Emission Factor Documentation for AP-42
Section 9.8.2

Dehydrated Fruits and Vegetables

Final Report

For U. S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Emission Factor and Inventory Group

EPA Contract 68-D2-0159
Work Assignment No. II-03

MRI Project No. 4602-03

September 1995

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Research Triangle Park, NC 27711

Attn: Mr. Dallas Safriet (MD-14)

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NOTICE

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PREFACE

This report was prepared by Midwest Research Institute (MRI) for the Office of Air Quality Planning and Standards (OAQPS), U. S. Environmental Protection Agency (EPA), under Contract No. 68-D2-0159, Work Assignment No. II-03. Mr. Dallas Safriet was the requester of the work.

Approved for:

MIDWEST RESEARCH INSTITUTE

Roy Neulicht
Program Manager
Environmental Engineering Department

Jeff Shular
Director, Environmental Engineering
Department

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1. INTRODUCTION

The document *Compilation of Air Pollutant Emission Factors* (AP-42) has been published by the U. S. Environmental Protection Agency (EPA) since 1972. Supplements to AP-42 have been routinely published to add new emission source categories and to update existing emission factors. AP-42 is routinely updated by EPA to respond to new emission factor needs of EPA, State and local air pollution control programs, and industry.

An emission factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. Emission factors usually are expressed as the weight of pollutant divided by the unit weight, volume, distance, or duration of the activity that emits the pollutant. The emission factors presented in AP-42 may be appropriate to use in a number of situations, such as making source-specific emission estimates for areawide inventories for dispersion modeling, developing control strategies, screening sources for compliance purposes, establishing operating permit fees, and making permit applicability determinations. The purpose of this report is to provide background information from test reports and other information to support preparation of AP-42 Section 9.8.2, Dehydrated Fruits and Vegetables.

This background report consists of five sections. Section 1 includes the introduction to the report. Section 2 gives a description of the dehydrated fruit and vegetable industry. It includes a characterization of the industry, a description of the different process operations, a characterization of emission sources and pollutants emitted, and a description of the technology used to control emissions resulting from these sources. Section 3 is a review of emission data collection (and emission measurement) procedures. It describes the literature search, the screening of emission data reports, and the quality rating system for both emission data and emission factors. Section 4 details emission factor development for dehydrated fruits and vegetables. It includes the review of specific data sets and a description of how candidate emission factors were developed. Section 5 presents the AP-42 Section 9.8.2, Dehydrated Fruits and Vegetables.

2. INDUSTRY DESCRIPTION

This section provides a brief review of the trends in the dehydrated fruits and vegetables industry and an overview of the dehydrated fruit and vegetable production process. No emission data exist for the dehydrated fruit and vegetable industry.

2.1 INDUSTRY CHARACTERIZATION[1-3]

Dehydration of fruit and vegetables (SIC 2034) is one of the oldest forms of food preservation techniques known to man and consists primarily of establishments engaged in sun-drying or artificially-dehydrating fruits and vegetables. "Dehydrated" fruits and vegetables are generally defined as food that has had its moisture content reduced to a level below which microorganisms can grow (8 to 18 percent moisture). "Dried" fruit and vegetables are defined as food that has had a reduction in moisture content in general, and has moisture contents below 30 percent. The moisture content of most dehydrated food is below 20 percent, and depends on the drying process used. Intermediate-moisture or semi-moist foods contain 15 to 30 percent moisture. Most fruit is dried using sun or solar drying, while most vegetables are dried using continuous forced-air processes.

In 1987, there were 131 companies involved in the dehydrated fruits, vegetables, and soups industry. These companies produced over 1.4 billion dollars in inventory and employed approximately 10,100 people. These figures were a decrease from 1982, where 151 companies employed 13,600 people. Fifty percent of the producers of dehydrated fruits and vegetables were located in California in 1987. Another 26 percent of the producers were located in (in descending order) Oregon, Idaho, Washington, New Jersey, Illinois, Pennsylvania, and Connecticut.

Although food preservation is the primary reason for dehydration, dehydration of fruits and vegetables also lowers the cost of packaging, storing, and transportation by reducing both the weight and volume of the final product. The reduction in bulk and weight is particularly attractive to campers and backpackers. Given the improvement in the quality of dehydrated foods, along with the increased focus on instant and convenience foods, the potential for increased production of dehydrated fruits and vegetables is high.

2.2 PROCESS DESCRIPTION[1-2]

Dried or dehydrated fruits and vegetables can be produced by a variety of processes. These processes differ primarily by the type of drying method used, which depends on the type of food and the type of characteristics of the final product. In general, dried or dehydrated fruits and vegetables undergo the following process steps: predrying treatments, such as size selection, peeling, and color preservation; drying or dehydration, using natural or artificial methods; and postdehydration treatments, such as sweating, inspection, and packaging. Figure 2-1 shows a flow diagram for a typical fruit or vegetable dehydration process. In general, *dried* refers to all dried products, regardless of the method of drying, and *dehydrated* refers to products that use mechanical equipment and artificial heating methods (as opposed to natural drying methods) to dry the product.

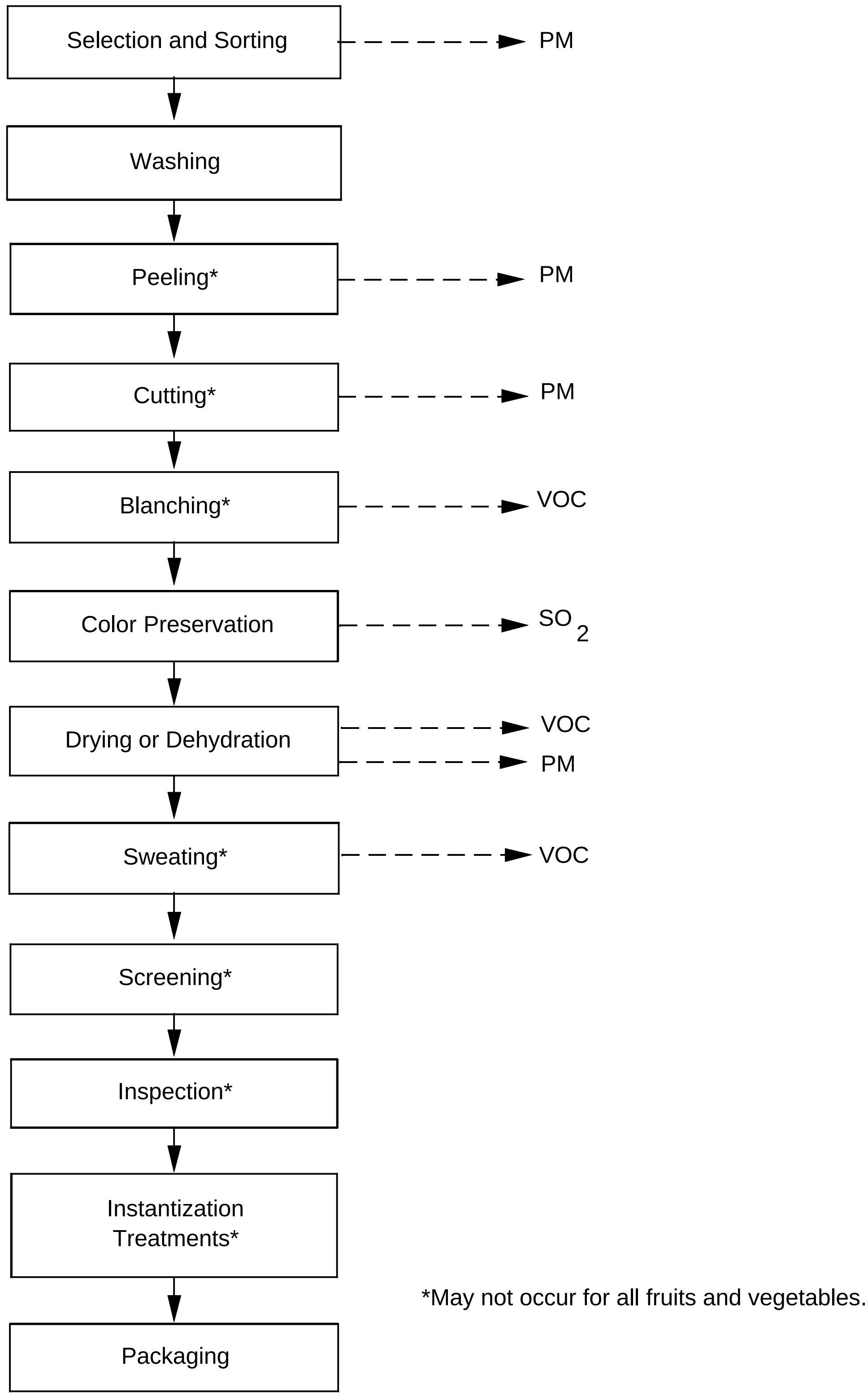

Figure 2-1. General flow diagram for dehydration of fruits and vegetables.

2.2.1 Predrying Treatments

Predrying treatments prepare the raw fruits and vegetables for the dehydration process, and include raw product preparation and color preservation. Most fruits and vegetables follow similar raw product preparation steps, although the peeling and the blanching steps may be specific to the type of fruit or vegetable that is being prepared. The color preservation method differs for fruits and vegetables, with most fruits using sulfur dioxide (SO_2) gas and most vegetables using sulfite solutions.

2.2.1.1 Raw Product Preparation. Raw product preparation prepares the raw fruit or vegetable for the color preservation step. Preparation includes selection and sorting, washing, peeling (some fruits and vegetables), cutting into appropriate forms, and blanching for some fruits and vegetables. The initial step involved in the common predrying treatments for fruits and vegetables is selection and sorting for size, maturity, and soundness. The raw product is then washed to remove dust, dirt, insect matter, mold spores, plant parts, and other material that might contaminate or affect the color, aroma, or flavor of the fruit or vegetable. Peeling or removal of any undesirable parts follows washing. Methods used for peeling fruits and vegetables for dehydrating include hand peeling (not generally used due to high labor cost), lye solution, dry caustic and mild abrasion, steam pressure, high pressure washers, or flame peelers. For fruits that are commonly dehydrated, only apples, pears, bananas, and pineapples are usually peeled prior to dehydration. Vegetables normally peeled include beets, carrots, parsnips, potatoes, onions, and garlic. Except for potatoes, onions, and garlic, the specific method of peeling is not identified for individual fruits and vegetables. Potatoes are commonly peeled using dry caustic and mild abrasion. Onions and garlic are peeled by either high-pressure washers or flame peelers. Prunes and grapes are dipped in an alkali solution to remove the waxy surface coating which enhances the drying process. Next, the product is cut into the appropriate shape or form (i.e., halves, wedges, slices, cubes, nuggets, etc.), although some items, such as cherries and corn, may by-pass this operation. Some fruits and vegetables are blanched, which inactivates the enzymes by heating. Fruits and vegetables are blanched by immersion in hot water (95° to 100°C [203° to 212°F] for a few minutes or exposure to steam.

2.2.1.2 Color Preservation. The final step in the predehydration treatment is color preservation, also known as sulfuring. The majority of fruits are treated with SO_2 for its antioxidant and preservative effects. The presence of SO_2 is very effective in retarding the browning of fruits, which occurs when the enzymes are not inactivated by the sufficiently high heat normally used in drying. Sun-dried fruits (e.g., apricots, peaches, raisins, and pears) are usually exposed to the fumes of burning elemental sulfur before being put out in the sun to dry. In addition to preventing browning, SO_2 treatment reduces the destruction of carotene and ascorbic acid, which are the important nutrients for fruits. Sulfuring dried fruits must be closely controlled so that enough sulfur is present to maintain the physical and nutritional properties of the product throughout its expected shelf life, but not be so large that it adversely affects flavor. Some fruits, such as apples, are treated with solutions of sulfite (sodium sulfite and sodium bisulfite in approximately equal proportions) before dehydration. Sulfite solutions are less suitable for fruits than burning sulfur (SO_2 gas), however, because the solution penetrates the fruit poorly and can leach natural sugar, flavor, and other components from the fruit.

Although dried fruits commonly use SO_2 gas to prevent browning, this treatment is not practical for vegetables. Instead, most vegetables (potatoes, cabbage, and carrots) are treated with sulfite solutions to retard enzymatic browning. In addition to color preservation, the presence of a small amount of sulfite in blanched, cut vegetables improves storage stability and makes it possible to increase the drying temperature during dehydration, thus decreasing drying time and increasing the drier capacity without exceeding the tolerance for heat damage.

Sulfur (as SO_2 or sulfite) is the most widely used compound to prevent browning of fruits and vegetables, but it can cause equipment corrosion, induce off-flavors, destroy some important nutrients, such as vitamin B_1, and is not approved in some countries. Therefore, several alternative methods of color preservation have been investigated. These include lowering pH by using citric or other organic acids, rapid dehydration to very low water contents, use of other antioxidants (e.g., ascorbic acid, tocopherols, cysteine, and glutathione), heat inactivation or individual quick blanching, reduction of the water activity (osmotic treatment), and the centrifugal fluidized bed (CFB) process.

The most commonly used sulfur-alternative treatments for fruits are osmotic treatment and the CFB process. In osmotic treatment, fruit pieces, slices, and chunks are exposed to concentrated sugar syrup (dry syrup) or to salt to remove the water from the fruit by osmosis. The partially dehydrated fruit piece is then further dried using conventional dehydration techniques (most commonly in a vacuum shelf drier). Fruits that have successfully used the osmotic treatment are apples, peaches, bananas, mangos, and plantains. Advantages of osmotic treatment are reduced exposure time to high temperature, minimized heat damage to color and flavor, reduced loss of fresh fruit flavor, and removal of some fruit acid by the osmosis process. However, the removal of fruit acid and addition of sugar may be disadvantages in certain products. In the CFB process, blanching and an approximate 50 percent reduction in water can be achieved in less than 6 minutes. This treatment can then be followed by any conventional dehydration process. This process eliminates the disadvantages associated with the addition of sugar or salt to the product during osmotic treatment and been successfully use in diced apples. Advantages of the CFB treatment include simplicity of design and an intimate gas-to-particle conduction that provides uniform particle exposure without mechanical agitation. However, the CFB process is limited to small (one-half inch or smaller) cubes.

2.2.2 Drying or Dehydration

Drying or dehydration is the removal of the majority of water contained in the fruit or vegetable and is the primary stage in the production of dehydrated fruits and vegetables. Several drying methods are commercially available and the selection of the optimal method is determined by quality requirements, raw material characteristics, and economic factors. There are three types of drying processes: sun and solar drying; atmospheric dehydration including stationary or batch processes (kiln, tower, and cabinet driers) and continuous processes (tunnel, continuous belt, belt-trough, fluidized-bed, explosion puffing, foam-mat, spray, drum, and microwave-heated driers); and subatmospheric dehydration (vacuum shelf, vacuum belt, vacuum drum, and freeze driers).

2.2.2.1 Sun and Solar Drying. Sun drying (used almost exclusively for fruit) and solar drying (used for fruit and vegetables) of foods use the power of the sun to remove the moisture from the product. Sun drying of fruit crops has remained largely unchanged from ancient times in many parts of the world, including the United States. It is limited to climates with hot sun and dry atmosphere, and to certain fruits such as prunes, grapes, dates, figs, apricots, and pears. These crops are processed in substantial quantities without much technical aid by simply spreading the fruit on the ground, racks, trays, or roofs and exposing them to the sun until dry. Advantages of this process are its simplicity and its small capital investment. Disadvantages include complete dependence on the elements and moisture levels no lower than 15 to 20 percent (corresponding to a limited shelf life). Solar drying utilizes black-painted trays, solar troughs, and mirrors to increase solar energy and accelerate drying. Indirect solar driers collect solar energy in collectors that, in turn, heats the air as it blows over the collection unit before being channeled into the dehydration chamber. In commercial applications, solar energy is used alone or may be supplemented by an auxiliary energy source, such as geothermal energy.

2.2.2.2 Atmospheric Dehydration. Atmospheric forced-air driers artificially dry fruits and vegetables by passing heated air with controlled relative humidity over the food to be dried, or by passing the food to be dried through the heated air. Various devices are used to control air circulation and recirculation. Stationary or batch processes include kiln, tower (or stack), and cabinet driers. Kiln driers utilize the natural draft from rising heated air to dry the product and are the oldest and simplest type of dehydration equipment still in commercial use. Tower or stack driers consist of a furnace room containing a furnace, heating pipes, and cabinets in which trays of fruits or vegetables are dried. In a typical design, each tower or stack holds approximately 12 trays and a furnace room holds about 6 stacks. Heated air from the furnace rises through the trays holding the product. As the trays of food at the bottom are dried, they are removed. All trays are then shifted downward and freshly loaded trays are inverted at the top. Cabinet driers are similar in operation to a tower drier, except that the heat for drying is supplied by steam coils located between the trays. This design provides some temperature control and uniformity, and thus represents an improvement over the tower drier. However, cabinet driers are suitable only for establishing the drying characteristics of a new product or for high-valued raw materials, such as bananas or mushrooms, due to small capacity and high operating costs.

Continuous processes include tunnel, continuous belt, belt-trough, fluidized-bed, explosion puffing, foam-mat, spray, drum, and microwave-heated driers. Tunnel driers are the most flexible and efficient dehydration system used commercially, and is widely used in drying fruits and vegetables. The equipment is similar to a cabinet drier, except that it allows a continuous operation along a rectangular tunnel through which tray-loaded trucks move. The tunnel is supplied with a current of heated air that is introduced at one end. Fruits and vegetables of almost any size and shape can (so long as they are solids) be successfully dried in a truck-and-tray tunnel drier. Continuous belt or conveyor driers are similar to tunnel driers, except that the food is conveyed through a hot air system on a continuous moving belt without the use of trays. This difference eliminates the costly handling of the product on trays before and after drying and allows continuous operation and automatic feeding and collection of the dried material. Belt-trough driers have a continuous stainless steel wire mesh belt that forms a trough about 10 feet (ft) in length and 4 ft wide. The raw material is fed onto one end of the trough and is dehydrated by forcing hot air upward across the belt and the product. Fluidized-bed driers, a modification of the belt-trough drier, uses heated airflow from beneath the bed to lift the food particles and at the same time convey them toward the outlet. However, if the air velocity becomes too great, channeling will occur and most of the air will escape without performing its function; therefore, fluidized-bed driers are limited to the preparation of food powders. In explosion puffing, fruit pieces (e.g., blueberries) are partially dehydrated in a conventional manner and then heated in a closed vessel, known as a gun because of its quick-opening lid. Pressure is built-up in the vessel to a specific level and the closure is then released, causing the pieces to expand by sudden volatilization of internal mositure. The fruit particles are then dried to 4 to 5 percent moisture content by conventional drying methods. Foam-mat drying involves drying liquid or pureed materials as a thin layer of stabilized foam by heating air at atmospheric pressure. The prepared foam is spread on perforated trays and dried by hot air, followed by crushing into powder. Spray driers involve the dispersion of liquid or slurry in a stream of heated air, followed by collection of the dried particles after their separation from the air. This process is widely used to dehydrate fruit juices. In drum driers, a thin layer of product is applied to the surface of a slowly revolving heated drum. In the course of approximately 300° of a full revolution, the moisture is flashed off, and the dried material is scraped off the drum by a stationary or reciprocating blade. Drum driers are generally heated from within by steam and are suitable for a wide range of liquid, slurried, and pureed products. Microwave driers have been tried experimentally for the dehydration of fruits, but no commercial installations are in place.

2.2.2.3 Subatmospheric Dehydration. Subatmospheric (or vacuum) dehydration occurs at low air pressures and includes vacuum shelf, vacuum drum, vacuum belt, and freeze driers. The main purpose of vacuum drying is to enable the removal of moisture at less than the boiling point under ambient conditions. Because of the high installation and operating costs of vacuum driers, this process is used for drying raw material that may deteriorate as a result of oxidation or may be modified chemically as a result of exposure to air at elevated temperatures. All vacuum-drying systems have the following essential components: vacuum chamber, heat supply, vacuum-producing unit, and a device to collect water vapor as it evaporates from the food. All vacuum driers must also have an efficient means of heat transfer to the product in order to provide the necessary latent heat of evaporation and means for removal of vapor evolved from the product during drying.

There are two categories of vacuum driers. In the first category, moisture in the food is evaporated from the liquid to the vapor stage and includes vacuum shelf, vacuum drum, and vacuum belt driers. Vacuum shelf driers and drum driers are batch-type driers and are suitable for a wide range of fruits and vegetables (e.g., liquids, powders, chunks, slices, wedges, etc.). Vacuum belt driers are continuous-type driers suitable for food pieces, granules, and discrete particles. It operates at a relatively high vacuum and has a capital cost much higher than a batch-type unit of similar operating capacity. In the second category of vacuum driers, the moisture of the food is removed from the product by sublimination, which is converting ice directly into water vapor. The advantages of freeze drying are high flavor retention, maximum retention of nutritional value, minimal damage to the product texture and structure, little change in product shape and color, and a finished product with an open structure that allows fast and complete rehydration. Disadvantages include high capital investment, high processing costs, and the need for special packing to avoid oxidation and moisture gain in the finished product.

2.2.3 Postdehydration Treatments

Treatments of the dehydrated product vary according to the type of fruit or vegetable and the intended use of the product. These treatments may include sweating, screening, inspection, instantization treatments, and packaging. Sweating involves holding the dehydrated product in bins or boxes to equalize the moisture content. Screening removes dehydrated pieces of unwanted size, usually called "fines." The dried product is inspected to remove foreign materials, discolored pieces, or other imperfections such as skin, carpel, or stem particles. Instantization treatments are used to improve the rehydration rate of the low-moisture product and include compressing the product after dehydration (flaking) and/or perforating the product after it is partially dehydrated and then dehydrating the perforated segments to the desired moisture level (used primarily for apples).

Packaging is common to most all dehydrated products and has a great deal of influence on the shelf life of the dried product. Packaging of dehydrated fruits and vegetables must protect the product against moisture, light, air, dust, microflora, foreign odor, insects, and rodents; provide strength and stability to maintain original product size, shape, and appearance throughout storage, handling, and marketing; and consist of materials that are approved for contact with food. Cost is also an important factor in packaging. Package types include cans, plastic bags, drums, bins, and cartons, depending on the end-use of the product.

2.3 EMISSIONS[1,4-6]

Air emissions may arise from a variety of sources in the dehydration of fruits and vegetables. Particulate matter (PM) emissions may result mainly from solids handling, solids size reduction, and drying. Some of the particles are dusts, but other are produced by condensation of vapors and may be in the low-micrometer or submicrometer particle-size range.

The VOC emissions may potentially occur at almost any stage of processing, but most usually are associated with thermal processing steps, such as blanching, drying or dehydration, and sweating. Particulate matter and condensable materials may interfere with the collection or destruction of these VOC. The condensable materials also may be malodorous. The color preservation (sulfuring) stage can produce SO_2 emissions as the fruits and vegetables are treated with SO_2 gas or sulfide solution to prevent discoloration or browning.

Wastewater treatment ponds may be another source of VOC, even from processing of materials that are not otherwise particularly objectionable. Details on the processes and technologies used in wastewater collection, treatment, and storage are presented in AP-42 Section 4.3. That section should be consulted for detailed information on the subject.

No emission data quantifying VOC, HAP, or PM emissions from the dehydrated fruit and vegetable industry are available for use in the development of emission factors. However, some data have been published on VOC emitted during the blanching process. Van Langenhove, et al., identified volatiles emitted during the blanching process of Brussels sprouts and cauliflower in laboratory and industrial conditions. The data represent only the relative concentration of compounds in the vapors from the rotary blanching drum and cannot be used for estimating emission factors. Aldehydes were the most abundant volatiles from cauliflower and isothiocyanates and nitriles were the most abundant from Brussels sprouts. In the industrial blanching process for cauliflower, a total of nine compounds were identified: four aldehydes, three isothiocyanates, one nitrile, and one organodisulfide. Nonanal was present at a relative concentration of 50.6 percent; the only other compounds greater than 10 percent were octanal (11.8 percent) and hexanal (10.7 percent). In the industrial blanching process for Brussels sprouts, a total of 12 compounds were identified: 5 aldehydes, 3 organosulfur compounds, 2 isothiocyanates, and 2 nitriles. But-2-enenitrile was present at a relative concentration of 61.1 percent followed by pent-4-enenitrile at a concentration of 28.5 percent. None of the other compounds were present at concentrations greater than 3 percent.

In addition, Buttery, et al., performed a quantitative study on aroma volatiles from fresh tomatoes, listing approximately thirteen volatiles with concentrations ranging from 0.005 to 5.2 parts per million (ppm). These findings cannot be used to estimate emission factors, however, because they represent relative compound concentrations and not actual emissions.

2.4 EMISSION CONTROL TECHNOLOGY[7]

A number of VOC and particulate emission control techniques are available to the dehydrated fruit and vegetable industry. No information is available on the actual usage of emission control devices in this industry. The following discussion focuses on control methods that are potentially applicable to this industry. Potential options include the traditional approaches of wet scrubbers, dry sorbents, and cyclones. Other options include condensation and chemical reaction. The specific type of control device or combination of devices will vary from facility to facility depending upon the particular nature of the emissions and the pollutant loading in the gas stream.

Control of VOC from a gas stream can be accomplished using one of several techniques but the most common methods are absorption and adsorption. Absorptive methods encompass all types of wet scrubbers using aqueous solutions to absorb the VOC. The most common scrubber systems are packed columns or beds, plate columns, spray towers, or other types of towers. Gas absorption is a diffusion controlled, gas-liquid mass transfer process. Most scrubber systems require a mist eliminator downstream of the scrubber.

Adsorptive methods could include one of four main adsorbents: activated carbon, activated alumina, silica gel, or molecular sieves. Of these four, activated carbon is the most widely used for VOC control while the remaining three are used for applications other than pollution control. Gas adsorption is a relatively expensive technique and may not be applicable to a wide variety of pollutants. The adsorbent is regenerated by heating or use of steam, which gives rise to new emissions to be controlled.

Particulate control commonly employs methods such as venturi scrubbers, dry cyclones, wet or dry electrostatic precipitators (ESPs), or dry filter systems. The most common controls are likely to be the venturi scrubbers or dry cyclones. Wet or dry ESPs could be used depending upon the particulate loading of the gas stream. These three systems are commonly used for particulate removal in many types of processing facilities.

Condensation methods and scrubbing by chemical reaction may be applicable techniques depending upon the type of emissions. Condensation methods may be either direct contact or indirect contact with the shell and tube indirect method being the most common technique. It also offers heat recovery as a bonus for certain applications. Chemical reactive scrubbing may be used for odor control in selective applications. The major problem with this technique is that it is very specific.

REFERENCES FOR SECTION 2

1. L. P. Somogyi and B. S. Luh, "Dehydration of Fruits," *Commercial Fruit Processing*, Second Ed., J. G. Woodroof and B. S. Luh, Editors. AVI Publishing Company, Inc., 1986.

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3. *1987 Census of Manufactures: Preserved Fruits and Vegetables*, U.S. Department of Commerce, Bureau of Census, 1990.

4. J. L. Jones, et al., "Overview of Environmental Control Measures and Problems in the Food Processing Industries." Industrial Environmental Research Laboratory, Cincinnati, Ohio, K. Dostal, Food and Wood Products Branch. Grant No. R804642-01, January 1979.

5. H. J. Van Langenhove, et al., "Identification of Volatiles Emitted During the Blanching Process of Brussels Sprouts and Cauliflower." Journal of the Science of Food and Agriculture, 55:483-487, 1991.

6. R. G. Buttery, et al., "Fresh Tomato Aroma Volatiles: A Quantitative Study." J. Agric. Food Chem, 35(4):540-544, 1987.

7. H. J. Rafson, "Odor Emission Control for the Food Industry." Food Technology, June 1977.

3. GENERAL DATA REVIEW AND ANALYSIS PROCEDURES

3.1 LITERATURE SEARCH AND SCREENING

Data for this investigation were obtained primarily through literature searches. Because this is a new section, the AP-42 background files located in the Emission Factor and Inventory Group (EFIG) did not contain any information on the industry, processes, or emissions. Information on the industry was also obtained from the *Census of Manufactures*. In addition, representative trade associations were contacted for assistance in obtaining information about the industry and emissions.

To screen out unusable test reports, documents, and information from which emission factors could not be developed, the following general criteria were used:

1. Emission data must be from a primary reference:

a. Source testing must be from a referenced study that does not reiterate information from previous studies.

b. The document must constitute the original source of test data. For example, a technical paper was not included if the original study was contained in the previous document. If the exact source of the data could not be determined, the document was eliminated.

2. The referenced study should contain test results based on more than one test run. If results from only one run are presented, the emission factors must be down rated.

3. The report must contain sufficient data to evaluate the testing procedures and source operating conditions (e.g., one-page reports were generally rejected).

A final set of reference materials was compiled after a thorough review of the pertinent reports, documents, and information according to these criteria.

3.2 DATA QUALITY RATING SYSTEM[1]

As part of the analysis of the emission data, the quantity and quality of the information contained in the final set of reference documents were evaluated. The following data were excluded from consideration:

1. Test series averages reported in units that cannot be converted to the selected reporting units;

2. Test series representing incompatible test methods (i.e., comparison of EPA Method 5 front half with EPA Method 5 front and back half);

3. Test series of controlled emissions for which the control device is not specified;

4. Test series in which the source process is not clearly identified and described; and

5. Test series in which it is not clear whether the emissions were measured before or after the control device.

Test data sets that were not excluded were assigned a quality rating. The rating system used was that specified by EFIG for preparing AP-42 sections. The data were rated as follows:

A—Multiple tests that were performed on the same source using sound methodology and reported in enough detail for adequate validation. These tests do not necessarily conform to the methodology specified in EPA reference test methods, although these methods were used as a guide for the methodology actually used.

B—Tests that were performed by a generally sound methodology but lack enough detail for adequate validation.

C—Tests that were based on an untested or new methodology or that lacked a significant amount of background data.

D—Tests that were based on a generally unacceptable method but may provide an order-of-magnitude value for the source.

The following criteria were used to evaluate source test reports for sound methodology and adequate detail:

1. Source operation. The manner in which the source was operated is well documented in the report. The source was operating within typical parameters during the test.

2. Sampling procedures. The sampling procedures conformed to a generally acceptable methodology. If actual procedures deviated from accepted methods, the deviations are well documented. When this occurred, an evaluation was made of the extent to which such alternative procedures could influence the test results.

3. Sampling and process data. Adequate sampling and process data are documented in the report, and any variations in the sampling and process operation are noted. If a large spread between test results cannot be explained by information contained in the test report, the data are suspect and are given a lower rating.

4. Analysis and calculations. The test reports contain original raw data sheets. The nomenclature and equations used were compared to those (if any) specified by EPA to establish equivalency. The depth of review of the calculations was dictated by the reviewer's confidence in the ability and conscientiousness of the tester, which in turn was based on factors such as consistency of results and completeness of other areas of the test report.

3.3 EMISSION FACTOR QUALITY RATING SYSTEM[1]

The quality of the emission factors developed from analysis of the test data was rated using the following general criteria:

A—Excellent: Developed only from A-rated test data taken from many randomly chosen facilities in the industry population. The source category is specific enough so that variability within the source category population may be minimized.

B—Above average: Developed only from A-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industries. The source category is specific enough so that variability within the source category population may be minimized.

C—Average: Developed only from A- and B-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. In addition, the source category is specific enough so that variability within the source category population may be minimized.

D—Below average: The emission factor was developed only from A- and B-rated test data from a small number of facilities, and there is reason to suspect that these facilities do not represent a random sample of the industry. There also may be evidence of variability within the source category population. Limitations on the use of the emission factor are noted in the emission factor table.

E—Poor: The emission factor was developed from C- and D-rated test data, and there is reason to suspect that the facilities tested do not represent a random sample of the industry. There also may be evidence of variability within the source category population. Limitations on the use of these factors are footnoted.

The use of these criteria is somewhat subjective and depends to an extent upon the individual reviewer. Details of the rating of each candidate emission factor are provided in Section 4.

REFERENCE FOR SECTION 3

1. *Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections*, EPA-454/B-93-050, Office of Air Quality Planning and Standards, U. S. Environmental Protection Agency, Research Triangle Park, NC, October 1993.

4. REVIEW OF SPECIFIC DATA SETS

This section describes the references and test data that were evaluated to determine if pollutant emission factors could be developed for AP-42 Section 9.8.2, Dehydrated Fruits and Vegetables.

4.1 REVIEW OF SPECIFIC DATA SETS

No source tests or other data that could be used to develop emission factors for the AP-42 Section were located during the literature search.

4.2 DEVELOPMENT OF CANDIDATE EMISSION FACTORS

No emission factors were developed because no source tests or emissions data were found.

5. PROPOSED AP-42 SECTION

The proposed AP-42, Section 9.8.2, Dehydrated Fruits and Vegetables, is presented on the following pages as it would appear in the document.

[Not presented here. See instead final AP-42 Section 9.8.2.]