# Water Efficiency

## Industry Specific Processes

## Food and Beverage

In the food and beverage industry, water plays a significant role in transporting, cleaning, processing and formulating products, as well as in meeting many federal sanitary standards. Facilities implementing water conservation programs sometimes struggle to balance these needs with the many benefits of reducing water usage. The following section discusses the methods and techniques that many facilities have used to implement successful water conservation programs while maintaining production requirements.

For general rinsing and cleaning operations, refer to Chapter 4 on cleaning, rinsing and in-process water reuse. Several opportunities in the beverage industry include:

- Adjust pumped cooling and flushing water to the minimum required.
- Investigate potentially reusable discharges, including final rinses from tank cleaning, keg washes and fermenters; bottle and can soak and rinse water; cooler flushwater; filter backwash; and

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pasteurizer and sterilizer water, as well as cooler water. Measure these uses to get a baseline inventory for monitoring.
- Potential areas for reuse include first rinses in wash cycles; can shredder; bottle crusher; filter backflush; caustic dilution; boiler make-up; refrigeration equipment defrost; and floor and gutter wash. Cooler water can be retreated and reused in many instances.

Several opportunities in the food industry include:

- Rechlorinate and recycle transport water where feasible.
- Use conveyor belts for product transport. Preference should be given to "rabbit-ear" or V-shaped roller supports because these are much easier to clean.
- Use pneumatic conveying systems where practical.
- Use flumes with parabolic cross-sections rather than flat bottom troughs.
- Consider these alternatives to water-intensive units: 1) rubber-disc scrubbing units vs. raw product cleaning and peeling; 2) steam rather than water blanchers, or 3) evaporative coolers rather than water-cooled systems.
- Establish optimum depth of product on conveyors to maximize wash water efficiency.
- Optimize nozzle size and pressure.
- Change eroded and non-functional nozzles.
- Divide spray wash units into two or more sections, and establish a counterflow reuse system.
- Control belt sprays with a timer to allow for intermittent application of chlorinated water.
- Consider soaking units where indicated.

Figure 5-5 provides a listing of potential reuse areas for specified canning operations.

## Water and Wastewater Use in the Food Processing Industry*

The following sections discuss major water-using and waste-generating processes in fruit, vegetable, dairy, meat, poultry and oil processing. The information is provided to help food processing managers evaluate water use performance and consider additional water efficiency measures. In the absence of water use data, wastewater (hydraulic) loadings information is presented as a reference for water use.

**Excerpts from "Waste Management and Utilization In Food Production and Process," CAST, October 1995.*

### CASE STUDY

**Recycling Transport Water**

A food processing facility in St. Paul, Minn., hired an intern to evaluate water usage in corn processing. For the transport water use (5,200 gallons per day) the intern investigated alternative dry methods: 1) screw conveyors were unacceptable because of the degradation of corn, 2) belt conveyors on the vertical cook tanks were a potential solution but only reduced water by 10 percent, making the initial investment unjustifiable. The intern found that 20 percent of the transport water could be recycled without affecting product quality (concerns included pH and cleanliness). Recycling 20 percent would reduce total plant water usage by 3.5 percent and save $1,570 annually.

Figure 5-5

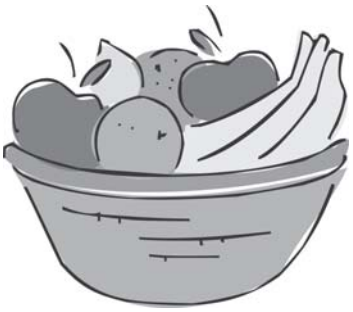
## Potential Water Reuse for Selected Food Processing Operations

| Operation | Can reserved water be used? | Can effluent be used? | Source of make-up water |
|---|---|---|---|
| Acid dip for fruit | yes | no | can coolers |
| Washing of product | | | |
| First wash, followed by second wash | yes | yes[1] | can coolers |
| Final wash of product | no | yes[1] | can coolers |
| Flumes | | | |
| Fluming unwashed or unprepared product | yes | yes[1] | can coolers |
| Fluming partially prepared product | yes | yes[1] | |
| Fluming fully prepared product | no | yes | any wastewater |
| Fluming waste | yes | no | can coolers |
| Lye peeling | yes | no | |
| Product holding vats (covered with water or brine) | no | no | |
| Blanchers, all types | | | |
| Original filling water | no | no | |
| Replacement of make-up water | no | no | |
| Salt brine quality graders with fresh water final wash | yes | this operation | |
| Washing pans and trays | | | |
| Tank washers, original water | no | no | |
| Spray or make-up water | no | no | |
| Lubrication of product inside machines | no | yes[1] | can coolers |
| Washing cans after closing | no | no | |
| Brine and syrup | yes | yes[1] | can coolers |
| Processing jars and underwater | no | | |
| Can coolers | yes | this operation | can coolers |
| Cooling canals | | | |
| Original make-up | no | yes[2] | |
| Make-up water | yes | yes[2] | |
| Continuous cookers (cans partially immersed) | | | |
| Original make-up | no | yes[2] | |
| Make-up water | yes | yes[2] | |
| Spray coolers with cans not immersed | yes | yes | |
| Batch cooling in retorts | yes | yes[2] | |
| Clean-up purposes | | | |
| Preliminary wash | yes | yes[1] | can coolers |
| Final wash | no | no | |
| Box Washers | yes | no | can coolers |

[1]Use in preceeding operation under precautions.

[2]Use in can coolers if quality is maintained.

# Fruit and Vegetable Processing



The fruit and vegetable processing industries may be described as consisting of two segments: fresh pack and processing. The former collects crops and field packs them into lug boxes or bulk bins for shipment to a produce finishing plant. Products are cooled to preserve integrity and fumigated or treated to control insect infestation or microbial disease development. Products may be culled, graded or trimmed. Product is sold as fresh produce. The processing segment, or packers, includes all unit operations, extending the shelf life of food being processed and adding value through produce modification to satisfy market niches.

The fresh pack segment of the industry shares unit operations with the processing segment. These operations are the sorting/trimming, washing, grading and packing lines. But after the packing lines, additional unit operations may add to the waste-generating scheme for the processing segment alone. Additional operations may include combinations of peeling, stemming, snipping, pitting, trimming, chopping and blanching. In some instances, the final product is dehydrated (e.g., chopped onions). In others, it is packaged and processed. Processing can include one treatment or a combination of several treatments (e.g., acidifying, brining, freezing, cooking or cooling).

Major water use and waste-generation points associated with the fruit and vegetable industry include the washing steps for raw and processed produce, peeling and pitting practices, blanching, fluming the produce after blanching, sorting and conveying the product within the plant and cooling after processing. Reducing size, coring, slicing, dicing, pureeing and juicing process steps, as well as filling and sanitizing activities after processing, also contribute to the waste stream.

## *Wastewater Characterization*

Major wastewater characteristics to be considered for the vegetable and fruit processing industry are the wide ranges of wastewater volume and the concentrations of organic materials. Wastewater characteristics can be influenced by a number of factors such as the commodity processed, the process unit operations used, the daily-production performance level and the seasonal variation, e.g., growing condition and crop age at harvest. Figure 5-6 presents historical data collected from raw wastewater discharged from the vegetable- and fruit-processing industry.

## *Water Use and Wastewater Sources*

In the processing environment for vegetable and fruit material handling, heating, cooling and packaging, there are six major contributing point sources for waste. These sources are the following operations: (1) raw produce washing, grading and trimming, (2) washing after steam/lye peeling and/or size reducing, (3) blanching and fluming, (4) filling, (5) sanitation/plant cleanup, and (6) processed product cooling. Plant management practices greatly influence process operation efficiency relative to final product yield and waste quantity generated. *(Refer to Figure 5-6 for industrial variability.)*

## *Water Use and Waste Minimization*

Ideally, considerable waste reduction can be achieved if harvesting equipment permits additional stems, leaves and culled materials to remain in the field during harvest. If crop washing, grading and trimming can occur in the field, then additional soil and food residues will remain at the farm. Realistically, most such wastes are being handled at vegetable and fruit processing plant sites. Primary

waste-management strategies used by this industry are water conservation and waste-solids separation.

Water use by the vegetable and fruit processing industry is essential to the washing, heating and cooling of food products. But the industry has adopted a number of practices, showing increased sensitivity to the need for water conservation:

1. Use of air flotation units to remove suspended debris from raw crop materials.
2. Recovery and reuse of process water throughout the processing plant.
3. Decrease of water volume use in peeling and pitting operations, as well as decrease of raw product losses.
4. Separation of waste process streams at their sources, for potential byproduct use.

Figure 5-6

**Representative Wastewater Loadings Per Ton of Product Associated with Typical Vegetable and Fruit Raw Products**

| Crop | Flow (1,000 gal/ton) minimum | Flow (1,000 gal/ton) mean | Flow (1,000 gal/ton) maximim |
|---|---|---|---|
| Vegetable products | | | |
| Asparagus | 1.9 | 8.5 | 29.0 |
| Bean, snap | 1.3 | 4.2 | 11.2 |
| Broccoli | 4.1 | 9.2 | 21.0 |
| Carrot | 1.2 | 3.3 | 7.1 |
| Cauliflower | 12.0 | 17.0 | 24.0 |
| Pea | 1.9 | 5.4 | 14.0 |
| Pickle | 1.4 | 3.5 | 11.0 |
| Potato, sweet | 0.4 | 2.2 | 9.7 |
| Potato, white | 1.9 | 3.6 | 6.6 |
| Spinach | 3.2 | 8.8 | 23.0 |
| Squash | 1.1 | 6.0 | 22.0 |
| Tomato, peeled | 1.3 | 2.2 | 3.7 |
| Tomato, product | 1.1 | 1.6 | 2.4 |
| | | | |
| Fruit Products | | | |
| Apple | 0.2 | 2.4 | 13.0 |
| Apricot | 2.5 | 5.6 | 14.0 |
| Berry | 1.8 | 3.5 | 9.1 |
| Cherry | 1.2 | 3.9 | 14.0 |
| Citrus | 0.3 | 3.0 | 9.3 |
| Peach | 1.4 | 3.0 | 6.3 |
| Pear | 1.6 | 3.6 | 7.7 |
| Pineapple | 2.6 | 2.7 | 3.8 |
| Pumpkin | 0.4 | 2.9 | 11.0 |

5. Countercurrent reuse of wash and flume/cooling waters.
6. Separation of low- and high-strength wastestreams.
7. Installation of low-volume, high-pressure cleanup systems.
8. Conversion from water to steam blanching.
9. Use of air cooling after blanching.

## Fruit Processing (Canning, Freezing, Fermenting, etc.)

The initial preparation processes for canned, frozen and fermented fruits are washing, sorting, trimming, peeling, pitting, cutting or slicing, inspecting and grading. Unwanted and undesirable materials must be removed before the fruits undergo additional processing, but not all fruits are subject to each step. For example, cherries and plums may be canned whole and unpeeled, whereas apples, peaches and pears must be peeled and either cored or pitted before being canned. Peeling can be by hand or with machines, chemicals or steam. After inspection and grading, the peeled fruits are conveyed mechanically or flumed to product handling equipment for processing.

The converted fruit handling processes are can filling, syrup adding, exhausting and sealing, thermoprocessing, can cooling and storing. Processing equipment and plant floors usually are cleaned at the end of each shift and so constitute a final source of waste materials (*see Figure 5-7*).

### *Water and Wastewater Management*

Several water conservation and waste prevention techniques are available by which to decrease water volume. These techniques include:

- The use of high-pressure sprays for cleanup.
- The elimination of excessive overflow from washing and soaking tanks.

Figure 5-7

**Wastewater Loadings Per Ton of Product from Canned Fruits**

| Fruit | Flow (gallon/ton) |
|---|---|
| Apple | 500,000 |
| Apricot | 500,000 |
| Cherry | 200,000 |
| Citrus | 300,000 |
| Peach | 400,000 |
| Pear | 400,000 |
| Pineapple | 50,000 |
| Other fruit | 800,000 |

- The substitution of mechanical conveyors for flumes, the use of automatic shutoff valves on water hoses.
- The separation of can cooling water from composite waste flow.
- The recirculation of can cooling water. When can cooling water is not recirculated, it may be reused in caustic soda (NaOH) or in water peeling baths, in removal of NaOH after peeling, in primary wash of the raw material, in canning belt lubrication, and in plant cleanup operations.

## Dairy Processing

The processing of dairy products often entails various unit operations. These generally include the receiving and the storing of raw materials, the processing of raw materials into finished products, the packing and the storing of finished goods and a number of ancillary processes (e.g., heat transferring and cleaning), associated indirectly with processing and distributing.

Equipment and facilities for receiving, transporting and storing raw materials are much the same industrywide. Bulk carriers unload

products in receiving areas by means of flexible lines or dump material into hoppers connected to fixed lines and subsequently transferred by pump to storage. Storage facilities can be of the refrigerator, vertical or silo type, with storage tanks containing either liquid or dry products and ranging in volume from a few thousand gallons to one million gallons or more.

Milk, a perishable product made up of fat, protein, carbohydrates, salts and vitamins, is an ideal food for microorganisms as well as for humans. Thus, it needs to be protected from contamination, and much of the efforts of the dairy industry are directed to this end. Milk and its byproducts are processed according to approved procedures, on machinery normally run no longer than about 20 hours per day. Much equipment is dismantled daily. Systems may be cleaned in place or after they are taken apart. Automated cleaning systems, now predominant in the industry, require less labor but more water and cleaning chemicals than hand washing of dismantled equipment.

### *Wastewater and Management*

Dairy processing wastewaters are generated during the pasteurization and the homogenization of fluid milk and the production of dairy products such as butter, ice cream and cheese. The principal constituents of these wastewaters are whole and processed milk, whey from cheese production and cleaning compounds.

Water use in the dairy products industry depends on plant complexity and water-management practices. Process wasteloads also differ considerably and are influenced greatly by the extent to which the plant controls raw material and product losses. Raw wastewater loading for the American dairy industry is summarized by commodity segment in Figure 5-8.

Milk product losses typically range from 0.5 percent in large, technologically advanced plants to greater than 2.5 percent in small, older plants. Given redoubled effort by management, water usage in most plants could be

Figure 5-8

**Summary of American Dairy and Milk Processing Plant Effluent Loadings**

| Products | Wastewater (kg ww/kg milk) range | Wastewater (kg ww/kg milk) average |
|---|---|---|
| Milk | 0.10-5.40 | 3.25 |
| Cheese | 1.63-5.70 | 3.14 |
| Ice cream | 0.80-5.60 | 2.80 |
| Condensed milk | 1.00-3.30 | 2.10 |
| Butter | | 0.80 |
| Powder | 1.50-5.90 | 3.70 |
| Cottage cheese | 0.80-12.40 | 6.00 |
| Cottage cheese and milk | 0.05-7.20 | 1.84 |
| Cottage cheese, ice cream and milk | 1.40-3.90 | 2.52 |
| Mixed products | 0.80-4.60 | 2.34 |

decreased to approximately 0.50 L/kg milk equivalent processed. Considerable improvements in water and waste management remain important and realistic industry goals.

### *Innovations*

In recent years, technological innovations with membrane systems have provided many new opportunities. For example, ultrafiltration now can be used instead of the biological separation of organic material from liquid substrate. And instead of using reverse-osmosis systems for tertiary waste treatment, some food plants use them to recycle internal liquid waste streams. The outflow from reverse-osmosis treatment can be of better quality than the native water.

## Meat and Poultry Processing

The meat and poultry processing industries in the United States together make up a $117 billion per year industry. The U.S. Department of Agriculture reported that the value of red meat production for 2007 totaled $36.1 billion. Most red meat processing plants are located in the Midwest; most poultry processing plants are in the Southeast and the Mid-Atlantic. Processing of prepared meats, including canned cooked products, luncheon meats, hot dogs, bacons, stews and other ready-to-eat meat products, has expanded rapidly in recent years.

Figure 5-9

**Typical Water Consumption for Beef, Turkey and Broiler Processing**

| Animal type | Water (gallon/animal) |
|---|---|
| Beef | 150 - 450 |
| Turkey | 11 - 23 |
| Broiler | 3.5 - 10 |

### *Waste and Byproducts*

Most waste products are recovered somehow by the industry. Blood, feathers and bone usually are processed into a meal product for animal feed. Similarly, meat scraps unsuitable for processing into food products are sold or given to rendering facilities for processing into animal and pet foods. The ultimate characteristics of solid materials and wastewaters generated by these source areas in a plant and unrecovered for another use differ greatly and are affected by:

1. Animal size and type
2. Processing level
3. Conveyance means
4. Processing water use
5. Cleanup and housekeeping procedures.

### *Water Usage*

Water use for broiler processing typically ranges from 3.5 to 10.0 gal/bird; for turkeys, 11 to 23 gal/bird. Flow rates of 350 gal/animal have been reported for beef slaughtering plants. In one beef slaughtering operation, water use dropped from 458 to 187 gal/head after water conservation measures were adopted. Similar water use numbers appear in the examples in Figure 5-9.

Water is used for chilling, scalding, can retorting, washing, cleaning and waste conveying. For example, poultry processing uses approximately 3.5 to 7.0 gallons of water per bird of four-pound average weight. All broiler processing plants are required to have a scalder overflow rate of 0.25 gal/bird and a chiller overflow rate of 0.50 gal/bird. In many instances, this water is used in the plant for the transport of feathers and offal from the processing area. One researcher, studying a broiler processing plant, reported that processing accounted for 76 percent of the water use, with 13 percent used in cleanup and 12 percent used in downtime.

Beef processing water usage, primarily from carcass washing and process clean-up, has been reported in the range of 150 to 450 gallons per animal processed. As a general rule, meat processors use about one gallon of water per pound of processed hamburger meat.

### *Use and Minimization of Wastes*

The amount of wastewater generated by the industries can be decreased largely through changes in cleanup practices. Water use can be minimized by means of commercially available high-pressure, restricted flow hoses, which can be fit with automatic shutoffs to prevent water loss during inactivity. Many materials can be handled mechanically. For example, flour and other dry material can be vacuumed from the floor, and augers and conveyors can be used to transport scrap meat and viscera.

Chiller and scalder water is reused in most poultry processing plants for flushing water to remove offal and feathers. Reconditioning of chiller overflow through the use of filtration and ultraviolet irradiation has been recommended. Limits to use include the potential of bacterial contamination by coliforms or by Escherichia coli. Recycling is limited by the characteristics of the wastestream and by the potential for contamination of food products.

## Grain Processing for Oils

The extracting, refining and processing of edible oils produces a variety of waste products. This chapter, which focuses on conventional caustic refinements and on related downstream processes, briefly reviews major processes and facilities, especially as they relate to waste generation and control.

### *Process Components and Major Wastewater Sources*

Figure 5-10 lists primary processes and associated wastewater loadings from a well-run fat and oil processing facility. Separate totals are presented with and without salad dressing and mayonnaise because these processes often are absent in a facility. Certain oil processing and refining operations have no oil seed processing facilities, but instead bring in crude vegetable oil. To account for this practice, adjustments can be made to the figures in the table. Data presented in Figure 5-10 are based on these operating parameters:

1. Milling and extracting: 80,000 bushels per day.
2. Caustic refining with single-stage water wash: 60,000 lb/hr, nondegummed soybean oil.
3. Semicontinual deodorizing with scrub cooler, barometric condenser with atmospheric cooling tower.

Figure 5-10

**Fats and Oils Processes and Wastewater Loads from a Well-run Facility**

| Process | Flow (gallons/day[1], avg.) |
|---|---|
| Milling and extraction | 75,000 |
| Caustic refining | 11,000 |
| Further processing | 5,000 |
| Deodorizing | 5,000 |
| Acidulating | 19,000 |
| Tank car washing | 5,000 |
| Packaging | 10,000 |
| Subtotal | 130,000 |
| Margarine | 70,000 |
| Salad dressing/mayonnaise | 50,000 |
| TOTAL | 250,000 |

[1]gallons/day = gallons per day

4. Acidulating of soapstock and washwater with 90 to 95 percent recovery efficiency.
5. Bottling line and/or other extensive liquid-oil packaging.
6. Margarine, mayonnaise and salad dressing production and packaging.
7. Washing of tank cars for finished oil only (cars carrying crude oil excluded)

Obviously, operations of an atypical size or those omitting certain processes will have different waste loads. This applies especially to operations involved in acidulation or in mayonnaise and salad dressing processing. The effects of process control and its impacts on wastewater loading are very important. As noted, these loadings are representative for an operation running reasonably well from a process loss control standpoint. But actual loadings depend on how well plants are run.

A final source of wastewater is contaminated runoff from truck and rail loadout areas and from tank farm drainage. During rainy periods, runoff from these sources can contribute the equivalent of five to 10 gal/minute to total daily average flow and, in fact, may affect peak flows to a much greater extent.

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The North Carolina Division of Pollution Prevention and Environmental Assistance provides free, non-regulatory technical assistance and education on methods to eliminate, reduce, or recycle wastes before they become pollutants or require disposal. Telephone DPPEA at (919) 715-6500 or (800) 763-0136 for assistance with issues in this fact sheet or any of your waste reduction concerns.

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