September 1952 AIC-344

SANITATION AND MICROBIOLOGY AS RELATED TO VEGETABLE DEHYDRATION

R. L. Olson
Western Regional Research Laboratory, Albany 6, Calif.

(A revision of the sections entitled "Sanitation" and "Control of Insects and Mites," in U.S.D.A. Miscellaneous Publication No. 540, Vegetable and Fruit Dehydration. A Manual for Plant Operators, June, 1944.)

Bureau of Agricultural and Industrial Chemistry
Agricultural Research Administration
UNITED STATES DEPARTMENT OF AGRICULTURE

CONTENTS

Page

SANITATION IN THE PRODUCTION OF DEHYDRATED VEGETABLES
- Introduction - - - - - - - - - -
- Water Supply - - - - - - - - - -
- Clean-up Procedure - - - - - - - - -
- Pest Control - - - - - - - - - -
- Sanitary Facilities and Personal Hygiene - - -
- Building and Equipment Construction - - - - -
- Sewage and Waste Disposal - - - - - - -
- General Housekeeping and Working Conditions - -
- List of References - - - - - - - - -

MICROBIOLOGICAL ASPECTS OF VEGETABLE DEHYDRATION
- Introduction
- Interpretation and Bacteriological Control Data in Appraisal of Dehydration Processes and Products -
- Methods of Measuring Microbial Contamination on Dehydrated Vegetables and Processing Equipment -
- List of References

FOREWORD

The present mimeographed information is a revision of two sections entitled "Sanitation" and "Control of Insects and Mites," of Miscellaneous Publication No. 540, Vegetable and Fruit Dehydration---A Manual for Plant Operators, published by the U.S. Department of Agriculture in 1944. It is hoped that this revision will provide a compact introduction to problems of sanitation and, at the same time, provide a series of check points which supervisors can use in judging the effectiveness of the plant sanitation program. Further, it is an attempt to designate areas for study and to provide a number of references that will be helpful in preparing the plant sanitarian for the adequate accomplishment of his responsibilities.

A section on microbiology supplies a general statement of problems, discussion of interpretation of data, and methods for the measurement of microbial contamination as developed in connection with the examination of dehydrated foods.

/

SANITATION AND MICROBIOLOGY AS RELATED TO VEGETABLE DEHYDRATION

Sanitation in the Production of Dehydrated Vegetables

Introduction: A primary essential in a dehydrating plant endeavoring to make products of highest quality is the maintenance of adequate standards of plant sanitation. According to the concept of adequate plant sanitation that is reflected in the Federal Food, Drug, and Cosmetics Act of 1938, food is deemed to be adulterated not only when it consists in part of filth, but also when it has been prepared, packed, or held under unsanitary conditions, whereby it may have become contaminated with filth, or whereby it may have been rendered injurious to health. Many progressive industrialists would consider the legal requirement as a minimum, to be conformed to as a matter of course, and to be exceeded in the establishment of individual standards. There are economic reasons, direct and indirect, that justify high standards of sanitation. These include reduction in maintenance and replacement costs (e.g., an unsanitary operation leads to increased corrosion of equipment and floors), employee efficiency, and consumer relations. Intelligent, interested, and energetic supervision can keep the plant at a satisfactorily high level of sanitation to meet this requirement if certain fundamental concepts are understood and acted upon. The sanitation program must have direction from a suitable administrative level to enforce the disciplines necessary for its successful operation.

Among important factors affecting plant sanitation are fresh water supply, clean-up procedures, pest control, sanitary facilities and personal hygiene, sanitary building and equipment construction, sewage and waste disposal, general housekeeping, and working conditions. Above all, education of operating personnel and establishment of a firm supervisory control program are essential in maintaining sanitary conditions.

Water Supply: A most essential matter in sanitary operations is a water supply that is both pure and abundant. The water should meet standards of suitability for drinking purposes, not only in the preparation of the product but also for plant clean-up as well. Contaminated water can be a source of entry for spoilage organisms and also a health hazard.

The plant water supply should be analyzed frequently, because its character is subject to change and it may become contaminated with waste from the plant or other sources. Analysis for potability of water is a routine service that can be performed monthly or oftener by a commercial laboratory or, in some cases, by local public health authorities.

Clean-up Procedures: Dirt, spillage, and other wastes should not be allowed to accumulate in a food processing plant. The equipment and working areas should be thoroughly cleaned at the end of each working shift, or oftener if conditions warrant. Frequently a two- or three-hour break is scheduled between working shifts on the preparation and traying lines to allow adequate time for a thorough clean-up at least twice a day. In such cases the production rate of these lines is geared to a faster rate than the dehydration tunnels, so that the drying operation can be uniform.

In general, hot water does a better job of cleaning than cold water. The use of a steam hose can be very beneficial, but the steam must be applied under pressure directly to the area to be cleaned. If improperly applied, steaming will spread microbial contamination with its blast rather than destroy it with heat. Furthermore, the heat will sometimes bake dirt onto equipment or floors, making it difficult to remove. It is generally advisable to loosen dirt by washing before application of steam.

Chemical cleaning aids (detergents and soaps) are available commercially and are beneficial in removing dirt from floor and equipment. Other chemicals (sanitizing agents) are used to improve the microbiological cleanliness of the plant.1/ The use of a sanitizing agent alone without the cleansing operation is of limited value. However, with the continuous application of chlorine, for example, to the water used in preparation lines and flume conveyors, sanitary levels can be kept relatively high and clean-up operations are simplified. In general, the concentration of the free chlorine is increased when processing lines are halted for the major clean-up and the highly chlorinated water is used in connection with the mechanical cleansing operation. It should be associated with or used immediately following cleaning, and prior to final rinsing. It should be stressed that inadequate use of chemical sanitizing compounds is not only inefficient and uneconomical but frequently contributes a false sense of security to the user.

Continuous spray or brush washers for conveyor belts and other equipment will not eliminate the need for occasional delay for clean-up. It may, however, make possible a reduction in required clean-up time as well as reduce the degree of contamination between clean-up periods.

Pest Control: Food manufacturing or processing plants, including dehydration plants, have the universal problem of elimination of rodents, insects, and other pests. Such pests are offensive in themselves and also are apt to be carriers of microbial contaminants. The most effective means of preventing the access of such pests to both raw and finished materials is by use of tight construction, rat-proofing, screening and thorough sanitation. Unceasing vigilance is necessary in removing waste food material and debris in and outside of buildings, and, if required, in cooperative effort in the neighborhood. Regular and thorough inspections of the premises and samples of raw material and finished product should be made and results used as a control on the sanitary practices established at the plant.

Rodent infestations are generally caused by (1) accessible food due to improper storage, housekeeping, or waste disposal; (2) accessible nesting facilities due to improper construction, poor equipment arrangement, improper storage, and careless disposal of trash and other debris; (3) easy entry, and (4) infested environs. Rodents can be controlled by a three-pronged attack of (1) closing possible ports of entry into the plant, (2) extermination of rodents within the plant, and (3) elimination of harborages.

1/ Selection of detergents and sanitizers to be used and their application are beyond the scope of this publication. The reader is referred to the list of publications on page 5 for further details in the operations involved in implementing a plant sanitation program.

Sanitation is the most important factor in insect control, because the insect problem is significantly reduced by removal of the attracting substance, the food supply, and the breeding place for many pests. Insecticides are a valuable supplement. Insecticides are classified as sprays, dusts, and fumigants; or as stomach, contact, and respiratory poisons. Moreover, some act as attractants, others as repellents. Almost all the stomach poisons (e.g., sodium fluoride, arsenious compounds, etc.) and some of the contact insecticides are poisonous and dangerous to humans. Extreme caution is required, not only to prevent poisonous insecticides from coming in contact with the food being processed, but also to prevent inclusion of non-toxic substances that might be considered adulterants.

The more commonly used fumigants are toxic to all forms of life (including man). In many states, licensed operators are required for fumigation activities. In the use of pesticides, the supplier's instructions should be followed to insure proper handling and to guard against inherent dangers.

A number of insects will feed on the dehydrated vegetables in storage.2/ Since dehydration temperatures will destroy all insect life, the infestation generally occurs between dehydration and packing operations. Rapid handling and prompt packaging in insect-free packing rooms is essential to prevent infestation by insects. Protective packaging and sanitation in warehouse operations will prevent infestation during subsequent storage.

Sanitary Facilities for Employee Service and Personal Hygiene: Legal requirements in some states establish minimum requirements for employee sanitary facilities in food processing plants. Above this requirement is the fact that proper construction and maintenance of such facilities may be reflected throughout the plant in the type of employee and his or her attitude. It is reasonable to expect an employee, who is provided with clean and proper sanitary facilities, to have an improved attitude toward his job and the proper production of the product. Such an employee should be more amenable to instructions in regard to his own habits as they may affect contamination of product or protect it.

Bacteriological tests for coliform organisms in finished product and on equipment are commonly used as presumptive tests for fecal contamination. While other sources of coliforms exist, positive tests should always lead to appropriate investigations to make certain that proper hygienic practices are being followed. The education of personnel and supervision of matters pertaining to personal hygiene are important aspects of a sanitary program, especially in regard to public health hazards.

In some cases washing facilities, including hot water, sanitary soap dispensers, and individual towels are provided outside the rest rooms and the toilet room. The employees must wash their hands where they can be seen by the supervisor, and no one is permitted to go back to work unless his hands have been washed at that place. The use of hair nets or hats is required for all who enter some food processing plants; and other techniques are sometimes established to enforce hygienic disciplines.

2/ References 2, 3, and 10 on page 5 give details on common insects affecting stored dried foods.

Building and Equipment Construction: Building design should be such as to prevent entrance of pests as far as possible and to provide no harbors for those that are able to enter. In addition, plan and construction should provide for maximum ease of clean-up with coved floor-wall joinings, sloped floors in areas where washing is required, and sufficient floor space to avoid congestion with a minimum of corners, ledges, recesses, and other places to collect debris.

Equipment should be designed and arranged to eliminate all possible recesses and allow for ease in dismantling where necessary to facilitate clean-up procedures. Wood construction should be limited as far as possible. Drains should be conveniently located to collect spillage. Corrosion-resistant materials should be used in preparation lines and the choice of machine should depend upon its sanitary as well as mechanical aspects.

Sewage and Waste Disposal: The selection of a dehydration plant site should include careful consideration of the waste-disposal problem. The capacity of the intended place of final disposal (treatment plant, available sites for land irrigation, lagooning or dilution in large bodies of natural waters) must be carefully evaluated. If the permissible loading is found to be less than that transported by the plant wastes, it will be necessary either to treat the wastes to lower their organic loading or move the plant to some other location where treatment will not be required. If wastes are not properly conducted away from the plant, they may cause an odor nuisance and even legal suits by property owners in the vicinity. The possibility of pollution of local water supplies must also be considered.

Volume of food processing wastes varies with products and processes used but in general is large. While the volume of waste water varies greatly with process used, the polluting value is approximately the same per ton of product, with some variation among vegetables.

In the dehydration of potatoes, there is a large loss of solids in peeling and preparation. A high organic load, due primarily to waste starch, can be readily settled and the removal of this starch by sedimentation would seem to be an essential step in making wastes amenable to disposal methods in most areas. Other vegetables will have waste and sewage loads of magnitude similar to conventional canning processes. Typical remedies proposed for canneries would apply.[3/]

Waste waters from various sources in the process will vary in relative volume and pollution character. Preliminary wash water will be in large volume, but with suspended matter settling fairly rapidly to form a non-putrefactive sludge. Peeling and post-peeling wash water will have a high concentration of suspended matter that will settle to a bulky sludge (gelatinous from starchy constituents in potato processing) that is highly putrescible. The waste water from blanching is very putrefactive but exists in smaller volume than the wash water. Keeping some of these wastes separate from each other and from plant sewage in many cases will provide for more efficient treatment for their disposal.

3/ References 2, 4, 5, 8, 11, 12, and 13 on page 5 give further details.

The methods available for disposal include dilution directly into large bodies of water, screening of solids, segregation of prime garbage from washer and other dirty wastes for local use as stock feed, garbage disposal, land irrigation, lagooning, biological filters, and chemical flocculation and sedimentation. Of course, combinations of these treatments are commonly used.

Combining industrial waste with domestic sewage in a metropolitan area may be a mutually advantageous disposal system. The industry is an asset to the economic stability of the town, and availability of a large sewage disposal system benefits the plant operations. However, the volume and pollution load of the industrial wastes may determine what treatment must be used.

Seasonal activities, as in most food processing plants, may disrupt normal operating procedures, and the effect of seasonal waste volume changes on treatment process and existing plant structure must be anticipated. Furthermore, if the plant waste is in large volume and polluting load relative to the local domestic sewage, individual treatment may often be more effective and economical.

General Housekeeping and Working Conditions: General housekeeping involves maintenance of noncongested, clean, well-lighted working areas, with freedom from refuse, garbage, and debris that might cause slipping or falling as well as provide food and home for plant pests. Greasy handrails, oily stairs or ladders, wet slippery floors and the like that are safety hazards should not be allowed to exist. Also, reasonable public health standards should be established in plant-owned feeding and housing facilities.

Insufficient lighting, overcrowding of machinery, unsafe operating practice, unsuitable clothing, failure to use safeguards, fatigue, improper ventilation, use of intoxicants, and inadequate supervision can be responsible for unfortunate accidents and costly work stoppages. In no instance should the bearer of communicable disease be allowed to work in contact with food for human consumption.

Intelligent considerations of all aspects of plant operation in regard to safety must be a fundamental part of management practice.

Literature Cited

Sanitation

1. California University School of Public Health. Preliminary Draft of a Sanitation Manual for Food Industries. Univ. California Press. 84 pp. (1946).

2. Association of Food Industry Sanitarians, Sanitation for the Food Preservation Industries, McGraw-Hill Pub. Co. (1952).

3. Cotton, R. T. The Insect Problems of Dried Food Storage. Proc. Inst. Food Technol. 49-53 (1945).

4. DeMartini, F. E. et al. Food Dehydration Wastes, Supplement No. 191 to the Public Health Reports, U. S. Public Health Service. 36 pp. and I-IV. (1946).

5. Eldridge, E. F., Industrial Waste Treatment and Practice, Mcgraw-Hill Pub. 401 pp. (1942).

6. Federal Security Agency, Federal Food, Drug, and Cosmetic Act and General Regulations for Its Enforcement (1939, revised March, 1949).

7. Goresline, H. E. A Discussion of Bacteriological Standards for Dehydrated Foods. Amer. Jour. Pub. Health 37, 1277-83 (Oct., 1947).

8. Jones, E. E. Disposal of Waste Waters from the Preparation of Vegetables for Drying. Jour. Soc. Chem. Indus. 64, 80-83 (1945).

9. Linsley, E. G., and Michelbacker, A. D. Insects Affecting Stored Food Products. Calif. Agr. Expt. Sta. (Berkeley) Bull. 676, 44 pp. (March 1943).

10. Parker, M. E. Food Plant Sanitation. McGraw-Hill Pub. Co., N.Y. 447 pp., illus. (1948).

11. U.S. Food and Drug Administration, Microanalytical Division. Food and Drug Circular No. 1. Microanalysis of Food and Drug Products. 171 pp. (1944).

12. Warrick, L. F. et al. Methods of Treating Cannery Waste. Nat. Canners Assoc. Bull. 28L. 91 pp. (1939).

13. Warrick, L. F. et al. Cannery Waste Disposal Lagoons. Nat. Canners Assoc. Bull. 29L, 48 pp. (April, 1945).

Microbiological Aspects of Vegetable Dehydration

Introduction: Although dried and dehydrated foods have a remarkably clean bill of health from the standpoint of food poisoning and other infections, for many years the possibility of such contamination has been considered by responsible bacteriologists and public health experts. Numerous surveys of commercial dried vegetables have been made to establish a general picture of the microbiological status of commercial dehydrating processes.

A heavy bacterial load is borne into the plant with the raw material but washing, peeling, and blanching remove or kill most of the contaminating organisms. Spores that are not removed are not killed and will survive dehydration; recontamination may occur after blanching. Viable bacteria tend to die out during storage but dehydrated vegetables are never sterile. Therefore, a considerable danger from the microbiological standpoint exists in the handling of the product during and after reconstitution.

The published surveys of dehydrated vegetables have not reported the occurrence of Clostridium botulinum, a food spoilage organism of menacing importance to food preservation. However, in some instances, related soil types have beenisolated, indicating the possibility of survival of the poison-producing botulinum organism. Experiments with vegetables inoculated with this organism were made without discovery of a trace of the organism after blanching and dehydration.

In spite of the past history and the favorable results of experiments, there remains the possibility that such bacteria will be present or gain access to the commodity during processing operations. It is therefore a prime requirement of the microbiological condition of the vegetable dehydration process that no opportunity exist for the development of bacterial toxins even if the causative organisms are present. The greatest probability of toxin formation would be from any condition in which a moist product, usually with some soil contamination, is given a heat treatment followed by prolonged holding under moderately warm conditions without access to air (as at the center of a dense mass).

Thorough washing (especially for root vegetables) and proper blanching are required to obtain a satisfactorily low level of the poison-producing organisms, and of bacteria generally. In addition to reduction of original contamination, the arresting of further development of contaminants that do exist may be accomplished by proper blanching, avoidance of in-process delay, and maintaining product temperature during dehydration above that at which a significant growth of the more common spoilage organisms will occur (usually about 122°F.). This temperature should be reached in all parts of the load before the end of the first hour of drying.

A second requirement of microbiological condition of dehydrated vegetables (also related to public health aspects of food dehydration) is the freedom from undesirable bacteria (e.g., Salmonella, Staphylococci, dysentery bacteria, etc.), irrespective of total numbers. The third requirement is the maintenance of reasonably low general bacteriological content so that no decomposition or undesirable odors or flavors develop in processing or in product reconstitution.

To meet the second and third requirements, the selection of sound raw material and maintenance of reasonably sanitary conditions at all stages of the process offer the most satisfactory means of control. Where blanching processes are used, the hot-water or steaming operation achieves a virtual sterilization of the product and bacteriological control centers on avoidance of undue recontamination thereafter. Conveyors, cooling waters (especially where recirculation occurs), workers' hands, trays, tray-loading equipment, and air-borne microorganisms may all contribute to such recontamination. With uneven tray loading and non-uniform heat distribution in dehydrators, low-temperature pockets may occur that will allow the build-up of very high microbial content and, in some cases, result in product spoilage during dehydration, even though the general temperature conditions in the dehydrator are satisfactory.

If the product is blanched on the trays that are used in the drier, much of the opportunity for recontamination may be avoided. By this means it is possible to keep bacterial flora at a very low level.

Other means of reducing the recontamination involve continuous sanitation of conveyors and use of chlorine or other sanitizing agents in cooling, conveying, and washing waters and during clean-up operations. The establishment of sanitary procedures, including the maintenance of a dust-free atmosphere, will do much to reduce recontamination of the product.

An important aspect of control of microbial organisms in dehydrated foods when served is the method of rehydration. While cooking will generally reduce bacterial content, long periods for rehydration at temperatures allowing bacterial growth can be responsible for spoilage or, possibly, development of dangerous levels of toxigenic or pathogenic organisms that may be present. The period of rehydration, in general, should not exceed four hours. A summary of the microbiological aspects of vegetable dehydration follows:

1. Raw vegetables will enter the plant with a heavy bacterial load.

2. Preparation and blanching remove or kill most of the microbes. Bacterial spores will survive blanching and dehydration.

3. Recontamination after blanching (including contamination of the dehydrated product) is the most general source of bacteria on dehydrated vegetables.

4. Improper tray loading or cool pockets in a dehydrator will allow bacterial growth during dehydration.

5. Viable bacteria tend to die out during storage but dehydrated vegetables are never sterile.

6. Rehydrated products are very perishable and should be handled accordingly.

Interpretation of Bacteriological Control Data in Appraisal of Dehydration Processes and Products

Attempts have been made to establish standards of microbial condition upon which judgment of dehydrated vegetables could be based. It seems probable that insufficient data exist at the present time for the establishment of specification limits of microbial contamination of dehydrated vegetables. However, check points for plant control can be obtained by proper interpretation of counts of total and viable bacteria, yeasts, and molds, and for specific organisms. Regardless of total counts, the presence of pathogens in dehydrated foods must be considered a potentially dangerous condition.

The magnitude of microbial counts will depend upon a number of factors, and sanitary aspects of operation may be one of the most significant. Other factors may in some cases have an overriding influence on microbial populations and, if ignored, could easily lead to misinterpretation of data. These factors include: (1) the kind and quality of raw material, (2) the pre-dehydration treatment involved in the process (peeling, washing, blanching, etc.), (3) in-process delays between operations, and (4) drying conditions (time and temperature relationships).

To illustrate: In onion dehydration, the product is not blanched and dehydration temperatures are relatively low. As a consequence, high counts of microorganisms are probably inevitable and would not necessarily reflect unsanitary conditions. Another product, such as sweetpotatoes, may be blanched (reducing contamination essentially to zero), and be dehydrated at product temperatures up to 160°F. (partially destroying and preventing development of organisms of post-blanch recontamination). In this case, very low counts would be found even under poor sanitary conditions. Non-uniform heat distribution in dehydrators and uneven or over-loading of trays may result in pockets of relatively low product temperature in early stages of drying that can lead to very rapid development of bacterial growth. Resultant high counts could not be materially altered by improvement in general plant sanitation.

While there is much room for exception, the presence of coliform organisms has common use as presumptive evidence of fecal contamination. Conversely, the absence of coliforms has been used as a demonstration of freedom from such contamination. This interpretation is probably not valid for onion products, since evidence has been presented that a principle in raw onions is selectively toxic toward *Escherichia coli* and some other organisms.

A significant reduction of viable organisms will occur on storage of dehydrated foods; the decrease will be greater the higher the storage temperature and most pronounced in the first weeks of storage. Low bacterial counts after an indeterminate storage period would not necessarily indicate low initial counts. High counts relative to variables of raw material and process might represent less than the best of handling and could lead to earlier spoilage on reconstitution.

The most valuable use of microbial counts would be to control operations under a given set of processing conditions. Unusual build-up of organisms following any unit operation would point to a likely place to improve sanitary procedures.

Higher counts following dehydration could point to non-controlled drying conditions in the tunnel, possibly related to uneven or too heavy tray loading or inadequate heat input.

Methods of Measuring Microbial Contamination on Dehydrated Vegetables and Processing Equipment

The person responsible for sanitation in vegetable dehydration plants should be versed in bacteriological techniques or have access to professional assistance. The application of these techniques to vegetable dehydration operations is presented below in sufficient detail to serve as a working basis for microbial control of product and process for the dehydration of vegetables.[4]

Method of Sampling: Microorganisms are not evenly distributed throughout dehydrated vegetable products; consequently different portions of the same lot may show appreciable variations in bacterial count. Nevertheless, faulty plant practices or lack of sanitation will almost always be reflected in the microbial content of all portions of the finished product.

The portion of the product intended as a sample should be taken from a larger quantity which has been mixed as thoroughly as possible. Mixing may be done with a clean, sterilized instrument such as a large spoon. The sample for bacteriological analysis should never be touched by hand, but should be placed in the sample container by means of sterile forceps or a spoon. The container should be treated by flaming the interior surfaces over a Bunsen burner. Where the latter is not available, containers should be passed through the blancher for 10 minutes and placed in the dry end of the dehydrator to dry.

Samples should be protected against the entrance of moisture and contamination by sealing. The containers should be labeled with date of pack and code number, while any special factor which might have a bearing on the microbial content should be indicated.

Viable Microbial Counts: I. Dehydrated vegetables:

A. Leafy vegetables--

1. Aseptically weigh 10 gm. of sample into a sterile screw-top pint jar and add 190 ml. of sterile water. Replace screw cap and allow to rehydrate for 2 hours at room temperature, but not to exceed 70°F.

2. At the end of this period shake thoroughly for 2 minutes.[5]

4/ These methods have been compiled from the following references, cited on page 12: Reference numbers 1, 5, 14, 21, and 24.

5/ An alternate method would be to blend samples in sterile water for 2 minutes in an electrically operated blender. Cost of equipment and difficulty of achieving a working sterility in blender cups are reasons cited for not using this method. It remains controversial whether a higher recovery of viable organisms can be obtained by use of this alternate method.

3. (a) Prepare suitable dilutions from the above 1:20 dilution according to the procedures given in Standard Methods for the Examination of Dairy Products,6/ and pour plates for total viable yeast and mold counts, using Difco Malt Extract Agar containing 30 gm. of agar per liter and adjusted to a pH of 3.5. (b) Incubate at 32°C. for 5 days, observing the usual practices described in Standard Methods for the Examination of Dairy Products,6/ and report the counts as numbers of yeasts or molds per gm. of dehydrated product. (c) Pour plates for total viable bacterial counts according to Standard Methods for the Examination of Dairy Products,6/ using Tryptone Glucose Extract Agar. (d) Incubate plates for 48 hours at 32°C. and report the count as numbers of bacteria per gram of dehydrated product.

B. Root vegetables--
Procedures for examination of dried or dehydrated root vegetables should follow those outlined for leafy vegetables except that it is desirable to permit the original dilution to stand overnight at refrigeration temperatures (32°-36°F.) to permit the sample to rehydrate before proceeding with the shaking of the sample and preparing subsequent dilutions.

Direct Microscopic Counts: In order to establish the sanitary history of the samples of dehydrated fruits or vegetables, prepare slides for direct microscopic examination according to the method outlined in the Standard Methods for the Examination of Dairy Products.6/

The liquid should be taken from the jar in which the sample was rehydrated after settling in order to avoid debris, spread on the slide, stained and examined according to the above methods. Report as microorganisms observed per gm. of dehydrated product.

Thermophilic Bacterial Counts: Further information on the microbial contamination of dehydrated vegetables may be provided by a count of thermophilic bacteria. This count is determined as described above for the viable microbial count, with the exception that the plates are incubated at 55°C. (131°F.) for 48 hours.

Coliform Bacteria: As a presumptive index of sanitary practice it may be advisable to determine the presence and numbers of coliform bacteria. From the 1:20 dilution, five 2-ml. portions, each representing 0.1 gram of product, are pipetted into a similar number of fermentation tubes containing 2 percent brilliant green bile broth for the coliform presumptive test. Tubes are incubated at 37°C. (98.6°F.) and observed at intervals over 48 hours. When gas formation is observed, a streak inoculation is made from the liquid over the surface of a plate of eosin methylene blue agar. After 18 to 24 hours' incubation at 37°C., plates are examined for the presence of colonies characteristic of the coliform group. In doubtful cases, one or more colonies from the eosin methylene blue plate should be transferred to a nutrient agar slant and a tube of lactose broth, which are incubated at 37°C. Formation of gas in the lactose broth and the demonstration, by microscopical examination, of Gram-negative, non-spore-forming, rod-shaped bacteria and the absence of spore-forming bacilli, indicate the presence of coliform bacteria.

6/ See reference No. 3, page 13.

Supplementary Plant Tests: In addition to the bacteriological procedures outlined above, a number of plant tests have been developed with the object of providing operators of dehydration plants with a simple method of estimating the approximate degree to which the products are contaminated. These tests are based on the fact that bacteria growing in vegetable products cause changes which can be detected by simple procedures. Within certain limits the extent of such changes is proportional to the bacteria content.

(1) Titratable Acidity Test: Ten grams of dried product are weighed into a sterile pint jar or other suitable container and rehydrated for 2 hours at room temperature with 190 ml. of sterile, or freshly boiled and cooled, water. After shaking for 2 minutes, 10 ml. of liquid is withdrawn by pipette and titrated against 0.1N sodium hydroxide, with 5 drops of a 1-percent alcoholic phenolphthalein solution used as indicator. The product is then held at room temperature for 12 hours. Then a second titration is made with 10 ml. of liquid, and the results are compared with those of the first titration.

An increase in titratable acidity, the significant value for which varies with the product, usually indicates a high microbial content. On the other hand, a product with a high plate count may show no appreciable increase in acidity due to the predominance of non-acid-forming bacteria. In such cases the presence of large numbers of bacteria may be detected by direct microscopical examination, or by the odor test. Usually the latter is sufficient, since large numbers of non-acid-forming types produce off-odors.

(2) Turbidity Test: The turbidity test has been found to be particularly applicable to dehydrated potatoes. The product is rehydrated as for the titratable acidity test. After the 12-hour holding period, a small quantity of liquid is poured off and examined. The degree of turbidity that has developed during this time is proportional to the original bacterial contamination.

(3) Utensil and Equipment Sanitation Test: With a sterile swab, moistened with sterile Butterfields' phosphate solution, 7/ scrub a 4-square-inch area guided by a sterile template having a central opening of 1x4-inch dimensions, and made of medium-gauge stainless steel. Break off swab aseptically into a 99-ml. dilution blank. For immediate dilution, prepare by vigorous shaking by hand (approximately 100 times) until the cotton swab becomes untangled from the end of the applicator stick. The shaken sample, considered as a 10^{-2} dilution, is then plated out in appropriate dilutions, and agar media is used as explained above for viable microbial counts, thermophilic counts, and coliform organisms.

Literature Cited

Microbiology

1. American Public Health Assoc., Committee on Standard Methods for the Microbiological Examination of Foods. Methods for the Microbiological Examination of Foods, Amer. Jour. Pub. Health 39(5):83-5 (May, 1949) (Yearbook 1948-49).

2. American Public Health Association, Committee on Food. Public Health Aspects of Dehydrated Foods, Amer. Jour. Pub. Health 36(3):248-60 (March, 1946).

7/ Reference 4, page 13.

3. American Public Health Association. Standard Methods for the Examination of Dairy Products. 9th Ed., 373 pp. (1948).

4. Butterfield, C. T., The Selection of a Dilution Water for Bacteriological Examination, Jour. Bact. 23, 355-68 (1932).

5. Canadian Dept. Agr., Division of Bacteriology and Dairy Research. Methods for the Bacteriological Analysis of Dehydrated Vegetables (July, 1945).

6. Clague, J. A., Microbiological Examination of Dried Foods, Food Res. 1(1): 45-59 (Jan.-Feb., 1936).

7. Fidler, J. C., Pre-cooked, Roller Dried Soup Powder (Jan., 1943). V, Bacterial Procedures, Gt. Brit. Dept. Sci. and Indus. Res., Ministry of Food. Dehydration VII, 1 (1943).

8. Goresline, H. E. Bacteriological Standards for Dehydrated Foods. Food Mfr. 24(4):171-73 (April, 1949). (Abstract of a paper presented before American Public Health Assoc.).

9. Haines, R. B. The Bacteriology of Dehydrated Foodstuffs (Jan., 1943). Gt. Brit. Dept. Sci. and Indus. Res., Ministry of Food. Dehydration IX, 1 (1943).

10. Haines, R. B., and Elliott, E. M. L. Some Bacteriological Aspects of Dehydrated Foods, Jour. Hygiene 43(6):370-81 (1944).

11. Hucker, G. J., et al., The Sanitation of Food Plants, New York Agr. Expt. Sta. (Geneva), 63rd. Ann. Rept. pp. 12-13 (1943-44).

12. Johns, C. K., Bacteriological Analysis of Edible Gelatin, Food Res. 16(3): 281-87 (May-June, 1951).

13. Jones, A. H., The Microbiological Aspects of Dehydrated Vegetables and Fruits, Food in Canada 3(7):16-18 (July, 1943).

14. Jones, A. H., and Ferguson, W. E., A Study of Preparing Food Products for Microbiological Analysis, Food Res. 16(2):126-32 (1951).

15. Kintner, J. H., and DeLay, P. D., Sanitation Aspects of Dehydrated Vegetables. U.S. Army Vet. Bull. 37(1):12-19 (1943).

16. Prescott, S. C., Some Bacteriological Aspects of Dehydration, Jour. Bact. 5, 109-125 (1920).

17. Prescott, S. C., What Should be the Basis of Control of Dehydrated Foods, Amer. Jour. Pub. Health 10, 324-26 (1920).

18. Prescott, S. C. et al., Bacteria and Moulds in Dehydrated Vegetables. Amer. Food Jour. 17(6):11-16 (June, 1922).

19. Rishbeth, J., The Bacteriology of Dehydrated Vegetables, Jour. Hygiene 45, 33-45 (1947).

20. Vaughn, R. H., Microbiological Survey, Fruit Prod. Jour. 24(7):196-97 (1945).

21. Vaughn, R. H., The Microbiology of Dehydrated Vegetables, Food Res. 16, 429-38 (1951).

22. Vaughn, R. H., and Kueneman, R. W., Preliminary Report on Microbiological Survey of Dehydration Plants in the Pacific Northwest Producing Food Products on Army Contracts (manuscript unpublished, Jan., 1945).

23. Vaughn, R. H., and Olson, R. L., Suggestions for Improvement in Date Packing Plant Sanitation. Date Growers Inst. Rept., Indio, Calif., pp. 28-32 (1947).

24. Vaughn, R. H., and Stadtman, T., A Method for Control of Sanitation in Food Processing Plants, Amer. Jour. Pub. Health 35(12):1292-96 (Dec., 1945).