

Mushrooms

Revised 2018

Thermal Properties

	English	Metric
Moisture, %	91.81	--
Protein, %	2.09	--
Fat, %	0.42	--
Carbohydrate, %	4.65	--
Fiber, %	1.20	--
Ash, %	0.89	--
Specific Heat Above Freezing	0.95 Btu/lb*°F	3.99 kJ/(kg*K)
Specific Heat Below Freezing	0.44 Btu/lb*°F	1.84 kJ/(kg*K)
Latent Heat of Fusion	132 Btu/lb	307 kJ/kg

Storage Conditions

	Temperature		Storage Period	Relative Humidity
Fresh	32 to 34°F (0 to 1.1°C)		3 to 5 days	87 to 92%
CA Storage	32 to 34°F (0 to 1.1°C)		5 to 8 days	87 to 92%
Refrigerated Quick-Blanched	32 to 38°F (0 to 3.3°C)		6 to 8 weeks	4.5- to 5.0-lb (2- to 2.3-kg) plastic pails w/ tight lids
Frozen	0 to -10°F (-17.8 to -23.3°C)		3 months	Vapor-proof packaging
	-10 to -20°F (-23.3 to -28.9°C)		6 months	
Canned	70 to 75°F (21.1 to 23.9°C)		1 year	30 to 50%
	40 to 45°F (4 to 7.2°C)		2 years	
Dehydrated	70°F	(21°C)	6 months	Preferably gas-tight Vacuum packaging
	36°F	(2.2°C)	1 year	
Freezing Point	30.4°F	(-0.9°C)		

Fresh Mushrooms

Over 75% of the mushrooms grown in the U.S. are marketed fresh. Cultivated mushrooms are delicate and discolor quickly after harvest, particularly if bruised. The addition of calcium chloride to irrigation water used in cultivation can increase shelf life of fresh mushrooms by making tissues less susceptible to damage by bruising. Trimming stems close to the caps also improves shelf life by delaying cap opening and browning. Mushrooms are not ordinarily stored prior to fresh sale but should be cooled quickly after harvest using vacuum or forced-air cooling systems and kept refrigerated for accumulation purposes before marketing or processing. They are sometimes cold stored after the pre-processing operations just prior to canning in order to increase canned product yield.

Mushroom quality is based on maturity, size, trimming, freedom from open veils, disease, spots, insect injury and decay. High quality requires a uniform, well-rounded cap with smooth glossy surface and fully intact veil. The cap color should be white or dark brown, and lack of growth medium on caps and absence of browning or other discoloration are also desirable quality factors, while visible open caps and absence of a stipe are negative factors. U.S. grades for mushrooms include No. 1 and No. 2. Sizes range from: Small (button), 0.75 to 1.25 inches (1.9 to 3.2 cm); Medium, 1.25 to 1.8 inches (3.2 to 4.5 cm); and Large, 1.8 inches (> 4.5 cm), measured as cap diameter. Mushrooms are commonly packed in trays or cartons with a perforated polyethylene film over-wrap to reduce moisture loss. Water condensation inside packages should be avoided.

Deterioration is marked by yellow to brown to black discoloration of the surfaces, dehydration, elongation of the stems or expansion of the caps, opening of the veils, and decay. Storage at 32°F (0°C) will retard the deterioration of tissues. If allowance is made for a marketing period of 1 day at higher temperatures immediately after storage, mushrooms should be kept at 32°F (0°C) for only 3 to 5 days or at 40°F (4.4°C) for about 2 days. When pre-cooled, mushrooms can be held for 7 to 9 days at 32 to 33.8°F (0 to 1°C) with 95% RH, or 3 to 5 days at 35.6°F (2°C). High relative humidity (RH) is essential to prevent desiccation and loss of glossiness. Refrigeration during transportation and display for sale is also essential. Mushrooms can absorb odors from some other products such as green onions, and therefore they should not be transported or displayed together.

Commercial washes containing sulfites are not legal for fresh mushrooms and do not prevent spoilage and deterioration but have been used in the past to give an initial attractive white appearance and extend usage for subsequent processing. A patented two-stage wash process was developed at Penn State for washing whole or sliced fresh mushrooms to inhibit decay and browning: Stage I: 0.05 M bicarbonate (NaHCO_3) buffer, pH 10.5, 30°C, 45-sec wash; Stage II: erythorbate buffer (0.6% erythorbic acid + 2.4% sodium erythorbate) + CaCl_2 (1000 ppm) + EDTA (1000 ppm), pH 4.5, 20°C, 45-sec wash.

Moisture-retentive film over-wraps or film caps are usually beneficial in reducing moisture loss, but increase spoilage caused by surface bacteria, especially with washed mushrooms. Such over-wraps, if sealed, may provide a modified atmosphere (MA). In fact, it has been reported that controlled atmosphere (CA) storage may extend mushroom storage life at 32 to 41°F (0 to 5°C) by retarding cap opening and inhibiting mold development. A CA atmosphere containing about 10% CO_2 is probably best, and the beneficial effect persists after mushrooms are removed to air. Reduced O_2 levels have little or no value;

Mushrooms

in fact, O₂ levels of 2 to 5% stimulate growth according to a University of California study. Oxygen levels below 6% are now discouraged as a safety measure to prevent the potential outgrowth of *Clostridium botulinum* spores in fresh market mushrooms (produces botulinum toxin). Film-wraps must be perforated with at least two 1/8-in (3-mm) diameter holes per package for ventilation.

Freezing

Frozen mushrooms are prepared as slices and stems, buttons, or large whole pieces. The most important step is speed, from the time fresh mushrooms are received at the freezer plant until they are fully frozen. A rapid freezing rate is essential. One processor aims for a center temperature of -10°F (-23.3°C) to be reached in 3 to 5 minutes for diced or 20 minutes for whole mushrooms. Because such rates are difficult to obtain in the freezing of packaged mushrooms, individual quick freezing (IQF) is recommended to obtain a high-quality frozen mushroom. Mushrooms have been successfully frozen on a semi-fluidized belt, approximately 1 layer deep for caps and 4 to 5 layers deep for diced. Both liquid nitrogen and powdered dry ice (solid CO₂) have also been successfully used to freeze mushrooms rapidly.

Mushrooms packed in pouches for boil-in-bags may be first individually quick frozen and then filled into the bag, or they may be filled in the unfrozen state. The latter technique is considered less desirable. In either case a sauce may be added, the bag sealed and placed in a carton, and the freezing completed in a plate freezer.

Vacuum packaging of mushrooms is desirable in order to eliminate discoloration from oxidation. A sauce coating may serve the same purpose. Mushrooms are particularly sensitive to the time-temperature relationship in storage and will darken rapidly in frozen storage at temperatures above 0°F (-17.8°C) if not blanched during processing. Since blanched mushrooms toughen extensively after freezing, blanching is usually avoided. Browning of un-blanched mushrooms during frozen storage can also be controlled by the previously described Penn State wash process without the use of sulfites.

Canning

Over 4 million cases of canned mushrooms are consumed in the U.S. annually. About 75% of the pack is in the form of pieces and stems packed in tins, with about 10% each packed as buttons or sliced. Less than 10% of the total is packed in glass, usually as whole or sliced buttons. Some marinated mushrooms are packed in glass as well. Because of the substantial heat processing required, canned mushrooms are not white but usually a light gray or tan. Speed of handling and processing and acidification help retain a lighter color and improve firmness. Use of vacuum hydration prior to blanching increases canned product yield and improves color according to research at Pennsylvania State University.

Dehydration

Dehydration of mushrooms has been practiced for many years, with the dehydrated product being used primarily as a condiment so that the inevitable dark-brown color was not detrimental. With the advent of freeze-drying, dehydrated mushrooms of excellent quality became possible. A part of the frozen

mushroom pack is now being used for freeze-drying. To maintain original quality, freeze-dried mushrooms should be packed in an oxygen-free atmosphere and, if held for more than just a few months, at cooler temperatures.

WFLO is indebted to Dr. Jeff Brecht, Horticultural Sciences Department, University of Florida, for the review and revision of this topic.