THE UNIVERSITY OF TENNESSEE
AGRICULTURAL EXPERIMENT STATION

BULLETIN NO. 168 JANUARY, 1939

HOME-PREPARATION OF FRUITS AND VEGETABLES FOR THE FREEZER-LOCKER

By

HARRY CARLTON

KNOXVILLE, TENNESSEE

PREFACE

For the past four years, Harry Carlton has been engaged in a study of the frozen-fruit-and-vegetable industry, visiting the leading packing areas, and interviewing growers, packers, cold-storage operators, distributors, and consumers. During his recent survey he visited many freezer-locker installations, from the Pacific Coast eastward, inspecting locker contents and discussing locker operation and use with owners and patrons. He has interviewed the leading research workers in both the commercial and locker frozen-food fields and studied their reports. Information thus obtained relative to the preparation of fruits and vegetables for freezing has been coordinated, and in this publication is made available by the Agricultural Experiment Station to locker patrons and operators.

C. A. MOOERS, Director

HOME-PREPARATION OF FRUITS AND VEGETABLES FOR THE FREEZER-LOCKER

By

HARRY CARLTON

INTRODUCTION

Quick freezing at low temperatures is essentially a method of fresh-food preservation. The object is to retain as far as possible the flavor, color, texture, and nutritional values of the fresh product. Frozen fruits and vegetables that are comparable to the best commercial frozen products have been prepared and packed in the home and frozen and stored in freezer-locker plants. For best results, care must be taken in the selection and preparation of the fruits and vegetables, as well as in the freezing and storage in the locker plant. Authorities differ and instructions vary so widely that it seems advisable to suggest methods which have proved successful in commercial freezing so far as they can be adapted to available home equipment. Since housewives undoubtedly will want to experiment with other products and varieties than those now being commercially frozen, instructions have been made as general and comprehensive as possible.

Practically all of our fruits and many of our garden vegetables have been successfully frozen. In general, vegetables having a high starch content, such as potatoes and too-far-ripened peas and beans, are not frozen. The same is true of those having a high water content, or those that are to be served raw for salad or other purposes where crispness is desirable, such as tomatoes, lettuce, celery, cucumbers, onions, and radishes.

FREEZING AND STORAGE TEMPERATURES

Since quick freezing is essential to a superior product, it is desirable to have a sharp-freezer room—a room held at 20 to 25 degrees below zero Fahrenheit—for freezing the products before storing in the locker. Not only is the product frozen more quickly, but the heat and moisture of the warm food is kept out of the storage room, lessening the frosting of the coils and the fluctuations of temperature.

Technical authorities and commercial packers agree that 0°F. is the highest safe temperature for holding frozen foods. At higher temperatures changes occur, and there is a slow deterioration of many products, especially non-acid vegetables. Tests made on many of the vegetables stored at 10°F. have shown a loss of vitamin C, the loss increasing rapidly at 15°F. The deterioration is attended by loss of color, the bright green changing to greenish yellow and then to greenish brown. The color of the vegetable usually is considered to be an indication of the vitamin content and quality. When stored at too high temperatures, fats oxidize, turn rancid, and spoil the flavor of meat products. Pork is especially susceptible to rancidity and deterioration. In the Midwest and East, where lockers are generally held at 10°F. to 20°F.,

locker instructions usually limit the storage of vegetables to 3 or 4 months, pork to 3 or 4 months, and beef and lamb to 6 months. In the Northwest, however, where lockers have been in operation for several years, locker operators interviewed, who were holding their locker rooms at a uniform temperature of 0°F., did not place limits on the length of storage. They reported that fluctuating temperatures had been found especially detrimental to quality and that the locker-room temperature should not vary more than 5 degrees.

CONTAINERS

In the selection of containers, it is necessary to take into account the dehydrating effect of the exceedingly dry air in the locker room. The frost covering the cooling coils is made up partly of moisture pulled out of insufficiently protected locker contents. This dry air will pull moisture through paper and other wrapping materials, which ordinarily are waterproof. Commercial packers use materials which they call moisture-vaporproof. Besides drying, fruits oxidize if exposed to the air, and vegetables lose their fresh coloring. Although the sterilized heat-sealing required in canning operations is unnecessary, the more effectively the product is protected from the air the better it will be.

Glass fruit jars, tin cans, heavily waxed paper cups such as are used for ice cream and cottage cheese, and miscellaneous containers that happen to be available, are used in locker storage. If these are of moisture-vaporproof material and are fitted with airtight covers, they will meet the moisture-vaporproof requirement. They should, preferably, be straight-sided or, still better, wider at the top, to permit easy removal of the frozen contents. If the food is completely enclosed in a wrapping of moisture-vaporproof cellophane, parchment, or waxed paper, any container may be used that will protect the contents and the wrapping against injury during handling and storage, and prevent leakage before freezing and after thawing.

Many locker operators purchase containers of the types used by commercial packers and resell them to their locker patrons. The most popular commercial container is a rectangular waxed paperboard carton, lined with cellophane, parchment, or other moisture-vaporproof material. This lining may be in the form of a bag, which is heat-sealed after filling. The heat-sealing may be done in the home, with a flatiron or soldering iron. The completely sealed bag is suitable for holding both dry and sirup packs. For dry packs the lining may be simply a sheet placed in the carton so that the edges can be closely folded after packing to form a substantially air-tight package. These rectangular cartons are light and convenient and will permit the storage of approximately one-third more food than round containers.

In general, containers should be chosen of a size that will meet the family's requirements for serving or cooking at one time, and thus avoid partly used packages, which deteriorate and spoil rapidly if allowed to thaw out. Since it is a generally accepted rule that the more quickly the food freezes the better the quality, small containers, which permit quick freezing to the center of the package, are preferable. Fruits for processing into preserves may be packed in convenient batches for cooking.

When a liquid pack is used, or fruit juices are being frozen, at least 10 percent space should be allowed for expansion, or 1 inch for pint cans and

1½ inches for quart cans. If sufficient space is not allowed, the container will break or the contents spill over the top when freezing.

GENERAL PREPARATION

Products should be selected at the best stage of maturity for serving or for cooking; that is, when flavor and appearance are at their best. The effect of quick freezing at low temperatures is to stop all the natural life processes and hold the product as nearly as possible in the state in which it enters the freezer. Freezing will not improve a poor product. Locker space usually is limited, and it is therefore poor economy to freeze products of doubtful quality.

Fruits and vegetables for freezing should be sorted and washed, and all non-edible parts removed, much as is done for canning or the table. They should be made ready to serve or cook without further handling. Cauliflower heads, broccoli, and other large items, should be divided into as small pieces as are suitable for serving. The small pieces blanch and freeze more quickly than larger pieces, and pack more easily into containers.

All vegetables must be blanched (scalded) before freezing, except rhubarb, which on account of its acidity is classed with the fruits. Blanching is necessary in order to stop certain natural changes which take place after the vegetable is harvested and which go on, although more slowly, even when the product is frozen solid and stored in the locker. If these changes are not stopped by thorough blanching, the vegetables soon lose their attractive color, and develop unpleasant flavor and odor. Although harmless to health, the products become undesirable as food.

The necessity for prompt handling between harvesting and freezing cannot be overemphasized. If this period is prolonged, freshness is lost, sugars change to starch, vitamins are destroyed, and bacteria multiply. Just as fruits and vegetables are best when served or cooked fresh from the garden, so are the same products best when frozen in the shortest possible time after harvesting. If delays at any stage of preparation are unavoidable, the product should be kept as cool as possible short of freezing. This is especially important in the case of vegetables after they are blanched. The moisture and broken surfaces offer ideal conditions for the growth of bacteria, and the vitamin loss increases rapidly. Peas and beans retain freshness better when left in the pod. All vegetables should be kept crisp and unwilted.

If equipment for washing, blanching, and packing were installed in the locker plant it would simplify the preparation of fruits and vegetables for freezing and shorten the preparation time required. This equipment might be used by locker patrons, or the locker plant operator might process and package the products at a moderate cost per pound. If these facilities were provided, berries and such vegetables as peas, beans, and corn could be frozen before packaging. The product can be spread out on trays in the sharp-freezer room, and an electric fan used to circulate the cold air. This method is followed by many commercial packers to insure a quick, uniform freeze of the individual pieces. Asparagus, spinach, and similar products, after freezing, are difficult to pack without breaking badly.

PREPARATION OF FRUITS

Fruits for freezing divide into two general classes; (1) the small fruits, which can be cleaned and prepared whole without excessive injury to the

skin and leakage of juice, and which do not oxidize, or darken, easily—such as strawberries, raspberries, blueberries, gooseberries, currants, cranberries, blackberries, dewberries, loganberries, youngberries, and boysenberries; and (2) the fruits which should be pitted or peeled, and which oxidize quickly when the cut or peeled surfaces are exposed to the air—such as cherries, peaches, and apples.

Three methods are used in packing fruit for freezer-locker storage; (1) dry pack (without sugar), (2) sugar pack, and (3) sugar-sirup pack. The method to be used should be decided upon according to the class of fruit to be preserved, the use to which it will be put, and the preference and convenience of the packer.

DRY PACK

All of the first class may be packed dry without sugar. The dry pack usually is preferred for making into pies, and may be used when the fruit is being frozen for later processing into preserves, jelly, or juice. The fruit should be carefully sorted, cleaned, and, if necessary, washed. It should then be well drained to remove excess water and to prevent freezing together into a solid mass.

Moisture-vaporproof containers should be used to prevent dehydration and loss of color. If unlacquered tin cans are used, they should be lined with cellophane, or with waxed or parchment paper, to prevent discoloration from contact with the tin.

SUGAR PACK

All of the first class, and also cherries, may be packed by the sugar-pack method. The fruit may be packed whole, sliced, chopped, or crushed. One pound of suger to 3 or 4 pounds of fruit should be used, according to taste and the acidity of the fruit. The sugar and fruit should be well mixed, so that the fruit is thoroughly coated by the dissolved sugar and juice when placed in the sharp freezer. All of the sugar should be dissolved before freezing starts.

Fruits for all uses may be packed by this method. The sugar pack is especially desirable, however, when the fruit is intended for dessert purposes. The sugar penetrates the fruit more evenly and the flavor usually is considered better than if the sugar is added when the frozen fruit is served. Commercial packers use the sugar pack for strawberries, packing them whole for preserves, whole or sliced for ice-cream manufacturers, and sliced for home consumption. Notes should be made of quantities of fruit and sugar so that correct amounts of sugar can be added when the frozen fruit is made into preserves or jelly.

Containers should be liquid-tight to prevent leakage either before freezing or after thawing in the package, and moisture-vaporproof if the product is to be left in the locker for more than a few weeks. Tin containers should be lacquered.

SUGAR - SIRUP PACK

All fruits may be packed in sirup. It is the only practicable method for home-preparation of peaches and apples to prevent oxidation and loss of the fresh coloring. It is not as desirable as the dry and sugar packs for pies, preserves, and jellies, because of the additional water that must be cooked

out. It helps to prevent dehydration and protects the product to some extent from fluctuating locker-room temperatures.

The fruit may be packed whole, sliced, chopped, or crushed, and then covered with 40 to 60 percent sirup (3¼ to 7 cups of sugar to 1 quart of water), according to taste and the acidity of the fruit. The sugar may be dissolved in hot water, but the sirup must be cooled before being added to the fruit.

Containers should be airtight and liquid-tight. Tin containers should have fruit-lacquer linings.

ADDITIONAL FRUIT-PACKING DIRECTIONS

Apples, peeled and sliced for pies, may be protected from browning by being dropped into a brine made of 4 teaspoonfuls of salt to 1 quart of water. They are then removed from the brine, drained, and packed in sirup. Another method is to scald the drained slices in boiling water or steam for 1½ minutes, cool quickly by dipping into cold water, drain, mix thoroughly 1 pound of sugar with 4 pounds of apples, and pack in container.

Cantaloup and other melons have been frozen sliced, but usually are diced or cut into balls for fruit cocktails or salads. They may be frozen dry, with waxed paper between layers to prevent freezing together, or in sirup.

Cherries of sour varieties should be stemmed and pitted. Sweet cherries should be stemmed but need not be pitted. Cherries darken if not well covered with sirup or sugar. Firm-fleshed varieties, such as Montmorency, are most desirable.

Cranberries are packed whole, either dry or in sirup.

Figs are packed whole, not peeled, usually in sirup.

Fruit juices may be frozen with or without sugar.

Peaches for the freezer-locker, in order to avoid browning, must be handled even more quickly than for canning, since the cooking restores or neutralizes the color to some extent. They should be peeled as for canning by being dipped quickly into boiling water and then into cold. They are left in cold water, after the peel is removed, until they can be sliced, packed into containers, and covered with sirup.

Prunes and plums may be frozen whole, but usually are pitted and halved or sliced, the sugar or sugar-sirup pack being used.

Rhubarb is trimmed, not peeled, cut into 1-inch pieces, and packed dry or in sirup.

PREPARATION OF VEGETABLES

Two methods are used in packing vegetables for freezer-locker storage: (1) dry pack, and (2) brine pack. The dry pack is used by commercial packers. The brine pack is often recommended for home-packing for freezer-locker storage. The vegetables are immersed in a brine, which freezes solid and gives some protection from dehydration and oxidation, and also affords some protection from fluctuating locker-room temperatures.

DRY PACK

Vegetables for the dry pack should be carefully washed, sorted, and trimmed, ready for packing, before they are blanched. In home-preparation

they are blanched by dipping into boiling water. A wire basket or cheesecloth bag may be used. At least one gallon of boiling water should be allowed for each pound of vegetables. Two gallons are recommended for spinach and other leafy vegetables, which wilt quickly and tend to cling together in a solid mass. The object is to have the temperature of every part of each individual piece raised to the boiling point, so that no part will be left untreated to start changes that will affect the whole product. For instance, corn on the cob must be left in the boiling water until the center of the cob has reached the required temperature; otherwise the corn within a short time will acquire a disagreeable cob flavor. If scalding continues too long it will result in loss of vitamins and quality. Special attention, therefore, should be given to this operation.

Following are blanching times for various vegetables[1]:

		Minutes			Minutes
Asparagus,	small stalks	3½	Cauliflower,	small pieces	3
	large stalks	4½		medium pieces	4
Lima beans,	small	1		large pieces	5
	medium	1½	Peas		1
	large	2	Spinach		2½
Snap beans		2	Corn on cob,	small ears	6
Broccoli,	small pieces	3		medium ears	8
	medium pieces	4		large ears	10
	large pieces	5	Cut corn		1½

[1]Donald K. Tressler, N. Y. State Agr. Exp. Sta., Farm Research, Oct. 1938.

After blanching, the vegetables must be cooled as quickly and thoroughly as possible. This should be done by dipping into the coldest water available. Running water or ice water is excellent for the purpose. When cool, the vegetables should be drained well, packed into containers, and placed in the sharp freezer as quickly as possible—within 3 or 4 hours at the longest.

Any moisture-vaporproof container will serve the purpose. Tin containers, when used for asparagus or snap beans, should be lacquered or otherwise lined so that the product will not come into contact with the metal. Corn on the cob usually is wrapped in moisture-vaporproof material, one or two ears to the package.

BRINE PACK

The same procedure is followed for brine pack as for dry pack, except that after blanching and cooling, the vegetables are packed in 2 percent brine, made by adding ¼ pound of salt to 6 quarts of water.

Containers should be airtight and liquid-tight. Tin containers should have lacquer linings.

ADDITIONAL VEGETABLE-PACKING DIRECTIONS

Brussels sprouts should have all loose outer leaves removed and be trimmed closely. Blanching time should be 3 to 5 minutes, according to size.

Carrots are diced and frozen by commercial packers for combining with peas. They may also be sliced, and should be blanched from 1 to 5 minutes, according to size of pieces. Small, tender carrots may be frozen whole.

Cut corn can be cut off the cob more easily and the kernels will stay whole better if blanched on the cob. Blanching time should be increased to 3 minutes. Brine pack is not recommended for corn.

Mushrooms should be handled quickly and carefully to prevent darkening. Blanching time for button-size is 2 minutes; for large size, 3 to 4 minutes. Large mushrooms usually are sliced.

Squash packed by commercial packers is cooked before it is packed for freezing.

Sweet peppers may be packed without blanching, but halves and slices pack more easily if blanched for 2 minutes.

If it is desired to freeze other vegetables than those mentioned, the general directions should be followed, and blanching times should be governed by the sizes of the parts to be blanched. It is advisable to freeze a small quantity and cook a test package before making large packs, if there is doubt as to the resulting product.

VARIETIES

The variety of the fruit or vegetable must be taken into consideration, since some varieties freeze much better than others. In general, the tender, fine-flavored, home-garden types are preferable to the tougher varieties, which have been developed to withstand shipment and long storage. Many of the varieties grown for commercial canning have proved unsatisfactory.

Until more extensive tests have been made in Tennessee, it will be impossible to make definite recommendations, as the same variety does not always freeze equally well when grown in different climates and soils. The tables are made up of varieties which have proved successful in other states and usually grow well in Tennessee.

FRUITS

Apples
- Golden Delicious
- Grimes
- Jonathan
- Rome Beauty
- Stayman
- Winesap

Blackberries
- Early Harvest
- Eldorado
- Common wild

Cherries
- Early Richmond
- Montmorency
- (Under favorable conditions sweet varieties are successfully grown in Tennessee)

Dewberries
- Boysenberries
- Youngberries
- Common wild

Figs
- Brown Turkey
- Celestial

Gooseberries
- Glendale

Grapes
- Concord
- Fredonia
- Thomas

Peaches
- Crawford
- Early Elberta
- Eclipse
- Elberta
- Georgia Belle
- Halehaven
- Hiley
- J. H. Hale
- Oriole
- Primrose
- South Haven

Plums
- Damson
- Gold
- Methley
- Wild Goose

Raspberries (black)
- Cumberland

Raspberries (red)
- Chief
- Latham
- St. Regis

(Cuthbert is the most popular variety for freezing, but is rarely grown successfully in Tennessee.)

Strawberries
- Blakemore
- Dorsett
- Klondike
- Missionary
- Premier

(Tennessee Blakemore and Klondike have proved satisfactory for commercial freezing, the Blakemore being especially liked for preserves. Aroma is not suited to freezing)

VEGETABLES

Asparagus
- Martha Washington
- Mary Washington

Beans (lima)
- Burpee Improved
- Fordhook
- Henderson Bush
- King of the Garden

Beans (snap)
- Early Refugee Stringless
- Full Measure
- Kentucky Wonder
- Mosaic Resistant Refugee
- McCaslan
- Stringless Green Pod
- Stringless Valentine

Carrots
- Chantenay
- Nantes

Cauliflower
- Snowball

Corn
- Country Gentleman
- Golden Bantam
- Hybrids of Golden Bantam
- Stowell Evergreen

Peas
- Gradus
- Laxton'an
- Laxton's Progress
- Thomas Laxton

(Alaska is not suited to freezing)

Spinach
- Bloomsdale Savoy
- King of Denmark

Squash
- Boston Morrow

While broccoli and brussels sprouts are not grown to any great extent in Tennessee, the following varieties are suggested for trial:

Broccoli
- Italian Green Sprouting (Calabrese)

Brussels sprouts
- Half Dwarf Improved
- Long Island Improved

While these tables may be used as a guide, the varieties listed are not the only ones suited to home freezing, and are not necessarily the best. Many of the varieties were selected because they were the best available for commercial operations, combining good freezing qualities with high productivity and other characteristics not so important for home use. For instance, the commercial packers must have bush varieties of peas and lima beans which mature uniformly and can be harvested, vined, and shelled by machinery. For home use, where small quantities are gathered and prepared by hand, pole beans and tall peas, which mature unevenly, may produce a

superior frozen product. It is advisable to freeze and test small quantities of any untried variety before making large packs.

CARE OF FROZEN FOOD IN THE HOME

Unless frozen food can be kept frozen, it should be used promptly. Once thawed, it should not be refrozen. Vegetables should be partially cooked if they cannot be used soon after thawing. Twenty-four hours may be allowed after thawing, if the vegetables are kept in the food compartment of an efficient refrigerator.

COOKING AND SERVING

Fruits are considered best when served just before they are completely thawed out. Dry-pack or sugar-pack fruits may be put into pies or into the preserve kettle without thawing.

Dry-pack vegetables are considered best when plunged into boiling water while frozen, but may be allowed to thaw first. It is possible to cook brine packs by plunging the frozen mass into boiling water; or they may be thawed and drained, the brine heated to the boiling point, and the vegetables added. Only enough water should be used to prevent burning, and the residue should be served with the vegetables.

Cooking times are shorter than for fresh vegetables by approximately one-half, starting from the time the thawed mass resumes boiling. Frozen vegetables, if overcooked, will lose their fresh flavor and color.

SUMMARY

1. Quick freezing is a new method of preserving fruits and vegetables which conserves their fresh flavor, their natural appearance, and their nutritional values to a greater extent than any other method of preservation. But care in the selection, preparation, freezing, and storage is essential for a good product.

2. Different varieties of fruits and vegetables do not all freeze equally well.

3. Fruits and vegetables should be harvested when at their best for serving or cooking. Freezing will not improve a poor product. Time, labor, and valuable locker space will be wasted if inferior products are used.

4. The necessity for prompt handling between harvesting and freezing cannot be overemphasized. If delays are unavoidable, the product should be kept as cool as possible.

5. All vegetables must be blanched before freezing.

6. Containers should be moisture-vaporproof to protect the frozen food from the drying and oxidizing effects of the extremely dry air in the locker room. Space should be allowed for expansion of liquids during freezing; otherwise, the contents will overflow or break the container.

7. Rapid freezing is generally accepted as essential to a quality product.

8. In commercial practice, 0°F. is recognized as the highest safe temperature for the storage of frozen products. Fluctuating temperatures are especially injurious to frozen food; storage temperatures should not be allowed to fluctuate more than 5 degrees.

THE UNIVERSITY OF TENNESSEE
AGRICULTURAL EXPERIMENT STATION
Knoxville

JAMES D. HOSKINS, President

AGRICULTURAL EXPERIMENT STATION COMMITTEE

I. B. TIGRETT W. P. COOPER W. P. RIDLEY CLYDE B. AUSTIN

STATION OFFICERS

ADMINISTRATION

C. A. MOOERS, Director
F. H. BROOME, Secretary, Editor
E. G. FRIZZELL, Associate Secretary

AGRONOMY

C. A. MOOERS, Agronomist
J. J. BIRD, Assoc. Agron., Crossville
E. L. BOHANAN, Asst. Agron., Crossville
A. G. BURG, Asst. Agronomist
W. A. CHRIESMAN, Plot Assistant
O. W. DYNES, Assoc. Agronomist
J. G. FAULKNER, Plot Assistant
N. I. HANCOCK, Assoc. Agronomist
O. H. LONG, Asst. in Agronomy
R. L. LONG, Plot Assistant
L. S. MAYER, Assoc. Agron (Corn Br'd'g)*
H. P. OGDEN, Assoc. Agronomist
J. K. UNDERWOOD, Assoc. Agronomist
J. L. VANDIVER, Asst. Agron., Greeneville
W. O. WHITTLE, Asst. in Agronomy

ANIMAL HUSBANDRY

M. JACOB, Vet. and Animal Husb.
H. R. DUNCAN, Assoc. Animal Husb.
C. E. WYLIE, Dairy Husbandman

BACTERIOLOGY

P. W. ALLEN, Bacteriologist
N. O. SJOLANDER, Assistant Bact.

CHEMISTRY

W. H. MacINTIRE, Soil Chemist
A. H. FITZGERALD, Asst. Chemist
BROOKS ROBINSON, Asst. Soil Chemist
K. B. SANDERS, Asst. Soil Chemist
W. M. SHAW, Assoc. Soil Chemist
G. A. SHUEY, Associate Chemist
E. K. WEATHERS, Asst. General Chemist
S. H. WINTERBERG, Assoc. in Soil Chem.
J. B. YOUNG, Asst. Soil Chemist

ECONOMICS AND SOCIOLOGY

C. E. ALLRED, Agricultural Economist
H. J. BONSER, Asst. Agri. Economist
B. H. LUEBKE, Asst. Agri. Economist
BENJ. D. RASKOPH, Asst. Agri. Econ.
J. E. WILLS, Assoc. Agri. Economist

ENGINEERING

M. A. SHARP, Agri. Engineering
H. A. ARNOLD, Asst. Agri. Engineer
R. BROOKS TAYLOR, Ind. Engineer

ENTOMOLOGY

S. MARCOVITCH, Entomologist
W. W. STANLEY, Assoc. Entomologist

HOME ECONOMICS

FLORENCE L. MacLEOD, Home Economist
MARTHA J. KEMMER, Asst. Home Econ., Crossville
EVELYN UTLEY, Asst. Home Economist
DOROTHY E. WILLIAMS, Nutr. Chemist

HORTICULTURE

BROOKS D. DRAIN, Horticulturist
H. F. BUTLER, Asst. Horticulturist
L. A. FISTER, Asst. Hort., Jackson
N. D. PEACOCK, Assoc. Horticulturist
C. R. SPANGLER, Asst. in Horticulture
A. B. STRAND, Asst. Horticulturist

LIBRARY

SARAH C. CURRELL, Librarian

MARKETS

HARRY CARLTON, Mkt. Investigator

PHYSICS

K. L. HERTEL, Physicist
BETH CHENEY, Asst. in Physics
ELIZABETH H. COTTER, Asst. in Physics
EMILY LOUISE McCAMY, Asst. in Physics
R. R. SULLIVAN, Asst. Physicist

PLANT PATHOLOGY

C. D. SHERBAKOFF, Plant Pathologist
J. O. ANDES, Assoc. Plant Pathologist
E. S. BROWN, Asst. in Plant Pathology
R. G. LAWLER, Asst. Plant Pathologist
G. M. STONE, Assoc. Pl. Path.(Tob.Invest.)*
R. K. ZUCK, Asst. Plant Pathologist

SUBSTATIONS

F. S. CHANCE, Superintendent, Tobacco Experiment Station, Greeneville*
BEN P. HAZLEWOOD, Superintendent, West Tennessee Experiment Station, Jackson
L. R. NEEL, Superintendent, Middle Tennessee Experiment Station, Columbia
LESTER WEAKLEY, Assistant, Mericourt Experiment Station, Clarksville

*Cooperative with U. S. Department of Agriculture.

The Agricultural Building, containing the offices and laboratories of the Experiment Station, the College class rooms, and the headquarters of the Agricultural Extension Service, is located at the University Farm, on Kingston Pike, about one mile west of the main campus. Farmers are cordially invited to visit the building and the experimental grounds.

Bulletins of this Station will be mailed free to any farmer in the State. Write Agricultural Experiment Station, University of Tennessee, Knoxville, Tennessee.