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New York City, a waiter set a of peach palm in front of me.	Pr	n to E-Mail This cinter-Friendly ave Article CHOCOCK COMING SOON
Witchell Feinberg for The New YorkBass with vanilla bean prepared byYannick Alléno/Le Meurice, Paris.	This was a watershed moment on two account because Keller had indeed managed to make s mundane as watermelon taste different it had density of a McIntosh apple. But also because dining has reached the level of sophistication waiter will assume that a diner knows what "C and that this knowledge will enhance the expet tasting diced watermelon. That won't be assumed here. "Cryovacking" is term for putting food in a plastic bag and vacu Sometimes the food is then cooked in the bag the pressure of the packing process is used to into ingredients. The watermelon, for instance packed with 20 pounds of pressure per square compact the fruit's cells and concentrate its flat texture of meat. Just the thing for backyard pic	something as ad the crisp e American at which a Cryovacked" is, erience of s an industry num-packing it. . Other times, infuse flavors e, was vacuum- c entimeter, to avor. It had the Most E-Mailed Articles Che Not Bork Cimes Most E-Mailed Articles Che Not Bork Cimes Past 24 Hours Past 7 Days 1. Well: Attention Disorders Can Take a Toll on Marriage 2. Prone to Error: Earliest Steps to Find Cancer 3. Adventures in Very Recent Evolution 4. Many States Adopt National Standards for Their Schools 5. Recipes for Health: Spicy Quinoa, Cucumber and Tomato Salad Go to Complete List ADVERTISEMENTS
Readers' Opinions Forum: Cooking and Recipes	Cryovacking, which is more often called <i>sous</i> for "under vacuum"), is poised to change the v chefs cook and like the Wolf stove and the i blender, it will probably trickle down to the he someday. Cryovacking has also given great m the scientific cooking revolution of the last fiv have begun using techniques developed for in production and advances in science to manipu chemical make-up of proteins, starches and fa new textures and flavors everything from fr mayonnaise to hot gelatins.	Election 2012 - Definitive Coverage
Polly Borland for The New York Times The Cryovacked Kitchen: Bruno Goussault, with a Multivac, left (to seal the food) and a thermal circulator (for cooking it).	Ferran Adriá is often seen as the hero of this r From his tiny restaurant, El Bulli, in Rosas, Sy sought to reform diners' expectations of ingree caviar (his might look just like osetra but is m ink and calcium chloride) and to invent new ft textures (carrot juice frothed to a texture he ca the man who helped Keller master the techniq compress watermelon and poach lobster with results, who taught Wylie Dufresne how to "ff water chestnuts with honey and sherry vinega having a greater impact on how people cook t since Escoffier is not even a chef.	pain, Adriá has dients like nade of squid lavors and alls "air"). But jue that would exquisite lash pickle" r and who is
	Bruno Goussault, 63, is both a scientist and ar He has been training chefs like Fabio Trabocc Ritz-Carlton and Michel Richard at Citronelle Washington, Dan Barber at Blue Hill in New Daniel Boulud at Daniel, also in New York, ne	chi at the e, both in York and

Under Pressure - New York Times



Mitchell Feinberg for The New York Times

A sous vide creation from Chef Yannick Alléno of Le Meurice in Paris. The bag is removed before serving. use sous vide but also to understand the science behind it. Where Escoffier organized the way chefs cook, dividing the professional kitchen into stations (sauces, cold foods, sautéing, pastry), Goussault has reprogrammed their approach to temperature, technique and taste -- their fundamental understanding of cooking. At Charlie Trotter's in Chicago, the intense heat and scrape of pans against the stove is giving way to an almost placid atmosphere, the barely audible hum of water baths that run 24 hours a day.

Dufresne, the chef at the innovative Manhattan restaurant WD-50, calls Goussault's contribution to cooking "monumental." The advancements he has made are on par with the invention of the food processor and the gas stove, Thomas Keller says, and they will be around forever. "With the Cuisinart," Keller says, "there was no one that came with it. You got the book inside. With sous vide, the technology is so complex and there are so many variables. The thing that comes with sous vide is Bruno."

When I met Goussault this past June, he was working at the American office of Cuisine Solutions, a food manufacturer in Alexandria, Va. He had on a blue checked shirt and a tie dotted with tiny bunnies. Goussault wanted to show me around the Cuisine Solutions plant, so we dressed in lab coats, booties, shower caps and masks, as if we were preparing for surgery, then headed into the damp, cold world of a food factory. In one room, a row of square steel vats was set on a platform. Inside one of the vats, hundreds of lamb shanks, sealed in vacuum-packed plastic bags, were submerged in water, cooking. There was no scent of food, nor the kind of steam and heat we normally associate with cooking. "When you cook at home, you have a lot of flavor in your apartment," Goussault explained. "And when you cook sous vide, all that flavor is inside the bag." The sous vide bag works as a hermetic seal, keeping in both juices and aroma; and by cooking in water, you get better heat transfer than you would in, say, an oven.

Goussault began working more intensively with Cuisine Solutions' American operations in 1998. The company, which now grosses \$50 million a year, prepares food for the Super Bowl, Costco, the first-class cabins on Air France and American Airlines, the MGM Grand in Las Vegas and large hotel chains like Westin and Hyatt. Much of that food is cooked sous vide. When you order braised short ribs at the Hyatt Regency in Phoenix, what you are served was actually cooked for 42 hours in Virginia and then simply reheated in the bag and garnished in Phoenix.

Until recently, Goussault's most significant work had been on this scale. He developed the sous vide process for a number of hotels and food companies in France, Japan, Hong Kong, the Philippines and the U.S., enabling them to produce higher quality foods without preservatives. And in Norway, Chile and Africa, he designed fish-processing factories, where line-caught fish are cleaned and cooked (some of them before the fish can go into rigor mortis, and therefore before enzymes begin breaking down the flesh), yielding better quality fish with a longer shelf life.

Goussault, who logged more than 120,000 miles on airplanes last year, has more plans yet: he hopes to take sous vide to the Niger River basin between Mali and Niger, where farmers from surrounding regions take their cattle. He would build feedlots, using the local abundance of cottonseed for feed. After slaughtering, the meat could be cooked, sous vide of course, using solar power.

Goussault designed the production line at Cuisine Solutions for 130,000 meals a day. Like most food factories, it is very cold, with large refrigerated rooms that decrease the risk of bacteria. Long conveyor grills sear hundreds of chicken breasts at a time; steel tumblers the size of jet engines are filled with ingredients, then pressurized, a process that forces seasonings to penetrate the foods more deeply. This is Goussault's real domain. He is as much an engineer as a scientist -- as pleased with his invention of nonslip doilies for French train tables as he is with his cooking techniques.

For decades, food was poached in sturdy plastic bags at traditional temperatures, simmering or boiling. Goussault discovered that keeping the temperature as low as possible and later cooling the food in several stages yielded a wildly different -- and tastier -- result. A piece of fish, for instance, can be cooked at about 130 degrees -- a hot bath, essentially -- for 30 minutes, then cooled, successively, at room temperature, in cold water,

then in ice water, before being reheated and served. Cooking in bags at such low temperatures was long considered a recipe for botulism, but Goussault has debunked this fear, proving that the long cooking times followed by proper cooling kill bacteria with the same effectiveness as higher temperatures, also stabilizing the food so it can be stored longer before serving.

Higher temperatures, Goussault argues, do irreparable damage to food. The cell walls in the food burst, making it impossible for the food to reabsorb the liquid it loses. Roasting a chicken at 350 degrees until its internal temperature reaches 180 degrees (as the U.S.D.A. recommends) causes the breast meat to dry out and juices to accumulate in the bottom of the pan. Tradition has it that cooks use those lost juices to make a gravy, which is later reapplied to the dry meat. All of which, come to think of it, doesn't make much sense.

Low temperatures make for extremely succulent food because there is virtually no loss of natural juices. All of the gravy is reabsorbed by the meat, intensifying its flavor and allowing it to retain its structural integrity. As Goussault explains, "You have the expansion, you have a little purge and during the chilling system -- if you have a good chilling system -- you can absorb this exudation." There's nothing more romantic to a chef than absorbing exudation.

Vacuum-packing foods provides a number of other advantages. The hermetic seal created in a sous vide bag traps flavor that would otherwise be lost. Carrots simmered in water, for instance, bleed off much of their flavor. As Yannick Alléno, the chef at Le Meurice, a two-star restaurant in Paris, points out, "You would almost be better off drinking the water." The atmospheric pressure created during the vacuum-packing process also promotes osmosis among the contents of the bag, so sous vide has become an important tool for marinating and curing foods and infusing oils with spices and herbs. As a result, chefs don't need to use as much seasoning, either. When they are marinating a food with an expensive aromatic like truffles, this can make all the difference.

After the tour, we sat down in a small test kitchen above the factory floor to taste some of the company's products -- a lamb shank that had been cooked for 36 hours, scallops and the like. Goussault ate with relish, washing it down with red wine. When he is at home in Paris, he likes to grill steaks and roast lamb, but for now those primitive techniques were far from view. Goussault instructed the chef in the kitchen to drop an egg into a thermal circulator, sous vide's "oven" -- a circulating water bath whose temperature can be adjusted to within a tenth of a degree. It was set at 64.5 degrees Celsius (about 148 degrees Fahrenheit), which he calculated as the perfect egg-cooking temperature.

Chefs, Goussault said, "need people like me to regulate and to push the creativity to the next place." He quantifies what chefs aim to do intuitively. Some need less help than others. "I was in Joël's kitchen," Goussault said, referring to Joël Robuchon, one of France's most revered chefs, "and he was cooking eggs, so I tested the temperature; I put in my probe, and it was 64.5. I asked him how he knew this, and he just said that was how he liked it best."

After 45 minutes, the chef removed the egg from the water and Goussault cracked it over his plate. I had never seen an egg like this: the whites and yolk, cooked to precisely the same consistency, spilled out like a wobbly custard, and Goussault, using a spoon, began pulling the whites from the yolk. The yolk was bright and creamy and stood up like a marshmallow. "You see, you see!" Goussault said. "It's all about the temperature."

Sous Vide has been around since the late 1960's, when food-grade plastic films and vacuum packing were mastered by French and American engineers and later manufactured under the aegis of the Cryovac division of the W. R. Grace Company. Originally, vacuum-packing was used to seal and pasteurize industrial foods for a longer shelf life. In 1974, Pierre Troisgros, a three-star chef in Roanne, France, decided to look for a new way to cook his foie gras, which shed 30 to 50 percent of its original weight in cooking. He enlisted Georges Pralus, a chef, to help. Pralus had the idea of wrapping the foie gras in layers of plastic before they cooked it and, after a number of experiments, they had their breakthrough: the foie gras lost only 5 percent of its weight -- an enormous savings. Pralus, now widely known as the father of sous vide, eventually worked with Cryovac to open his own school, Culinary Innovation, where he taught the technique. Over the years, thousands of chefs from around the world have come to study with him.

Goussault, as it happens, was working along the same lines, but at an industrial level. In 1974, Goussault worked on a study that was presented on the sous vide cooking of beef shoulder at an international frozen-foods conference in Strasbourg, France. They found

that cooking the beef sous vide extended its shelf life to 60 days. France, however, would not change its food-safety laws regarding perishability until the 1990's.

"The thing I write today is the same thing I wrote 34 years ago," Goussault says, laughing, "but nobody listened. Now, a few people listen." Today Goussault is friends with Pralus and even invests in his school, although they teach different approaches (Pralus cooks sous vide at higher temperatures), and they continue to subtly disparage each other's work. "He might have done the research," Pralus said of Goussault, "but I was the first one who did sous vide for restaurants, who made it a culinary endeavor." Without Pralus, sous vide might never have reached the temples of cuisine.

Smiling, Goussault said: "Pralus calls himself the pope of sous vide. He tells people he invented sous vide, but it's not true. But I let him say that because it makes him feel better. So after he said he was the pope, I said I was the sous-pope." Chefs say that Pralus is the artist, Goussault the scientist. It just happens that the artistry in sous vide can be extremely dangerous from a food-safety perspective, which is why the two began collaborating in 1980, when executives at Cryovac asked Goussault to add a scientific basis to Pralus's training. "They asked me to give it the right system because Georges Pralus is completely undisciplined," Goussault explained. He has been the man behind the curtain all along.

Goussault became a scientist almost as a last resort. He had previously studied in a seminary (an experiment that ended, he said, "because I was not able to respect the vow of chastity"), lived in a commune, earned degrees in economics, agriculture and psychology and spent time in Niger before settling in Paris in 1970 as a scientist in food-safety laboratories.

In the 1980's, a project with SNCF, France's national train system, gave him the opportunity to work with Joel Robuchon to create a menu for its first-class service between Paris and Strasbourg. Robuchon, concerned about the fragility of high-quality food, knew there was no way to assemble fresh ingredients at 100 miles per hour. With Goussault, he developed a menu based on foods that could be prepared sous vide and simply reheated on the train.

In 1991, Goussault started his own consulting company, the Centre de Recherche et d'Études Pour l'Alimentation, where he now trains chefs like Michel Bras and Alain Ducasse in everything from the use of carrageenan and seaweed extracts to sous vide. Goussault's team of seven engineers also develops products for companies like Nestlé, and it tests equipment for manufacturers, like a new oven that can go from 200 degrees Fahrenheit to 500 degrees in less than three minutes.

Even though many chefs in France use sous vide in their restaurants, it had long been considered a technique suitable only to chains and factories. The fact that some old-guard French chefs like Alain Senderens, Paul Bocuse and Joël Robuchon have signature lines of sous vide convenience foods in supermarkets has not helped to remove the stigma. A television news report in the mid-90's revealed that the French restaurant chain Chez Margot was cooking some of its entrées sous vide; it went bankrupt soon after.

"Joël Robuchon is the only chef who openly admits he uses it," Goussault said. "One member of Le Club des Cents" -- an esteemed gastronomy club -- "said that any chef who uses sous vide is a fraud."

Indeed, when I interviewed Senderens recently, he initially denied using sous vide in his kitchen at Lucas Carton, his three-star restaurant in Paris. But when I mentioned that the cooks at Le Meurice, a nearby up-and-coming restaurant, were using sous vide to prepare more than 50 items on the menu, Senderens suddenly remembered that he does use sous vide at Lucas Carton -- but only for the chicken with truffles.

Even in America, where there are fewer such prejudices, sous vide has taken more than two decades to gain acceptance. In 1988, just when Cuisine Solutions, then called Vie de France, and a few chain restaurants were gearing up their sous vide operations, The Washington Post published an article questioning the safety of sous vide and other food-storage techniques like modified-atmosphere packaging, which were new at the time. Although sous vide was legal to use, the Food and Drug Administration has always warned of its potential dangers in restaurants. Still, sous vide is part of the F.D.A.'s Food Code, and any manufacturer who wants to use it can get permission by applying to the U.S.D.A. Chipotle, a burrito chain backed by McDonald's, now cooks all its braised pork sous vide. There may be hope for airline food yet.

n high-end restaurants, sous vide began as a rarefied curiosity. Sous vide machines cost \$3,000 to \$6,000; thermal circulators start at \$1,200; and staff training by Goussault runs

\$2,000 a day for a minimum of four days. David Bouley, who learned from Pralus, was one of the first American chefs to use sous vide at his restaurant, then called Bouley Bakery. Shea Gallante, the chef at Cru in New York City, who then worked for Bouley, admitted, "At the time, no one was really sure how it worked."

Thomas Keller, who has done work with Cuisine Solutions for a sous vide product line, has had Goussault train the kitchen staff at both the French Laundry, his signature restaurant in Yountville, Calif., and Per Se, in New York. Two years ago, Michael Anthony at Blue Hill contacted Goussault to learn more about the technique. Since then, word about Goussault has spread among American chefs. Recently, Fabio Trabocchi invited Goussault to spend four days training his team at the Ritz-Carlton in Washington.

Sous vide has reached the stage where the art must now catch up to the science. While industrial food companies use sous vide primarily for braising -- where all of the ingredients are in the bag -- chefs are beginning to see it as a way to prepare and manipulate individual ingredients, sometimes without even cooking them. And, naturally, they are using much higher quality ingredients, so the results are quite different from what you might get, say, on American Airlines. If you go to Cru and order Gallante's Wagyu beef, it will be unlike any piece of beef from a saute pan or broiler. Instead of a brownish rim and increasing redness toward the center, it will be evenly rare from the outer edge all the way through. At Per Se and the French Laundry, cooks are using sous vide to compress peaches, cucumbers and tomatoes. They've found that compressing celery has the same effect as blanching it and therefore saves them a step. "Pineapple is extraordinary," Keller says. They're also using it to infuse oils and slow-cook pig's head.

Chefs have found less lofty ways to employ the technique as well. At CityZen, in the Mandarin Oriental hotel in Washington, they make ice cream bases in sous vide. "There's no putting your sugar and egg and cream in a pan and stirring," says Eric Ziebold, the chef. His pastry chef blends the ingredients, seals them in a bag and cooks it in water.

"More than anything, the vegetables and the proteins taste remarkably more like themselves," Dan Barber, the chef and owner of Blue Hill, wrote in an e-mail message. "When it comes to things like artichokes, steaming and boiling and braising are fine, but there's a great loss of liquid as it cooks -- which is another way of saying a great loss of flavor because the juice of the artichoke itself, while mostly water, is very flavorful. Sous vide eliminates this loss, and hence the sensation that you're tasting a true artichoke -- not just a delicious artichoke, but an artichoke the way it was intended to taste."

Much is made of the artistry of chefs, but running a restaurant kitchen well often has more to do with control and consistency. And in large kitchens or multiple restaurants, those things can get out of hand pretty quickly. Alléno, the chef at Le Meurice, oversees 72 cooks; Daniel Boulud has a staff of 65 to 70 among his three New York restaurants. Most cooking relies on the cook's ability to judge doneness based on sight and feel. With sous vide, it is all about precise times and temperatures. "You can have your restaurant 6,000 miles away," Ziebold says, "and you don't have to worry about the cooks at your restaurant in D.C. getting the duck right because they're cooking it sous vide and they know the temperature." Every year, Janos Kiss, the corporate executive chef for Hyatt Hotels and Resorts, prepares a dinner for more than 5,000 people on Super Bowl weekend. It used to take 20 chefs four days to cook the dinner. Now, with sous vide, they do it with six chefs in two days.

In the long run, sous vide's great contribution may well be this consistency. A chef with a restaurant empire, like Nobuyuki Matsuhisa, may finally be able to guarantee that the lobster with wasabi-pepper sauce at Nobu in London is every bit as good as the one at Nobu in New York. It may spell the end to bad wedding food. And if it catches on at companies from Stouffer's to Whole Foods, it could forever alter the state of convenience food.

In the meantime, all the attention being paid to temperature and laboratory precision has pushed chefs in more creative directions. When Grant Achatz built his new restaurant Alinea in Chicago, thermal circulators from PolyScience, a laboratory-equipment manufacturer, were part of the kitchen design. To these, he has added a 40,000-r.p.m. homogenizer (what Philip Preston, the president of PolyScience, calls a "coffee grinder on steroids") -- for making the world's most emulsified vinaigrettes and confections like carrot pudding made with carrot juice, cocoa butter and grapeseed oil -- and an entirely new mechanism they're calling the Antigriddle, which has a surface that chills to minus 30 degrees Celsius (minus 22 Fahrenheit), allowing you to freeze food in the same way you would saute it. A dollop of sour cream becomes brittle on the bottom and stays at room temperature on top.

For all chefs' forward thinking, though, top kitchens still run on frat-house principles. So sous vide also comes in handy for hazing new cooks. At WD-50, Dufresne said, "I've seen virtually every kind of personal belonging end up in one of these bags." Veteran cooks are known to take a new cook's clothing from his locker and put it through the sous vide machine, compressing his jeans and shirt to the size of hockey pucks.

In late July, Goussault went to Citronelle in Washington for a follow-up training session with Michel Richard's head cooks, David Deshaies and Cedric Maupillier. They were having trouble with the salmon and sweetbreads done sous vide. The salmon had a perfect silky texture but was too fragile and, they worried, undercooked. And the sweetbreads were losing too much liquid.

Goussault is often called in to help chefs perfect their technique. "My job is to repeat, repeat, repeat, "he says. He unpacked his briefcase, removing a laptop, a box of batteries, a jumble of wires and a number of handheld monitors that, when hooked up to the foods with probes, can record their minute-to-minute temperature arc during the cooking process. The large stoves around the kitchen were mostly unoccupied. Two thermal circulators sat poised on a steel countertop, humming like Jacuzzis. Deshaies dropped two pieces of salmon in ice water that contained 10 percent salt, then set a timer for 10 minutes. Salt, according to Goussault, "modifies the osmotic pressure in the cells," meaning it prevents the albumen, that white substance, ghastly to chefs, that gathers on the surface of fish, from leaching out of the salmon when it cooks. They sealed the salmon in sous vide and inserted probes. It now looked as if the salmon had a heart monitor.

For meats and fish, there is a window of doneness between 52 degrees Celsius (about 125 degrees Fahrenheit) and 62 degrees Celsius (about 144 degrees Fahrenheit). Below 52, you risk bacteria. Above 62, you begin denaturing proteins. Goussault then put one piece of salmon in a thermal circulator set at 56 degrees Celsius and one set at 53 degrees Celsius to see if they could raise the final internal temperature to 54 and 50 degrees respectively without changing the texture they had achieved in the piece they had cooked to 47 degrees. Food cooking in a thermal circulator looks a bit like an animated version of a Damien Hirst sculpture -- abstract animal parts suspended in a vibrating liquid.

Standing over his cutting board, Deshaies said, "Some chefs the other day, they said to me: 'What? So you put it in the plastic and put it in the water and that's it?' " He shook his head. "It's not so easy." It takes practice to get the sous vide machine to seal correctly. Foods must be chilled before sealing, otherwise the pressure inside the machine will cause them to cook during the sealing process. The pressure must also be calibrated for every type of food, so the food stays compact but firm. Once the food is sealed, its proper cooking temperature and internal temperature must be determined. Citronelle's lamb loin, for instance, is first infused with garlic in a sous vide pouch, then it is sauteed, chilled, resealed in sous vide and cooked in a thermal circulator at 60 degrees Celsius until its internal temperature reaches 56 degrees. It is then cooled at room temperature, in cold water, then further cooled in ice water, then chilled until an order comes in, at which point it is reheated in a warm water bath, still in its sous vide bag.

As Barber at Blue Hill explained: "If you're patient, and you try different temperatures and different times, at some point you'll achieve a taste from the product that's better than it's ever tasted before. I'm not exaggerating. That's happened to me with nearly everything, almost never the first time I try it, but over time and with experimentation, that's the reward."

After 40 minutes or so, the pieces of salmon registered at 50 degrees and 54 degrees. Each was removed from the hot water, and cooled systematically. It was time to taste. On three plates, Deshaies lined up the pieces of salmon, including the one cooked the day before to 47 degrees. All three pieces were pink all the way through and glistening with moisture, a consistency unlike that of any piece of salmon cooked in an oven.

The piece cooked to 54 degrees was dismissed as "airplane food." Deshaies and Maupillier preferred the fish they had cooked to 47 degrees, a temperature that Goussault insisted was unsafe. The salmon cooked to 50 degrees was a good compromise, moist and delicate, but without any signs of rawness. Goussault seemed tense. He had recently done a similar experiment with Thomas Keller's team at the French Laundry, and he now explained that Keller had also preferred the 47 degree salmon.

"Like us!" Deshaies said.

"But his sous-chef feels the difference between 47 and 50 is too little and 50 is safer,"

Goussault said. He then added: "His is different. He does it with olive oil. Delicious."

For Deshaies, it was suddenly no longer about science. He shot a concerned look at Richard. "We can do that, too," he said.

Amanda Hesser is the magazine's food editor and the editor of T: Living.

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