



# MUSHROOM SWISS BURGER

*Emmental cheese single, mushroom ketchup, shallot rings*

The hamburger is an icon of American cuisine. But this simple sandwich has spawned an impressive range of guises. At Louis' Lunch in New Haven, Connecticut, the hamburger is interpreted with puritanical asceticism: a broiled beef patty between toast, no condiments.

At the other extreme, Daniel Boulud's decadent version is made with a complex blend of meats—and stuffed with foie gras. Many inhabitants of America's heartland attach a deep cultural importance

to the local White Castle Original Slider, while folks on the West Coast are more likely to sing the praises of an In-N-Out burger, Animal Style.

All of these burgers are fantastic in their own way. But to our taste, it's hard to beat a juicy, tender mushroom burger with Swiss cheese. We therefore humbly present a no-holds-barred Modernist cheeseburger—one of the tastiest products to emerge from our culinary laboratory.

YIELD:

*four portions*

SPECIAL EQUIPMENT:

*sous-vide equipment, meat grinder with 4 mm / 3/16 in plate*

OPTIONAL EQUIPMENT:

*food processor*

TIME REQUIRED:

*30 h overall, including 2½ h preparation time and 20 min to assemble*

## ORDER OF PREPARATION:

COMPONENT	PREP	TIME TO		QUANTITY
		COOK	FINISH	
<b>Tomato Confit</b> see page 62	30 min	5 h*		40 g
<b>Brown Beef Stock</b> see page 2.296	30 min	2 h*		90 g
<b>Short-Rib Patty</b> see page 3.234	20 min	2 h*	5–8 min	four patties, about 120 g each
<b>Hamburger Bun</b>	1 h	30 h*	2 min	four buns, about 90 g each
<b>Mushroom Broth</b>	5 min	1 h		14 g
<b>Freeze-Dried Shiitake Mushroom</b> optional, see pages 3.372 and 2.450	5 min	48 h*		30 g
<b>Mushroom Ketchup</b>	20 min	45 min		10 g
<b>Restructured Emmental Slice</b> see page 4.222	10 min	2 h* and 15 min	1½ min	four slices, 15 g each
<b>Ultrasonic Fries</b> optional, see page 3.325	10 min	1½ h*	3 min	350 g
<b>Strawberry Milk Shake</b> optional, see page 2.473	5 min	1 h*	2 min	400 g
<b>Onion Rings</b> optional, see page 3.342	5 min	1 h and 4 h*	2 min	200 g
<b>Hamburger Glaze</b>	2 min	30 min	1 min	40 g
<b>Sautéed Maitake Mushroom</b>	2 min	5 min	2 min	14 g
<b>Smoked Lettuce</b>	10 min			325 g
<b>Compressed Tomato</b>	5 min			80 g

*\*(unattended times)*

## ASSEMBLY:

**Preheat** griddle to 230 °C / 450 °F, or use grill.

**Preheat** frying oil to 200 °C / 390 °F for onion rings or fries.

**Cook** patties on griddle or grill until done.

*While patties are cooking:*

**Brush** cut sides of hamburger buns with rendered beef suet.

**Toast** buns on griddle.

**Sauté** Maitake mushrooms in suet until tender and golden, about 3 min on each side.

**Deep-fry** fries (if using) until golden and crisp, about 3 min.

**Drain** fries on paper towels, and keep warm.

**Dredge** frozen onion rings in tapioca starch; shake off excess.

**Dip** rings in egg.

**Roll** rings in onion cracker breading until evenly coated, and transfer to silicone mat.

**Deep-fry** onion rings for 2 min, taking care not to puncture or crack breading.

**Drain** fried onion rings on paper towel.

**Warm** hamburger glaze.

**Top** patties with cheese 1½ min before they finish cooking.

*While patties are resting:*

**Brush** bottoms of hamburger buns with mushroom ketchup. Brush tops of buns with hamburger glaze.

**Season** tomato slices. If serving milk shake, place ground dry ice in glasses and pour milk shake base evenly among them.

**Top** with patties, lettuce, tomato, mushrooms, and bun.

**Serve** onion rings and bubbling strawberry milk shake on the side.

For more on food safety considerations when cooking ground meats, see page 1-174.

For a tender bun, use White Lily bread flour, which is made from soft wheat and milled to produce a minimum of damaged starch.

Aficionados of Southern biscuits swear by this brand, but other soft wheat pastry flours may be used instead. If substituting all-purpose flour, use a little more water when making the dough. The buns will be chewy and tougher but still presentable.

If using instant yeast, use one-third of the amount indicated in the recipe.

L-cysteine is an amino acid that causes gluten to relax. It gives this dough its characteristic flowing texture.

For more on fat-rendering strategies, see page 3-145.

## HAMBURGER BUNS

Yields 12 buns

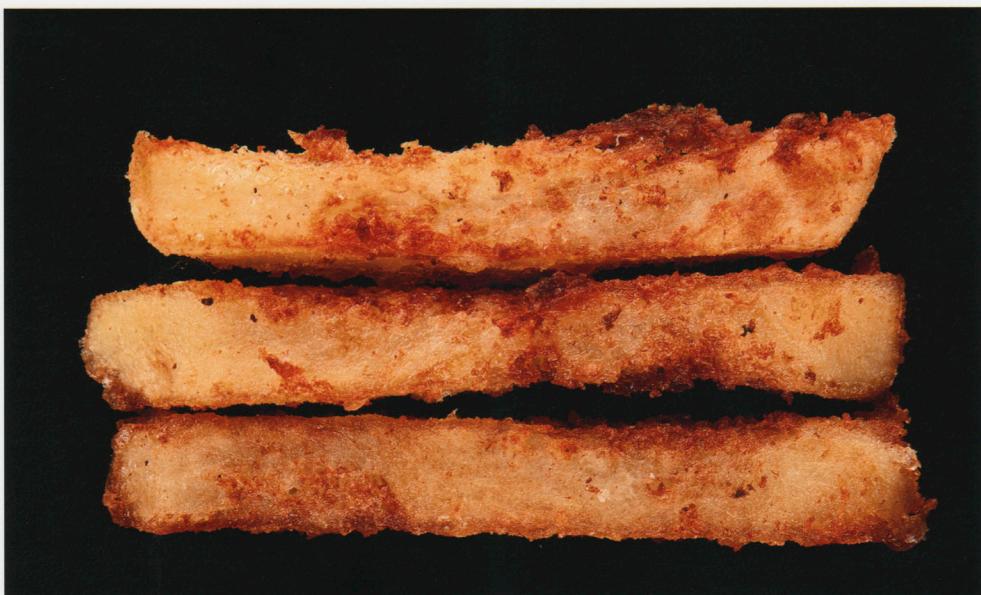
INGREDIENT	QUANTITY	SCALING	PROCEDURE
<b>For the sponge:</b>			
White Lily bread flour	310 g	65%	① Mix together on low speed, using a paddle attachment, for 8 min.
Yeast (fresh)	2 g	0.4%	② Cover tightly, and refrigerate for 24–48 h.
Water (5 °C / 41 °F)	189 g	40%	
<b>For the dough:</b>			
White Lily bread flour	480 g	100%	③ Mix together flour and water on low speed for 4 min.
Water (30 °C / 86 °F)	270 g	56%	④ Stop mixer, and cover bowl with hot, wet cloth for 45 min.
Yeast (fresh)	9.5 g	2%	⑤ Mix into flour mixture.
Sponge, from above	120 g	25%	⑥ Add to flour mixture, and mix on medium speed for 4 min.
Sugar	72 g	15%	⑦ Ferment dough, covered, at room temperature for 1 h.
Egg yolks	50 g	10%	⑧ Form into twelve 90 g balls.
Vegetable shortening	25 g	5%	⑨ Arrange balls into 11 cm / 4⅓ in ring mold.
Salt	9.5 g	2%	⑩ Proof at 85% RH and 40 °C / 104 °F until dough has expanded to fill ring, about 1½ h. If proofing cabinet is unavailable, cover with oiled plastic wrap and keep in warm place until proofed, at least 1½ h.
Vanilla extract	0.5 g (two drops)	0.1%	⑪ Press gently on proofed buns to flatten.
Lemon essential oil	0.2 g (one drop)	0.04%	
L-cysteine	0.04 g	0.01%	
Whole milk	as needed		⑫ Brush bun tops lightly.
Black poppy seeds, toasted	as needed		⑬ Combine, and sprinkle on bun tops.
Black onion seeds	as needed		⑭ Bake in 260 °C / 500 °F oven for 6 min.
Black sesame seeds, toasted	as needed		
Rendered beef suet	40 g	8.5%	⑮ Measure and refrigerate for service.

**MUSHROOM KETCHUP**

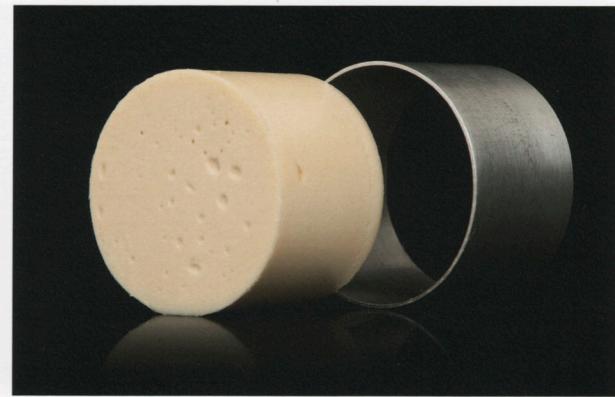
Yields 750 g

INGREDIENT	QUANTITY	SCALING	PROCEDURE
Yellow onions, thinly sliced	350 g	54%	① Sauté until translucent, about 7 min.
Olive oil	53 g	8%	
Garlic, thinly sliced	32 g	5%	② Add to onions, and cook for 1 min.
Ginger, thinly sliced	7 g	1%	
Crimini mushrooms, thinly sliced	650 g	100%	③ Combine with onion mixture and simmer, stirring frequently, until mushrooms are very tender and liquid has evaporated, about 35 min.
Malt vinegar	155 g	24%	④ Blend until smooth.
Dark ale	105 g	16%	⑤ Pass through fine sieve.
Mushroom broth, from above	70 g	11%	⑥ Adjust seasoning to taste.
Barley malt syrup	40 g	6%	⑦ Measure 800 g of ketchup.
Cane vinegar	40 g	6%	
Molasses	40 g	6%	
Fish sauce	34 g	5%	
Freeze-dried shiitake mushrooms (or dried shiitake powder)	30 g	4.5%	
Sea salt	15.5 g	2.5%	
Honey	10 g	1.5%	
Horseradish, freshly grated	7 g	1%	
Mace blades	4.2 g	0.6%	
Allspice berries	2.2 g (two berries)	0.3%	
Freeze-dried coffee powder	0.6 g	0.1%	
Ketchup, from above	800 g	123%	⑧ Blend together until smooth, and refrigerate.
Xanthan gum	1.6 g	0.25% (0.2%)*	

\*(% of weight of ketchup)



For more on ultrasonic fries, including a step-by-step procedure, see page 3-325.



For more on restructuring cheese, including a step-by-step procedure, see page 422.

### RESTRUCTURED EMMENTAL SLICES

Yields 350 g

INGREDIENT	QUANTITY	SCALING	PROCEDURE
Sodium citrate	10 g	6.7%	① Combine.
Salt	3.75 g	2.5%	
Iota carrageenan	4.5 g	3% (0.95%)*	
Kappa carrageenan	1.5 g	1% (0.32%)*	
Water (5 °C / 40 °F)	100 g	67%	② Combine water and ale.
Wheat ale	75 g	50%	③ Blend in carrageenan powder. ④ Simmer for 2 min to fully hydrate.
Aged Emmenthal cheese, grated	150 g	100%	⑤ Add to simmering mixture, a little at a time, blending constantly with a hand blender until texture is fluid.
Comté cheese, grated	135 g	90%	⑥ Pour into greased cylindrical mold 7 cm / 2 1/4 in. in diameter and at least 14 cm / 5 1/2 in. deep. ⑦ Refrigerate until set, at least 2 h. ⑧ Unmold, and slice to desired thickness. ⑨ Reserve between sheets of plastic wrap.

(\*% of total weight of all ingredients)

### MUSHROOM BROTH

Yields 250 g

INGREDIENT	QUANTITY	SCALING	PROCEDURE
Shallots, thinly sliced	37 g	25%	① Sauté until golden, about 15 min.
Olive oil	8.5 g	6%	
Water	250 g	180%	② Pressure-cook with shallots at a gauge pressure of 1.4 bar / 21 psi for 45 min.
Crimini mushrooms, thinly sliced	140 g	100%	③ Strain and cool. ④ Reserve for mushroom ketchup.



For more on breading onions rings, including a step-by-step guide, see page 4302.

### HAMBURGER GLAZE

Yields 100 g

INGREDIENT	QUANTITY	SCALING	PROCEDURE
Brown beef stock see page 2-296	90 g	100%	① Combine.
Tomato confit, pureed see page 62	40 g	45%	② Simmer until reduced to 100 g. ③ Refrigerate.
Rendered beef suet	1.5 g	1.7%	
Smoked salt	1.5 g	1.7%	

**SAUTÉED MAITAKE MUSHROOM**

Yields 100 g

INGREDIENT	QUANTITY	SCALING	PROCEDURE
Maitake mushrooms, each cut into four even slices about 1.5 cm / $\frac{5}{8}$ in thick	90 g	100%	① Measure and reserve individually.
Rendered beef suet see page 3-145	40 g	44%	
Salt	1.5 g	1.5%	

**SMOKED LETTUCE**

Yields 90 g

INGREDIENT	QUANTITY	SCALING	PROCEDURE
Water	150 g	167%	① Mix together.
Hickory liquid smoke (Wright's brand)	0.8 g (three drops)	0.9%	
Iceberg lettuce, cut 1 cm / $\frac{3}{8}$ in squares	90 g	100%	② Pour smoky water over lettuce. ③ Place container, uncovered, in vacuum chamber. ④ Pull vacuum until water boils, then turn off machine and allow lettuce to absorb smoky water in vacuum chamber for 20 min. ⑤ Drain lettuce, and refrigerate.



For more on smoking techniques, see page 2-132.

**COMPRESSED TOMATO**

Yields 300 g

INGREDIENT	QUANTITY	SCALING	PROCEDURE
Large beefsteak tomato	300 g	100%	① Cut X in bottom, then blanch for 10-15 s. ② Shock in ice water. ③ Peel. ④ Cut four slices about 1 cm / $\frac{3}{8}$ in thick. ⑤ Vacuum seal to compress. ⑥ Trim to match size of bun, and refrigerate. ⑦ Reserve individually.
Black pepper	to taste		
Flaky salt	to taste		

For more on vegetable compression techniques, see page 2-213.



## ASSEMBLY:

**Reheat** braised veal shank portions in 62 °C / 144 °F bath for 25 min.

*While meat is reheating:*

**Reheat** bone marrow custard in combi oven set at 75 °C / 167 °F with 100% humidity for 8 min or water-vapor oven set comparably. If combi oven is unavailable, reheat in steamer for 5 min.

*While custard is heating:*

**Whisk** butter and olive oil into squash glaze, season with salt and lemon juice.

**Heat** tomato vinegar foam mixture to 35 °C / 95 °F.

**Whip** mixture with handheld wand mixer until thick foam forms.

Allow foam to drain for 1 min before using.

**Reheat** braised pine nuts, and fold in kuri squash puree.

**Fold** in olive oil, cheese, and pickled squash, season with orange zest, black pepper, and salt.

**Warm** squash glaze.

**Remove** veal shank portions from bags, brush with glaze, and season with sea salt.

**Arrange** veal shank portion, marrow custard, and braised pine nuts on each plate.

**Garnish** veal with tomato vinegar foam and gremolata crisps.

## TOMATO CONFIT ADAPTED FROM HESTON BLUMENTHAL

Yields 150 g

INGREDIENT	QUANTITY	SCALING	PROCEDURE
Tomatoes	1 kg	100%	① Core tomatoes. ② Cut small X in blossom end of each tomato. ③ Blanch until skin begins to lift at X, about 10 s. ④ Shock in ice-water bath for 2 min. Peel off skins. ⑤ Cut in half vertically, and scoop out seeds. ⑥ Pat dry. ⑦ Place cut side down on baking sheet lined with silicone mat, and reserve.
Glycerol	20 g	2%	⑧ Combine.
Water	20 g	2%	⑨ Brush evenly on tomatoes.
Extra-virgin olive oil	40 g	4%	⑩ Brush evenly on tomatoes.
Garlic, thinly sliced	15 g	1.5%	⑪ Sprinkle equally and evenly over tomatoes.
Thyme leaves	4 g	0.4%	
Bay leaves, finely sliced	1 g	0.1%	
Salt	2 g	0.2%	⑫ Season tomatoes evenly.
Sugar	2 g	0.2%	⑬ Dry in 110 °C / 225 °F oven for about 1 h. ⑭ Turn tomatoes over, reduce heat to 95 °C / 200 °F, and dry until deep red and shriveled, 3–4 h. Cool. ⑮ Discard dried herbs from tomatoes. ⑯ Vacuum seal tomatoes and cooking oil. ⑰ Refrigerate.



## BRAISED VEAL FORESHANK

Yields 500 g

INGREDIENT	QUANTITY	SCALING	PROCEDURE
Veal foreshank	1 kg (one whole)	100%	① Vacuum seal together. ② Cook sous vide in 62 °C / 144 °F bath for 72 h. ③ Remove from bag, and cool in ice-water bath for 30 min. ④ Divide meat into four equal portions, reserving cooking juices and bones. ⑤ Vacuum seal meat portions individually, and refrigerate. ⑥ Refrigerate cooking juices for making glaze, and reserve bones for making custard. ⑦ Reserve.
Water	125 g	12.5%	
Flaky sea salt	to taste		

See page 3-109 for cooking other tough cuts of meat that can be substituted for the veal shanks.

Veal cheeks, veal breast, and pork or lamb shank are good options if veal shank is not available.

# STOCKS



Right after ingredient quality, stocks are perhaps the most important building block of a gourmet kitchen. The step in culinary evolution from plain water to flavorful infusions of meat or seafood, bones, vegetables, and herbs as the starting point for cooking was an inflection point in Western cuisine. In creating original, flavorful stocks that could be reduced into complicated sauces, chefs freed themselves from a reliance on pan drippings or jus. The systematic exploration and refinement of stocks led to the codification of sauces, which many consider to be the foundation of classic French cuisine (see page 1.9).

In many ways, the present age of experimentation mirrors that influential era. Today's culinary pioneers still value classical stocks, but they are also embracing new ingredients, culinary ideas from around the world, and modern cooking techniques like sous vide, pressure-cooking, and ultrasonic baths. Cooking stocks in a closed environment holds evaporation to a minimum, so more flavors remain in the broth.

Stocks and broths are both essential ingredients, but they are not the same. Stocks are unseasoned and never stand alone. Broths are finished, well-seasoned components.

## Best Bets for Stocks

Stock	Fat	(scaling)	Bone	(scaling)	Meat	(scaling)	Liquid	(scaling)
chicken, duck, or pigeon	frying oil	8%	wings	40%	ground chicken	75%	water	100%
beef	suet	5%	calf's foot, split	20%	ground beef	80%	water	100%
veal	frying oil	5%	veal knuckle	50%	ground veal	25%	water	100%
lamb	frying oil	5%	lamb shoulder and neck	35%	ground lamb	100%	water	100%
pork	frying oil	7.5%	pork ribs	50%	ground pork	50%	water	100%
shellfish	clarified unsalted butter	5%	lobster, shrimp, or crab shells and heads	65%	squid or scallop meat (optional)	20%	water	100%
vegetable	vegetable oil	5%	n/a		n/a		water	100%
fish	olive oil	10%	fish bones	100%	n/a		water	100%
Chinese banquet			pork ribs duck wings chicken wings	20% 20% 15%	cured ham, thinly sliced	10%	water Shaoxing wine	100% 5%
Chinese everyday			chicken carcass	30%	ground pork	40%	water	100%
Japanese			chicken carcass chicken feet pork trotter	24% 6% 12%	ground pork shoulder	8%	water	100%
Thai			chicken wings pork ribs	20% 12%	ground pork	35%	water coconut water	100% 40%

*\*for brown stock only*

## PARAMETRIC RECIPE

# HAMBURGERS

The hamburger has a colorful past, reflected in the many ways ground beef has been prepared. Legend has it that 13th-century Mongol riders put patties of minced lamb or mutton under their saddles to tenderize the meat, and then ate it more or less raw. As the Mongols swept across Russia, their humble patties became steak tartare, a delicacy.

The citizens of Hamburg, Germany, imported tartare and began eating it in sandwiches. In the U.S., the first modern beef burger was reportedly served in 1885, either at the Outagamie Country Fair in Wisconsin or at the Erie Country Fair in Pennsylvania. Today, grilling burgers has become a form of pop art, but no one pays much attention to the preparation of the raw patties. The technique shown here yields a patty that quickly crumbles in the mouth—the hallmark of a succulent hamburger. We adapted it from Bernard Mense.

## MAKING BURGERS

**1** Choose a blend of well-marbled meat, and chill the meat deeply. The table Best Bets for Burgers lists several good options, each of which has a different flavor, texture, and cooking profile.

**2** Put ice cubes or liquid nitrogen in the grinder to chill it to just above 0 °C / 32 °F.



**3** Cut. Cut away any large chunks of fat from the meat, and cut into cubes about 2 cm / 3/4 in on a side. Chill the meat to -1 °C / 30 °F. Do not salt the meat.



### Best Bets for Burgers

Meat blend	Ingredients	(scaling)	(% fat)	Leanness	Cook
				(°C)	(°F)
rare beef	fillet mignon	100%	20	52	126
	rib eye cap	45%			
short rib	short-rib meat	100%	30	54	129
	aged rib eye	100%			
MC team favorite	hangar	25%			
				56	133
steak-house blend	chuck	100%	25	54	129
	sirloin	50%			
	flank	50%			

**4** Grind the cubes through a 3–4 mm / 1/8–3/16 in plate. (For tender meat blends, chop by hand, and then shape into a loose patty 3 cm / 1 1/4 in thick, and skip to step 9.) When using a grinder, tighten the collar to prevent mashing and tearing. Don't force the meat through the grinder; let the auger pull it through.



**5** Collect the extruded strands of ground meat in a cylindrical mold cut in half and lined with plastic wrap. (Select a mold slightly wider than the diameter desired for the patties.) Slowly pull the mold toward you as the meat exits the grinder so that the strands run straight along the mold. Build up layers of strands to fill the mold.



**6** Repeat with a second mold, and then press the two molds together to form a complete cylinder of meat.



**7** Use the surrounding plastic wrap to remove the meat from the mold. Tighten the wrap slightly to gently compress the cylinder—but take care not to overtighten and mash the meat together, which will make the patties less tender. The meat cylinder can be frozen at this point, but then it will have to be sawed into patties.



**8** Use a sharp knife to cut hamburger discs of the desired thickness. Remove the plastic wrap from the cut patties, and refrigerate them until cooking.

**9** Cook, season, and garnish.  
See the recipes for Mushroom Swiss Burger on page 5-11 and for Sous Vide Hamburger on page 86.

When is the best time to add flavorful liquids and powdered seasonings to ground beef? Mixing them with the cubed meat before grinding is not the best approach because most additives bind the meat strands together. Seasonings containing salt, for example, extract the meat protein myosin, which forms a strong, elastic gel when cooked. That may be desirable in sausage making, but it produces a rubbery burger.

For the tenderest burgers, season the meat after you have cut it into patties. Avoid adding eggs, starches such as bread crumbs, or protein-laden liquids such as milk. During cooking, these ingredients gel and act like edible glue.



## PARAMETRIC RECIPE

# FREEZE-DRIED FRUITS AND VEGETABLES

Dehydration has many advantages, but also some drawbacks.

Simple drying evaporates water with heat, which can change the taste and texture of food, particularly over the long time it takes to complete. Vacuum desiccation substitutes low pressure for high temperature, which reduces heat-related side effects. But any process that moves liquid water through the food will have some side effects, such as shrinking and cracking.

The trick to freeze-drying well is controlling the air pressure as well as the temperature. At low pressures, ice transforms directly from solid to vapor through a process called sublimation. This process avoids the traumatic thawing process, so the cell walls inside frozen plant foods don't collapse as they dry.

The result is brightly colored, crunchy produce with antioxidant and flavor concentrations nearly as high as it had when fresh.

You can find freeze-dried plant foods in the grocery aisle as novelty snacks and ingredients in breakfast cereals. Increasingly, you can also find them in restaurants, where chefs finely grind freeze-dried fruits and vegetables to add full-bodied flavor to dishes without adding moisture or bulk, characteristics that make freeze-dried foods ideal for dressings or sauces. They can also boost the flavors of baked goods, breadings, and spice mixes.

Freeze-drying equipment is still expensive, but freeze-dried produce is now widely available. If you do make or buy some, store it in a dry, dark environment, vacuum-sealed if possible.

## FREEZE-DRYING PLANT FOODS

**1** Prepare the ingredients. The table Best Bets for Freeze-Drying Plant Foods below lists our recommendations.

**2** Arrange in a single layer on a tray.

**3** Freeze-dry for the time indicated. Temperature and pressure settings for primary and secondary drying are given in chapter 10 on The Modernist Kitchen, page 2-450.

For more on sublimation, see page 1-326.

### Best Bets for Freeze-Drying Plant Foods

Ingredient	Preparation	Cut (mm)	Dry (in)	Dry (h)	Typical use	See page
apples	peeled	2	1/16	24	whole; grind into a fine powder, and use to enhance apple recipes	
bananas	peeled	3	1/8	48	whole; grind into a fine powder, and add to Thai spice mix or to mustard base	
butternut squash	peeled	2	1/16	36	grind into a fine powder, and add to fresh butternut squash puree to deepen the flavor and thicken	
carrots	peeled and sliced, then blanched for 30 s	1	1/32	12	instant ramen	2-455
chives, mint and other herbs		whole leaves		12	grind into a fine powder for seasoning	
corn, kernels		whole		36	whole; grind into a fine powder and use in Modernist breading, add to corn bread recipes or broths	4-36
grapes	perforated with a needle	whole		48	whole; pickled; add to pastry recipes; infuse into broths	
lettuce		whole leaves		24	caesar salad	next
mushrooms		1	1/32	12	infuse into stocks and broths; rehydrate to make a puree; grind into a fine powder for breading	5-14
onions	cooked until tender	2	1/16	12	grind into a fine powder, and add to savory pastry	next
piquillo peppers	blanched, peeled	quartered		36	grind into a fine powder, and add to spice blends	5-239
raspberries		whole		24	whole; grind into a powder, and add to pastry or infuse into vinegar	
strawberries		2	1/16	24	whole; grind into a fine powder for seasoning and breading	5-277
tomatoes	peeled, cored	thinly sliced		24	whole; infuse into oils; grind into a fine powder, and add to sauces and spice blends	2-403

## PARAMETRIC RECIPE

# FREEZE-DRYING

Freeze-dried foods are unlike any other. They are brittle and explosive with bold, fresh flavors and bright colors but are devoid of moisture. Freeze-drying works beautifully with fresh fruits and vegetables. Stocks can be concentrated into dry cubes with all the vibrancy of a fresh preparation and none of the saltiness of commercial bouillon cubes. Meats and seafood, freeze-dried when they are cooked and tender, will reconstitute into forms and textures remarkably similar to their fresh counterparts. And for creating unique and unexpected presentations, freeze-drying is unparalleled. Arzak in San Sebastián, Spain, was one of the first restaurants to experiment with the process.

To get good results from a freeze dryer, the most crucial step is the initial freezing. The formation and development of ice crystals are key to how the cellular structure withstands the freeze-drying and rehydration process (see page 1-304). Freeze the food in a traditional or laboratory freezer or even in liquid nitrogen. Oily

or fatty foods should always be frozen very quickly for best flavor and results. Refer to Prefreezing Temperatures for Freeze-Dried Foods, next page, for our recommendations.

Once the ingredients are frozen, set the temperatures of the shelf compartment and the condenser. Because freeze-drying is done in a vacuum, there must be contact between the cold shelf and the tray that holds the food. We like to use disposable aluminum foil trays.

Storage of freeze-dried foods is important. They are so dry that they will absorb atmospheric moisture. Store all foods in a dark, completely airtight environment. Adding a desiccant will help. Take care in rehydrating the foods you have taken so much time to prepare. Meats can easily become overcooked by rehydrating at high temperatures or even at the temperature of boiling water. Fruits and vegetables also are best not rehydrated in boiling water. Grind up anything that isn't pretty, and use it as a powder.

## MAKING FREEZE-DRIED FOODS

**1 Prepare the ingredients.** Cut the food into bite-size pieces or thin slices to greatly reduce drying times. Arrange the food in a single layer on conductive trays that fit in your dryer. Aerate liquids and purees before freezing or grind them into small pieces after freezing.

**2 Prefreeze the food to below the critical temperature.** See the table Prefreezing Temperatures for Freeze-Dried Foods on the next page for suggested temperatures. Faster freezing will yield better texture but will slow sublimation. Some foods have critical temperatures so low that liquid nitrogen or a laboratory freezer is needed to reach them.

**3 Set the freeze dryer temperatures.** Set the shelf temperature to 20 °C / 36 °F above the critical temperature of the prefrozen food. Set the condenser to 20 °C / 36 °F below the critical temperature.

**4 Freeze-dry the food.** Insert a fine temperature probe into the core of the frozen food. Engage the vacuum pump, and run it until the core temperature of the food is within 1 °C / 2 °F of the shelf temperature. Because of the physics of freeze-drying, the core temperature of the food may fall at first. This is not unusual. But if the core temperature of the food fails to increase within a few hours, increase the shelf temperature by 5 °C / 10 °F to supply more energy.

**5 Increase the shelf temperature to 5 °C / 40 °F.** When the core temperature of the food exceeds 0 °C / 32 °F, preliminary drying is complete.

**6 Begin secondary drying.** Set the condenser to the coldest temperature available and increase the shelf temperature to the temperature recommended in the table on the next page, or 20–60 °C / 70–140 °F (as warm as the food will tolerate without damage). When the core temperature of the food reaches the shelf temperature, freeze-drying is complete.



## Prefreezing Temperatures for Freeze-Dried Foods

Ingredient	Freeze to below	
	(°C)	(°F)
fruit	-45	-49
eggs	-40	-40
ice cream	-35	-31
vegetables	-30	-22
meat	-25	-13
pastas, grains, and legumes	-20	-4
stocks, broths, and sauces	-20	-4
seafood	-15	5



When freeze-drying liquids such as stocks, grind the frozen liquid before spreading it out as a thin layer for much faster drying. A Pacojet does a good job on the grinding.

## Best Bets for Freeze-Drying

Ingredient	Prep	Dimension	Drying temperatures				Total drying time	Example use
			Primary Shelf (°C)	Condenser (°C)	Secondary Shelf (°C)	Secondary (°F)		
beef	raw, sliced	1 $\frac{3}{8}$	-20	-4	-45	-49	30 86	8
beef tenderloin	raw, pounded paper-thin		-20	-4	-45	-49	30 86	4
eggs	cooked, peeled	sliced or quartered	-35	-31	-60	-76	60 140	12
fruits	sliced	0.1 $\frac{1}{32}$	-40	-40	-65	-85	30 86	4
	pureed	1 $\frac{3}{8}$						8
	chunks	2 $\frac{3}{4}$						64
ice cream	sliced	2.5 1	-30	-22	-55	-67	40 104	96
lettuce and tender greens	leaves	whole	-25	-13	-50	-58	40 104	12
lobster	raw, whole, shelled		-10	14	-35	-31	20 68	120
noodles	cooked	0.1 $\frac{1}{32}$	-15	5	-40	-40	70 158	12
pork belly	cooked or raw, thinly sliced	0.5 $\frac{1}{4}$	-20	-4	-45	-49	30 86	6
pork shoulder	cooked tender, shredded		-20	-4	-45	-49	30 86	12
scallops	raw, pureed		-10	14	-35	-31	20 68	8
	whole							48
stocks, broths, and sauces	cubed	2 $\frac{3}{4}$	-15	5	-40	-40	70 158	36
	ground	1 $\frac{3}{8}$						8
vegetables	fine julienne		-25	-13	-50	-58	40 104	4
	minced							4
	sliced	0.1 $\frac{1}{32}$						4
	mushroom caps	whole						24
	pureed	1 $\frac{3}{8}$						8

## EXAMPLE RECIPE

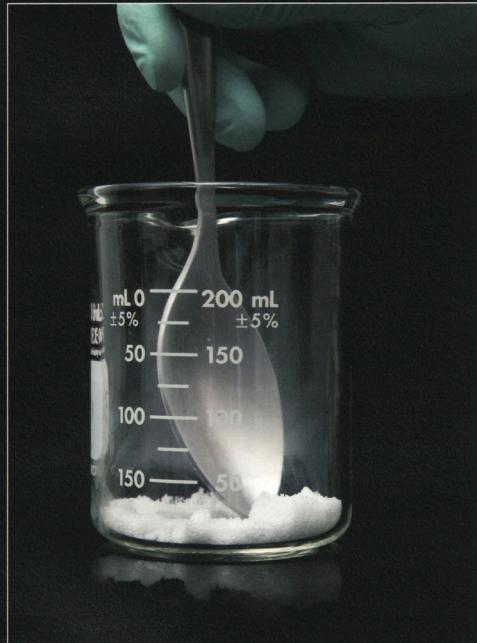
## STRAWBERRY MILK SHAKE ADAPTED FROM JUAN MARI ARZAK

Yields 1.2 kg

INGREDIENT	QUANTITY	SCALING	PROCEDURE
Strawberries, washed and trimmed	1 kg	167%	① Arrange in one layer, and dust with fructose. ② Freeze.
Fructose	400 g	67%	③ Thaw at room temperature. ④ Puree. ⑤ Strain through fine sieve and reserve 600 g of strawberry juice.
Skim milk	600 g	100%	⑥ Disperse powders in milk.
Sweet whey powder	12 g	2% ( <i>1%</i> )*	⑦ Bring to a simmer, and remove from heat. ⑧ Cool.
Locust bean gum (Tic Gums brand)	1.2 g	0.2% ( <i>0.1%</i> )*	
Strawberry juice, from above	600 g	100%	⑨ Blend cooled milk into reserved juice.
Dry ice	100 g	16.7%	⑩ Crush dry ice in blender to fine powder. ⑪ Divide evenly among four glasses. ⑫ Pour 200 g of milk shake into each glass. Wait 10 s; milk shakes will bubble over. ⑬ Serve alongside our Mushroom Swiss Burger (see page 5-11).

(published 2009, adapted 2010)

(% of total weight of the strawberry juice and milk)



Make certain that all dry ice has sublimated before serving.

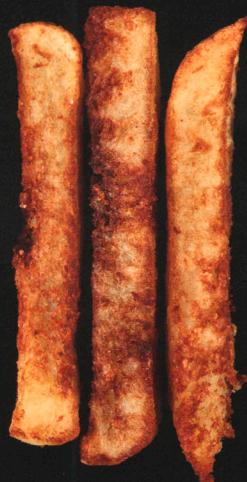


## ULTRASONIC FRIES

Yields 350 g

INGREDIENT	QUANTITY	SCALING	PROCEDURE
Russet potatoes	500 g	100%	① Cut into batons 1.5 cm / $\frac{5}{8}$ in thick by 1.5 cm / $\frac{5}{8}$ in tall, and rinse thoroughly to remove surface starch.
Water	500 g	100%	② Vacuum seal with potatoes in one even layer.
Salt	10 g	2%	③ Cook at 100 °C / 212 °F for 15 min. ④ Transfer to ultrasonic bath, and cavitate for 45 min. ⑤ Flip bag, and cavitate in ultrasonic bath for another 45 min. ⑥ Drain. ⑦ Place hot fries in single layer on wire rack. ⑧ Cool at room temperature, with or without fan. ⑨ Blanch in 170 °C / 340 °F oil for 3 min, and cool. ⑩ Deep-fry in 190 °C / 375 °F oil until golden and very crisp, about 5 min. ⑪ Drain on paper towels.

(2010)

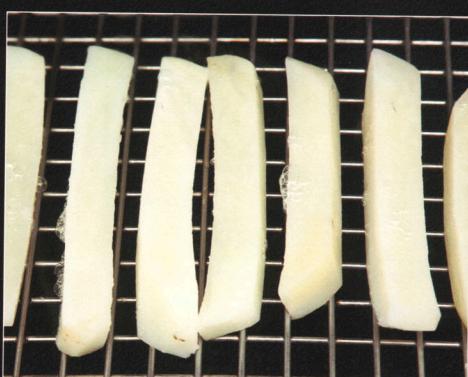


## STARCH-INFUSED ULTRASONIC FRIES

Yields 350 g

INGREDIENT	QUANTITY	SCALING	PROCEDURE
Russet potatoes	500 g	100%	① Cut into batons 1.5 cm / $\frac{5}{8}$ in thick by 1.5 cm / $\frac{5}{8}$ in tall, and rinse thoroughly to remove surface starch.
Water	500 g	100%	② Vacuum seal together with potatoes.
Salt	10 g	2%	③ Cook at 100 °C / 212 °F for 15 min. ④ Drain. Cool and reserve.
Water	100 g	20%	⑤ Whisk together.
Potato starch	50 g	10%	⑥ Vacuum seal carefully with cooked potatoes. ⑦ Cavitate in ultrasonic bath for 45 min. ⑧ Flip and cavitate in ultrasonic bath for another 45 min. ⑨ Drain. ⑩ Place hot fries on wire rack in vacuum chamber. ⑪ Pull vacuum until surfaces of fries are dry. ⑫ Blanch in 170 °C / 340 °F oil for 3 min, and cool. ⑬ Deep-fry in 190 °C / 375 °F oil until crisp, for 3 min. ⑭ Drain on paper towels.

(2010)



The chips must be cooled and dried both after the boiling step and after parfrying. Vacuum cooling and air cooling both work, but yield different textures—see page 322.

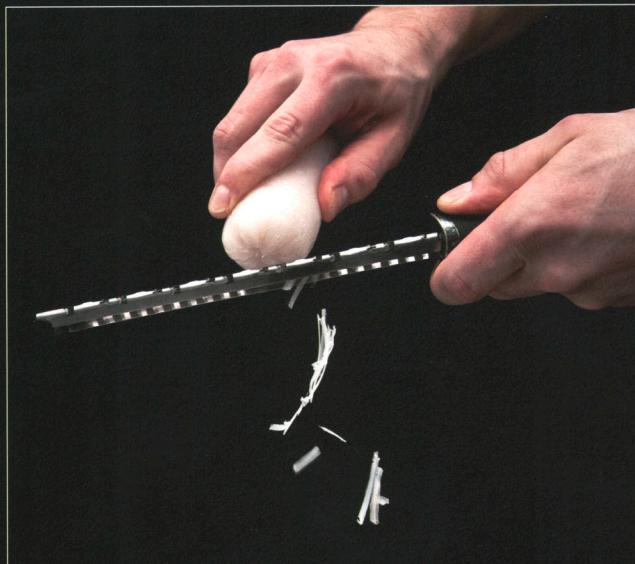
We use a 21 l / 5½ gal Branson 8150 ultrasonic bath set at a frequency of 40 kHz for making these fries.

## ONION RINGS

Yields 250 g (about 10 onion rings)

INGREDIENT	QUANTITY	SCALING	PROCEDURE
Onions, thinly sliced	750 g	375%	① Sauté until light golden, about 10 min and cool.
Unsalted butter	100 g	50%	② Vacuum seal cooked onions with water.
Water	150 g	75%	③ Cook sous vide in 90 °C / 194 °F bath for 1 h.
Onion stock, cold, from above	45 g	22.5%	④ Strain and cool onion stock. Measure 245 g for recipe.
Methocel A15C (Dow brand)	4 g	2%	⑤ Bring onion stock to simmer, and disperse Methocel A15C and salt.
Salt	1.5 g	0.75%	⑥ Refrigerate Methocel solution for at least 8 h to hydrate fully, and reserve cold.
Onion stock, cold, from above	200 g	100%	⑦ Combine and blend all ingredients in food processor to fine, smooth paste.
Tapioca starch	120 g	60%	⑧ Vacuum seal.
Salt	3 g	1.5%	⑨ Cook sous vide in 93 °C / 200 °F bath for 20 min. ⑩ Cool completely until hardened, at least 12 h. ⑪ Remove from bag, and grate with Microplane. ⑫ Dehydrate at 70 °C / 160 °F until hardened, about 3 h. ⑬ Reserve breading in airtight container.
Yellow onions, thinly sliced	500 g	250%	⑭ Brown onions over low heat.
Neutral oil	50 g	25%	⑮ Deglaze with water as needed until very tender, about 40 min. ⑯ Drain excess oil, and blend to smooth puree. ⑰ Cool completely, and measure 100 g. ⑱ Blend 100 g of puree with Methocel solution, and transfer mixture to pastry bag. ⑲ Pipe onion ring shapes onto silicone mat. ⑳ Freeze.
Tapioca starch	100 g	50%	㉑ Dredge frozen onion rings in tapioca starch, and shake off excess.
Egg, blended	50 g	25%	㉒ Dip rings in egg.
Frying oil	as needed		㉓ Dredge rings in breading until evenly coated, and place on silicone mat. ㉔ Deep-fry rings in 190 °C / 375 °F oil for 2 min, ensuring that puree stays inside coating. ㉕ Drain on paper towels.

(2008)



11



19



20



23



22

Here we make a puffed starch snack and grate it to make the breading for the onion ring. The ring itself is made of onion puree.