5.38 to 10.53
Cl	1.64	3.23 to 4.93
CO_2	3.69	1.78 to 3.19
SiO_2	20.99	2.61 to 12.75
Sand	13.79	8.08 to 23.10
Water	0.12	.....
Carbon	0.75	.....
	99.80	.....
O equiv. to Cl	0.37	.....
Corrected total	99.43	.....

ADULTERATION.

Remarkable as it may seem, chicory, though an adulterant, is itself often adulterated. Some of its adulterants are themselves adulterated, and the adulteration reaches in some cases back through other adulterants. Yet when complaint is made of the poor quality of certain coffees, the only adulterant the public mentions is chicory! Fortunately, however, the adulteration of chicory is not so extensively practiced in America as it is in Europe, and not in as low forms. Adulterated chicory found in the American market is largely confined to the imported article, which is generally sophisticated before it is shipped. It is usually imported in the kiln-dried form, on account of the lower rate of duty, and the adulteration of this import is almost limited to roots, such as carrots, parsnips, and turnips, which, when sliced and dried, can not be distinguished at sight from genuine kiln-dried chicory. Adulterations made in America are generally restricted to products

[1] Battershall, op. cit., p. 36.

[2] Special analysis made for this investigation, reported March 31, 1898.

[3] Foods, vol. 2, pp. 46, 57.

which, with the exceptions of dandelion roots and acorns, are used as articles of human food. The manufacturers of American-grown chicory are too deeply interested in the establishment of the home industry, which already gives employment to more than a thousand hands, and in which they have invested upward of $100,000, to jeopardize their reputation by foisting an adulterated article upon the public.

It is probably safe to say that the only article likely to find its way into the American grown and prepared chicory is sugar beet, which, however, as far as can be learned, has not been put to this use in America. A mixture of this with chicory, in the proportion of 25 per cent beet root to 75 per cent chicory, is considered more palatable by many persons, by reason of its increased sweetness, than chicory alone. By beet root is meant the root treated in exactly the same manner as chicory root, and not the dried waste product of the beet-sugar factories, which is used in Europe as a filler in the roll chicory, and which has nothing whatever, aside from its bulk and its cheapness, to recommend it as an article of human diet. If the addition of beet root be regarded as legitimate, its presence should be stated on the outside of the package.

Doubtless many of the substances used to adulterate chicory are not intrinsically hurtful, but it is certain that few of them would be purchased for home consumption in their natural form by the average housewife. It is also safe to say that where adulteration is practiced, cheap substances are almost sure to have been employed from the beginning, and instead of pure butter, lard, or oil, it may safely be conjectured that use has been made of the cheapest fats and butters, some of which should not under any circumstances be used for food.

It is a common custom, when discussing an adulteration of a food, to pay special attention to the vilest substances that have been found in the food, whether they are still employed or not, and this discussion becomes the more interesting when the article is, as in the case of chicory, itself an adulterant. Some of the substances, good and bad alike, said to have been found in prepared chicory, are roasted cereals and legumes, spent malt and rye from the distilleries and breweries, date seed, cocoa shells, dried coffee grounds, vegetable ivory, dog biscuit, logwood and mahogany saw dust, croats (spent tan bark), sand, brick dust, coal ashes, Venetian red, reddle, refuse bone black, baked livers and lungs, and even rope yarn, burnt rags, and crusts of bread picked up on the street.[1] It is believed that but few of these are now used to any extent as chicory adulterants, and further that under the pure-food laws the use of those still employed will be discontinued.

Since adulteration is still practiced, however, it may be well to discuss briefly some methods for detecting foreign substances in chicory. The

[1] Dodd, Foods of London, p. 420 (1856). Hassall, Food: Its Adulteration and the Methods for their Detection, pp. 182 et seq. (1876.) Blyth, Foods: Composition and Analysis, pp. 378 et seq. (1888.) Battershall, Food Adulteration and its Detection, pp. 29 et seq. (1887.)

substances used are mainly of vegetable origin, and may, in many cases, be readily detected by means of the microscope. The size, shape, and character of the cells and of the dotted vessels and vessels of the latex are useful in distinguishing chicory from such adulterants as beets, carrots, parsnips, and turnips. The cells are mainly rounded, although they are sometimes narrow or elongated. The first occur where the root is fleshy and the pressure, consequently, less; the other two appear where the pressure is greater, viz, in the neighborhood of the vessels. The dotted vessels, arranged in bundles, are more abundant in the more central, woody part of the root, which, when the stem is thrown up, becomes very hard and rigid. They are cylindrical and unbranched, tapering at each end, and spirally marked upon their surfaces with short fibers. The latex, or milky juice vessels, which are characteristic, are smaller than the dotted vessels, and form branched and frequently intercommunicating tubes, with smooth, membranous walls. None of these cells or vessels contain starch; at least there were no starch grains to be found by the iodine test in roots gathered in November. It may be—but this is merely speculation, which can not be verified at this season—that starch is present in the second spring, when the plant is putting forth its energies in seed production. At any rate, chicory, as commonly used for roasting, does not contain starch, and the presence of this substance in a sample proves adulteration. The form of the starch granules will reveal the identity of the adulterant. The presence of starch may also be determined by chemical means, as follows: Add enough dilute sulphuric acid to an infusion of the chicory prepared by boiling to make the liquid slightly acid to the taste; bleach with permanganate of potassium, added a drop at a time till the liquid is clear, then add a drop of tincture of iodine. The appearance of a blue color proves the presence of starch. The common adulterants of chicory that contain starch are the various cereals and potatoes.

The presence of coffee grounds may be sometimes detected by chewing some of the suspected article, when the coffee may be perceived by its being harder than the chicory. The grounds may also be detected by mixing some of the suspected article with a little chlorinated soda (Labarraque solution). The chicory will be very quickly bleached, while the coffee will be but slowly affected.[1] But perhaps the simplest way is to drop a portion of the powder when thoroughly dried upon still cold water in a glass. The chicory very soon absorbs water and sinks, forming a brown solution more or less dense at the bottom of the glass, while if the water is perfectly still, the upper part of it may yet be clear. The coffee grounds will remain upon the surface sometimes even for several days without any change whatever. A similar test will also reveal the presence of chicory in coffee.

The presence of ground acorns may be discovered by the iodine test, which gives a marked blue coloration to the liquid, though this disappears in a few minutes. It may also be detected by adding a little sul-

[1] U. S. Department of Agriculture, Division of Chemistry Bulletin 13, p. 910.

phate of iron, which produces a black coloration from the combination of the tannic acid and the iron. Chicory contains no tannic acid.

Cocoa shells may be discovered by the microscope, or by the water method of detecting coffee grounds.

It is said that animal adulterants may be detected as follows: Boil some of the suspected article and let it cool. If adulterated with animal matter a scum of more or less greasy appearance and offensive smell will form. The nature of the adulterant may then be determined by means of the microscope.

Venetian red, reddle, and other earthy matters may be detected by burning some of the suspected article. The ash of all vegetable substances, no matter what their color in life, ranges from white to gray. Colored earthy matters remain practically unchanged by fire and their presence may frequently be seen at a glance, the color of the ash departing more or less distinctly from the characteristic grayish white. The amount of adulteration may be approximately reached by weighing. Pure chicory yields about 5 per cent of ash, but the apparent percentage is liable to considerable variation, since more or less earth is left clinging to the roots after even the most careful washing. On this account a slight discoloration of the ash must not be taken as an evidence of an adulteration with colored earths. To discover the exact nature of these substances chemical analyses must be resorted to.

IMPORTATION.

The following tables, which have been compiled from the official commerce reports published by the Bureau of Statistics of the Treasury Department, give, according to rates of duty, in detail and in aggregates, the weights and values of the annual importations of chicory into the United States for the last twenty-eight years.

It will be noticed in Table I that "burnt or prepared" chicory is not separately scheduled after 1883, but is classed with the "ground or unground," with which it was taxed at the uniform rate of 2 cents per pound until 1891, when the tariff was again altered and "raw, dried, or undried, but unground" chicory was placed upon the free list. It will further be noticed that since the last change there has been a steady falling off in the importations of the finished product and as steady an increase in the receipts of the crude, kiln-dried root. Tables II and III and the paragraph which accompanies them will throw some light upon the cause of this movement of the figures from one to the other list. The commerce reports from which these tables were compiled do not give, for the crude root, the importations by countries and customs districts for the years 1891, 1892, and 1893. This is the more to be regretted, since Table III could not be compiled to show the marked decrease of shipments during the period of time covered by Table II, which shows the steady increase in consignments of the crude root from Belgium.

These figures relate wholly to chicory imported as such, and do not

include that imported among "coffee substitutes," under which title large quantities formerly were invoiced in order to avoid the extra one-half cent of duty per pound upon chicory imported under its own name.

TABLE I.—*Importations of chicory from 1869 to 1896.*

Year.	Burnt or prepared.			Ground or unground.			Total value.
	Duty per pound.	Pounds.	Value.	Duty per pound.	Pounds.	Value.	
	Cents.			*Cents.*			
1869	5	3,334,864.00	$126,794.31	4	36,346.00	$1,195.00	$127,989.31
1870	5	2,715,970.00	97,471.00	4	40,241.00	918.00	98,389.00
1871	5	2,315,822.00	70,324.00	4	8,243.00	171.00	70,495.00
1872	5	3,003,241.00	102,199.00	4	54,062.00	1,640.00	103,839.00
1873	5	40,304.00	1,641.00	1	3,832,773.00	153,754.00	155,395.00
1874	5	83,588.00	4,195.00	1	4,067,629.00	163,663.00	167,858.00
1875	5	348,215.00	14,809.00	1	3,411,053.00	134,427.00	149,236.00
1876	5	233,349.33	11,872.00	1	3,892,763.00	141,928.39	153,800.39
1877	5	253,809.00	12,019.00	1	3,684,946.00	129,105.00	141,124.00
1878	5	231,175.80	11,132.00	1	3,216,555.00	107,426.00	118,558.00
1879	5	268,411.00	13,731.00	1	3,196,671.00	112,911.00	126,642.00
1880	5	145,911.00	9,117.00	1	4,122,211.00	148,102.00	157,219.00
1881	5	25.00	3.00	1	3,576,753.00	132,533.00	132,536.00
1882	5	520.00	57.00	1	4,197,650.00	152,952.00	153,009.00
1883	5	536.40	45.00	1	6,725,490.00	241,851.00	241,896.00

Year.	Ground or unground and burnt or prepared.						Total value.
	Duty per pound.	Pounds.	Value.	Duty per pound.	Pounds.	Value.	
	Cents.						
1884	2	1,459,735.00	$49,400.00	.....	.....	.....	$49,400.00
1885	2	3,776,754.00	130,964.00	.....	.....	.....	130,964.00
1886	2	4,046,109.00	132,144.00	.....	.....	.....	132,144.00
1887	2	5,333,585.00	163,682.00	.....	.....	.....	163,682.00
1888	2	6,059,411.00	187,012.00	.....	.....	.....	187,012.00
1889	2	6,211,392.00	201,802.00	.....	.....	.....	201,802.00
1890	2	7,566,841.00	231,600.66	.....	.....	.....	231,600.66

Year.	Burnt or roasted, ground or granulated, or in rolls or otherwise prepared.			Raw, dried, or undried, but unground.			Total value.
	Duty per pound.	Pounds.	Value.	Duty per pound.	Pounds.	Value.	
	Cents.						
1891	2	9,695,765.00	$298,027.80	Free..	1,867,577.00	$35,560.00	$333,587.80
1892	2	2,688,574.00	85,793.00	Free..	5,492,864.00	93,179.00	178,972.00
1893	2	1,900,408.00	69,894.00	Free..	6,899,022.00	134,070.00	203,964.00
1894	2	2,459,940.00	94,798.20	Free..	7,951,042.00	168,892.00	263,960.20
1895	2	463,579.00	15,433.80	Free..	9,544,186.00	158,142.00	173,575.80
1896	2	464,599.00	15,001.31	Free..	15,841,875.00	210,228.00	225,229.31
1897	2	399,008.00	13,899.00	Free..	16,930,162.00	232,494.00	246,393.00

TABLE II.—*Chicory, raw, dried, or undried, but unground.—Free.*

1891.

Entered at—	Pounds.	Value.	From—	Pounds.	Value.
New York	1,361,126	$25,514	Belgium	1,115,262	$21,503
Philadelphia	410,800	8,168	Germany	533,942	9,849
Boston and Charlestown	39,645	961	Great Britain	140,321	2,770
Detroit	53,250	869	Netherlands	53,250	869
			France	22,046	521
Total 1891	1,864,821	35,512	Total 1891	1,864,821	35,512

TABLE II.—*Chicory, raw, dried, or undried, but unground.—Free*—Continued.

1892.

Entered at—	Pounds.	Value.	From—	Pounds.	Value.
New York	4,802,355	$79,977	Belgium	4,698,730	$80,050
Philadelphia	552,419	10,299	Germany	538,928	9,177
Detroit	93,866	2,046	Netherlands	252,938	3,939
Buffalo Creek	44,092	857	Great Britain	2,136	43
Total 1892	5,492,732	93,179	Total 1892	5,492,732	93,179

1893.

New York	6,460,335	$128,032	Belgium	5,705,648	$112,430
Philadelphia	222,337	5,378	Netherlands	498,470	12,888
Chicago	3,300	553	Germany	477,590	8,541
Grand Rapids	3,360	107	Great Britain	7,624	211
Total 1893	6,689,332	134,070	Total 1893	6,689,332	134,070

1894.

New York	7,547,800	$160,822	Belgium	6,895,379	$145,477
Philadelphia	390,019	7,730	Germany	909,065	19,414
Detroit	11,023	290	Netherlands	116,404	3,246
Grand Rapids	2,200	50	Great Britain	30,194	755
Total 1894	7,951,042	168,892	Total 1894	7,951,042	168,892

1895.

New York	8,880,714	$148,230	Belgium	9,512,896	$157,608
Philadelphia	641,162	9,301	Denmark	26,880	460
San Francisco	17,900	537	Netherlands	4,410	74
Grand Rapids	4,410	74			
Total 1895	9,544,186	158,142	Total 1895	9,544,186	158,142

1896.

New York	15,402,985	$204,703	Belgium	15,354,918	$202,993
Philadelphia	415,419	5,119	Netherlands	294,811	3,574
San Francisco	14,740	270	France	96,653	1,172
Grand Rapids	8,811	136	Germany	77,106	2,009
			Austria-Hungary	18,467	480
Total 1896	15,841,955	210,228	Total 1896	15,841,955	210,228

1897.

New York	16,662,442	$228,852	Belgium	15,697,914	$215,937
Philadelphia	196,209	2,580	Netherlands	777,511	9,478
San Francisco	66,000	977	Germany	454,737	7,079
Grand Rapids	5,511	85			
Total 1897	16,930,162	232,494	Total 1897	16,930,162	232,494

TABLE III.—*Chicory, burnt or roasted, ground, etc.—Dutiable.*

1894.

Entered at—	Pounds.	Value.	From—	Pounds.	Value.
New York	1,663,342	$64,859	Germany	1,429,458	$56,784
Philadelphia	79,581	4,598	Belgium	287,480	10,571
San Francisco	126,608	3,851	Great Britain	186,612	7,031
New Orleans	19,650	661	France	2,750	130
Puget Sound	13,430	386			
Chicago	3,359	141			
St. Louis	330	20			
Total 1894	1,906,300	74,516	Total 1894	1,906,300	74,516

1895.

New York	287,872	$9,908	Belgium	205,620	$6,925
San Francisco	153,640	4,734	Great Britain	197,155	6,301
Boston and Charlestown	1,812	69	Germany	39,640	1,435
Brazos de Santiago	1,406	68	Mexico	1,406	68
Chicago	453	21	France	750	57
St. Louis	275	16	Austria-Hungary	887	30
Total 1895	445,458	14,816	Total 1895	445,458	14,816

1896.

New York	350,087	$11,948	Belgium	210,540	$7,727
San Francisco	121,226	3,717	Great Britain	240,868	7,239
Pittsburg	4,363	169	Germany	23,985	849
Philadelphia	132	8	Switzerland	440	24
Willamette, Oreg	125	7	Netherlands	100	10
Total 1896	475,933	15,849	Total 1896	475,933	15,849

1897.

New York	281,010	$9,813	Belgium	185,047	$7,198
Galveston, Tex	64,909	2,578	Great Britain	166,464	4,842
San Francisco	47,484	1,255	Germany	46,997	1,821
Pittsburg	5,555	250	Austria-Hungary	500	38
Philadelphia	50	3			
Total 1897	399,008	13,899	Total 1897	399,008	13,899

From Table III it will be seen that during the last few years Belgium has exported the largest quantity of the crude product to the United States—a fact which has considerable significance, if it is remembered that when crude chicory was upon the taxed list its importation was very light, since to the original cost and the expense of preparation the duty had to be added. When the duty had been raised certain Belgian manufacturers removed their factories from the fatherland to the United States, imported the dried root from their own European kilns at the mere cost price, and put it through the roasting and grinding processes upon its arrival in America. They were thus enabled to grow the crop abroad at the nominal European rates of wages, import the roots at these exceedingly low figures, and place the product, after its final preparation, upon the American market at a much lower figure than it could

be profitably grown at in this country, thus virtually shutting up many American factories by controlling the market.

The present tariff of 1897 reads as follows: "280. Chicory root, raw, dried, or undried, but unground, one cent per pound; chicory root, burnt or roasted, ground or granulated, or in rolls, or otherwise prepared, and not specially provided for in this act, two and one-half cents per pound."

CHICORY GROWING FOR FODDER.

Chicory owes its value as a forage crop to its ability to produce well upon very poor, even almost barren soils, such as the extreme chalky soils of Texas. Its long taproots help to carry it through dry seasons in even the driest of land.

In continental Europe its cultivation has been practiced for centuries, though since the popularization of alfalfa it has declined in general favor. It is somewhat singular that it should remain for Arthur Young, in 1788, to introduce it to the farmers of the British Isles. An English writer in the Rural Cyclopædia says: "Though frequently and urgently recommended to the attention of the British and Irish farmers and cottiers, particularly for the feeding of cattle and swine, it continues to lie under a degree of neglect in this country (Great Britain) which is greatly inconsistent with its merits." This neglect was probably owing to the humidity of the atmosphere, which practically precluded the chicory leaves being properly dried. When used in the green state, either in the field or as a soiling crop, it is highly esteemed, since it may be cut at times when green food is usually somewhat scarce. Upon waste land it will frequently yield better than almost any other fodder crop, and yet it is grateful for generous treatment, being especially responsive in soils more or less rich in nitrogen, which substance tends to increase the growth of the tops. It may be sown either in drills or broadcast. In Europe, where labor is cheap, the former method is usually followed, particularly when the crop is to be used in the stable. By this method, where the rows are 15 inches or so apart, and the plants 4 to 6 inches asunder, some horse cultivation may be given the young crop and heavier cuttings secured. But where labor is high-priced, as in America, the broadcasting system probably is the most economical. The sowing should be done about the middle of May. In well-prepared ground, and if grown in drills, the plants should be thinned in much the same manner as when cultivated for the roots. For drilling, from 4 to 5 pounds of seed per acre will be ample; for broadcasting, from 10 to 12 pounds will be required. When chicory is used for feeding in the stall at least one cutting may be made the first season, and sometimes even a second crop may be obtained late in the autumn, although when this is done it is generally at the expense of the vigor of the plants and certainly precludes the possibility of obtaining a very early cutting in the spring of the following season, since the plants require more time to recuperate. In the second year three or

four or even five cuttings can be made, and this may, under ordinarily favorable conditions, be continued for the four or five following seasons, particularly if the first cutting be made prior to the appearance of any flowers, say when the stalks are just commencing to branch and are still juicy and succulent. If left until later the stems become too tough and the vitality of the roots is likely to be impaired. As much as 20 tons of green food has been cut from an acre the second season and 38 tons the third and fourth years.

Since, when used as a fodder crop, chicory remains long upon the land, it can not enter into rotation systems except in the same way as alfalfa and similar crops. But it so readily adapts itself to the poorer situations that it may be planted for forage upon the steep land and in out-of the-way places, where it may be useful for grazing and where most other forage crops are generally unsuccessful. When through age or other cause it becomes unprofitable, it may readily be eradicated by plowing and fallowing.

The only objection recorded against its use is that if fed in considerable quantities to milch cows it is liable to impart a bitter flavor to the milk. But turnips also unpleasantly affect the flavor of milk and butter when dairy cattle get all they desire, yet the turnip is not discarded. Where the dairy herd is fed in the stall, and where the food they get is under the control of the attendant, chicory may be added to their ration with advantage. Hogs are especially fond of the root and thrive upon it. Horses at first do not relish either the leaves or the roots, but having once acquired the taste they will eat them greedily. The plant seems to have an aperient, stomachic, and tonic effect upon the animal economy, and is also credited with preventing cutaneous disorders.