WEBER
VACUUM COOLING

VACUUM COOLING OF MUSHROOMS

Premium performance - Affordable cost!

WeberCooling is a worldwide leader in Vacuum Cooling Technology.

Having the correct cooling processes in place is important in the handling of any fresh produce but for mushrooms it can be even more critical. While consumer demand for nutritious and delicious mushrooms continues to grow, the popular mushroom present particular challenges for growers because of their shorter shelf life compared to other produce. Once harvested, mushrooms are highly susceptible to bacteria growth. They can dehydrate and deteriorate rapidly unless quickly cooled and maintained at the correct storage temperature. Vacuum cooling offers the best solution to growers, allowing them to rapidly cool their mushrooms.

Weber Cooling can offer you cost efficient vacuum cooling solutions, with highest possible cooling speeds. At lowest TCO, with global support. In the past few years Weber Cooling has installed many vacuum pre-coolers at mushroom farms, all over the world. With our systems exceptionally short cycle times (10-15 min.) can be achieved.

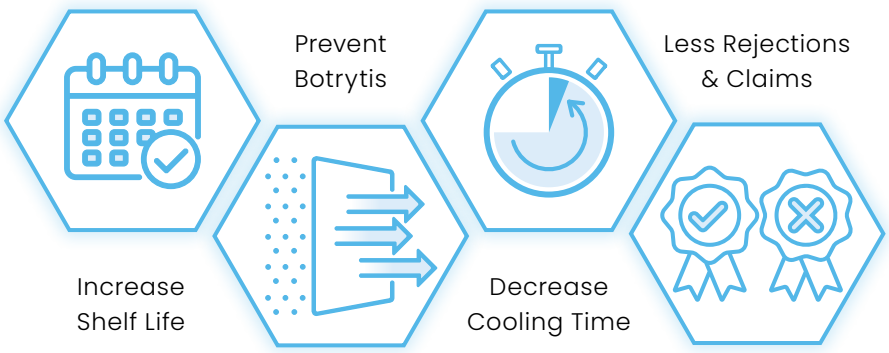
An added benefit of vacuum cooling is that the skin of the mushroom is dried, preventing browning. With vacuum cooling, you can preserve freshness and prolong shelf life!

The importance of Pre-Cooling

Pre-cooling refers to the rapid removal of field heat (normally around 80–85%) shortly after the harvest of a crop. Field heat can be defined as the difference in temperature between the temperature of the crop harvested and the optimal storage temperature of that product.

Pre-cooling is a very important step in the post-harvest stage as mushrooms get intro stress after the harvesting process. This results in transpiration (sweating, resulting in loss of weight and in the building of moisture on the skin of the produce), and high respiration (breathing = burning sugars), resulting in loss of life, but at the same time in an increase in product temperature, especially when packed tightly. Mushrooms at 20˚C produce 600% more heat energy compared to mushrooms at 2˚C! This is why it is critical to get them cooled quickly and correctly.

Both respiration and transpiration can be greatly reduced by rapid pre-cooling. On average both can be reduced by a factor of 4, 5 or even more, if cooled down from harvesting (on average at 20–30 ˚C/ 68–86 ˚F down to below 5 ˚C /41 ˚F). The perfect end temperature is defined by many factors, like produce to be cooled and the post harvesting steps following the pre-cooling.



Proper pre-cooling will:

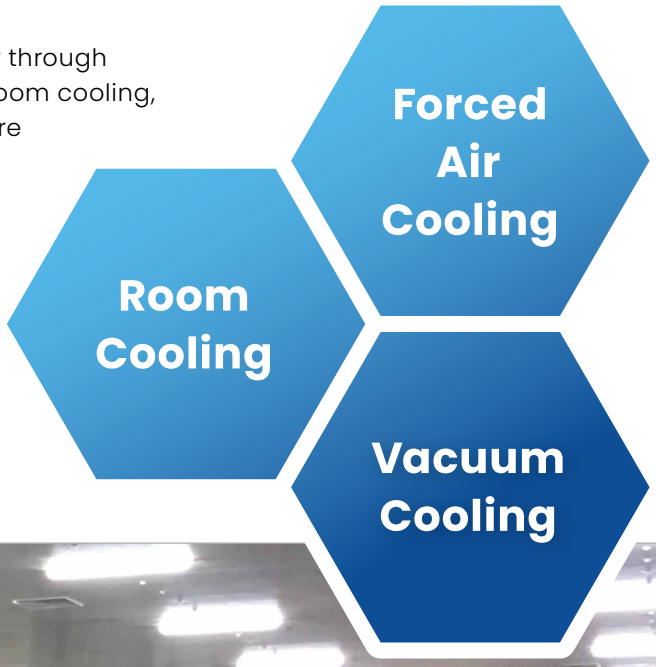
- Reduce respiration, resulting in quality preservation
- Prevent mushroom browning by drying of the skin
- Slow the rate of decay by inhibiting microbial growth (fungi and bacteria)
- Reduce the rate of ethylene production
- Increase market flexibility through longer storage life
- Meet customer requirements on freshness and shelf life

Overall rapid pre-cooling helps to reduce the loss in quality of produce once it has been harvested. Likewise, precooling increases the shelf-life of fresh produce. Higher quality and longer shelf-life means more profits to mushroom growers.

Available **Pre-Cooling Methods**

There are different alternative methods for the pre-cooling of mushrooms:

- **Room Cooling** (in a conventional cold storage)
  There is a trade-off with Room Cooling. It requires relatively low energy but is very slow.
- **Forced Air Cooling** (or blast air cooling, forcing cold air through your produce) Forced air will cool faster compared to room cooling, but it will always cool "outside-in" and will reach the core of the product only after long cooling
- **Vacuum Cooling** uses the boiling energy of water to cool down your produce.
  For the water in the product to boil, the pressure in the vacuum room must be brought down to ultra-low pressures. Cooling to the core of the boxes is easy – and fast.



Comparison of Pre-Cooling Methods

The table below compares pre-cooling methods as applied to fresh fruits and vegetables. In this document we will tell you more about the technology of Vacuum cooling, the applications and benefits it offers.

Variable	Cooling method				
	Ice	**Hydro**	**Vacuum**	**Forced-air**	**Room**
Cooling Times (h)	0.1 - 0.3	0.1 - 1.0	0.3 - 2.0 *	1.0 - 10.0	20-100
Water contact with the product	yes	yes	no	no	no
Product moisture loss (%)	0 - 0.5	0 - 0.5	1.0 - 3.0	0.1 - 2.0	0.1 - 2.0
Capital cost	high	low	medium	low	low
Energy efficiency	low	high	high	low	low

Source: Kader and Rolle, 2004

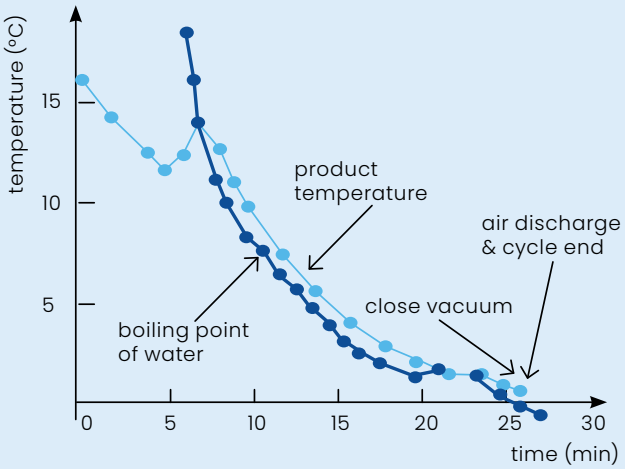
** It is decreased in the last 10 years down to 0.25 - 0.4 hours.*

Vacuum Pre-Cooling

By far the most important part of maintaining the quality of mushrooms is ensuring that they are cooled as soon as possible after harvest and that optimum temperatures are maintained during distribution. Mushrooms are usually harvested at relatively high temperatures. As they are living products, they continue to create heat (and moisture). To prevent excessive temperatures, to increase shelf life, to reduce rejects and to prolong the potential shipping times, quick pre-cooling right after harvesting or packing is vital.

Vacuum cooling is 5-20 times faster and more effective than conventional cooling!

Only vacuum cooling can cool ultra-fast and uniformly to the core down to 0-5 °C for most produce within 15-30 minutes! The more surface the produce has related to its weight, the faster it can cool, providing you have chosen the right vacuum cooler: depending on the desired end temperature, **mushrooms can be cooled within 10-20 minutes**.



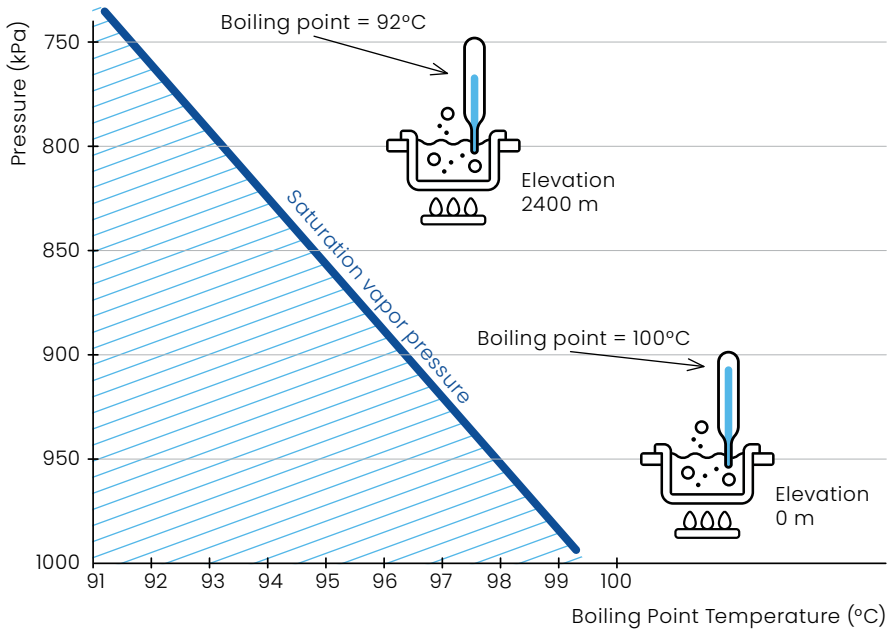
Flash point reached, cooling process starting

The final cooling temperature plays an important role in the time to cool. The first stage of cooling, down to around 5 °C, is always very fast (providing the vacuum cooler is fast enough), but cooling down to reach temperature around freezing point, some more time is needed.

A huge advantage of vacuum cooling is that paper and plastic packaging materials in the boxes do not affect the efficiency of cooling, free water is removed, **boxes can be packed tightly** and stacked in any manner in the pre-cooler.

Vacuum Cooling **Technology Explained**

Vacuum works with pressure. There is a relation between the pressure level and the boiling point of water. The lower the pressure, the lower the boiling point of water. When introducing a product recently harvested into the vacuum room, vacuum pumps start evacuating the air in the room, lowering the pressure. When the pressure level reaches the product's temperature, a fraction (0,8-2%) of the moisture inside the product is being forced to evaporate. This evaporation process extracts energy (= heat) from the product. Because of the created vacuum, not only the outside is cooled down, but the product's core as well, as cooling takes place from inside the product.



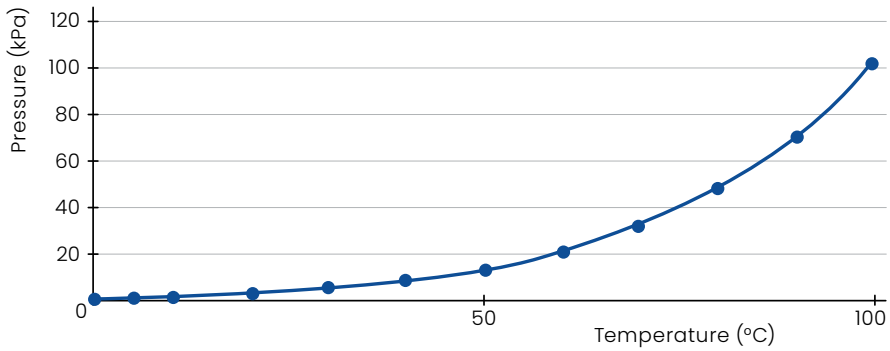


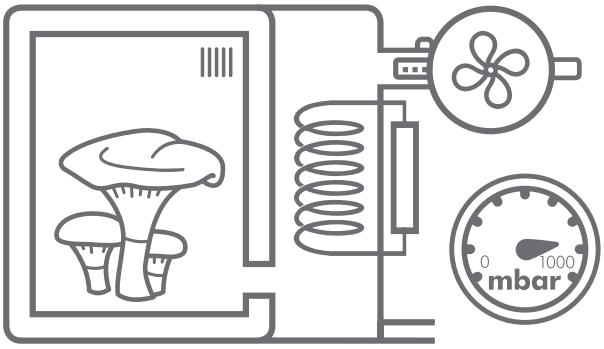
Table relation Pressure and Boiling point of water

Pressure on system		Temperature at which water boils	
mBar	Torr mm Hg	°F	°C
1000	760	212	100
56.2	42.2	95	35
42.4	31.8	86	30
31.7	23.8	77	25
28.4	21.3	68	20
20.6	15.5	64.4	18
18.2	137.7	60.8	16
17.0	12.8	59	15
16.0	12.0	57.2	14
15.0	11.3	55.4	13
14.0	10.5	53.6	12
13.1	9.8	51.8	11
12.3	8.6	48.2	9
10.7	8.0	46.4	8
10.0	7.5	44.6	7
9.3	7.0	42.8	6
8.7	6.5	41	5
8.1	6.1	39.2	4
7.6	5.7	37.4	3
7.1	5.3	35.6	2
6.6	5.0	33.8	1
6.1	4.6	32	0

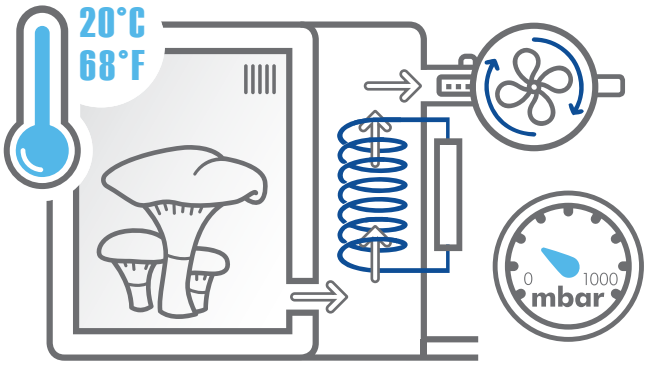
A condensing system is used to condensate the water vapor coming from the produce. This system is being cooled by a refrigerant, or by (glycol) water. Based on intensive research, and hundreds of vacuum coolers installed in the market – Weber Cooling has optimized the vacuum – cooling balance for each product to be cooled. For mushrooms, we offer systems which allow cycle times of even 10 minutes or less. In this **»VIDEO«** you can see we can even cool down the mushrooms in 2-3 minutes if needed!

Note: For every 6-7°C reduction in temperature, approximately 1% of the produce weight needs to be turned into water vapor. In an average cycle of 15-25 minutes, weight loss can vary between 2-3%.

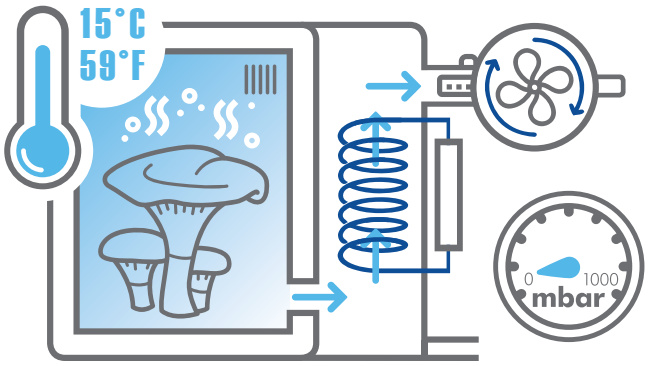
Vacuum Cooling **Cycle**



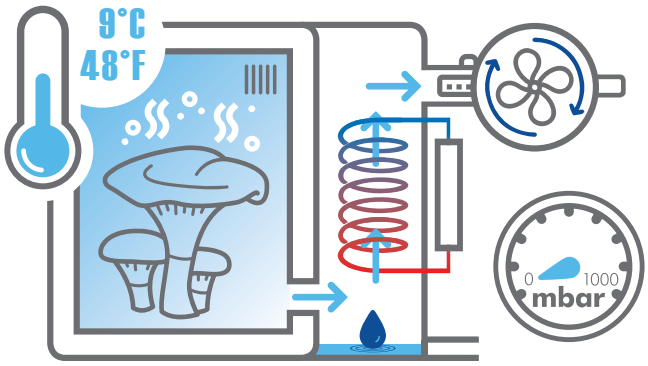
1 The product is placed in the vacuum room and room is closed.



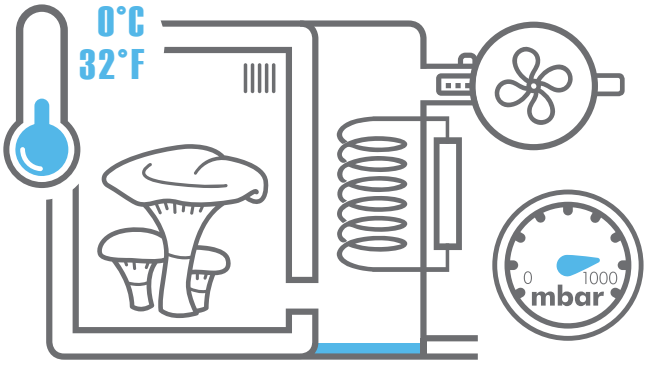
2 The vacuum pump starts and reduces the air pressure in the room from 1000 mbar to the desired pressure.



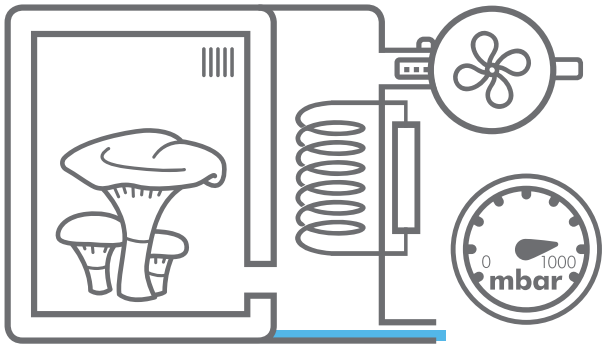
3 A small amount of water within the product will start boiling when pressure reaches temperature level of the product. This boiling process requires heat that is extracted from the product, enabling the cooling.



4 The water vapor is condensed by passing a "cold wall". The dried air goes out through the vacuum pump.



5 The cycle ends when the product is cold and the pressure returns to 1000 mbar.



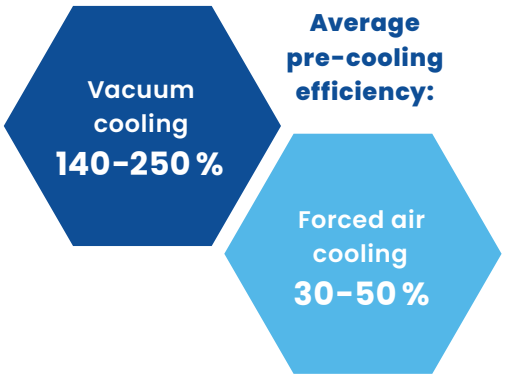
6 The condensed water is drained and the vacuum cooler is ready for the next load.

Energy consumption comparison

There is no discussion about the fact that vacuum cooling is the most energy efficient method for cooling down mushrooms and can be applied more efficiently than forced air. As a rule of thumb, you can say that due to the difference in energy coefficient, forced air cooling will need up to 4 or 5 times more energy compared to vacuum cooling!

To cool 100 kg of produce in a vacuum cooler, you will need roughly 1 kWh of energy (+/- 20 %), to cool down from 23 °C to 3 °C. The energy needed will be lowest for flowers and highest for vegetables & herbs (as they have a higher specific heat).

Beside the energy efficiency of vacuum cooling, it also reduces the energy requirement or workload of a cold store system.



The importance of Cold Chain Management for optimal Logistics & Shelf Life

Vacuum cooling is the perfect pre-cooling method for all mushrooms and has been successfully implemented at many mushroom farms. Why is vacuum cooling so perfect?

The technical story:

Vacuum cooling significantly lowers the superoxide generation of mushrooms, which causes many types of cell damage and is associated with the aging process and several diseases of mushrooms. The significant lower number of superoxides **increases shelf life and prolongs freshness and quality**.

On top of that, a significant increase of peroxidase activity can be found in mushrooms after vacuum cooling treatment. Peroxidases play an important role in defending against pathogens, having a positive effect on the shelf-life of the mushroom. Vacuum cooling reduces the level of lipid peroxides, thereby **reducing cell damage and preventing oxidative injury to the mushrooms**.

The practical story:

With vacuum cooling, you can quickly reduce the temperature of mushrooms down to 1-3°C, to the core, normally within around 15 minutes. This brings the mushroom into hibernation, minimizing respiration & transpiration, preserving freshness and maximizing storage and shelf life. **The mushroom stays firm & strong, for longest time.**

An additional advantage is that with vacuum cooling you dry the skin; this minimizes the risk of browning. Browning of the mushroom cap, which is the main criterion of quality, can be measured as loss of whiteness using a reflectometer. There is a significant difference in reflectance between vacuum cooled and conventionally cooled mushrooms if the cold chain is broken. Here you see that the vacuum cooled mushrooms remain much less brown than those conventionally cooled, again maximizing storage and shelf life.

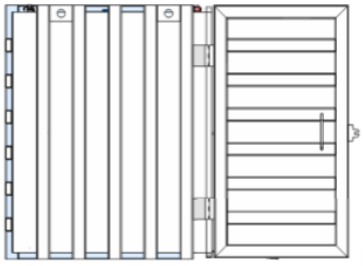
The mushroom stays perfectly white or brown.

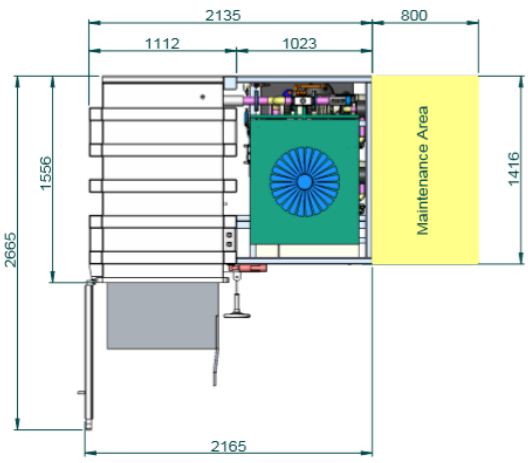
Vacuum coolers for **Mushroom Farms**

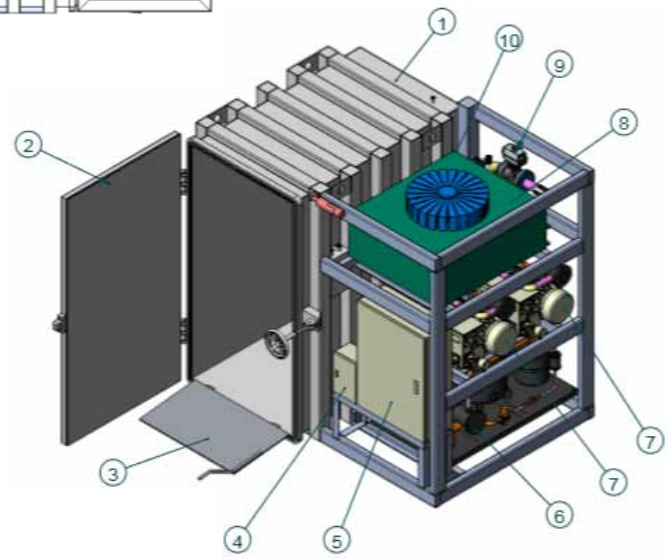
As mushrooms have approximately 90 % water and the porous structure of the mushroom allows water to escape very readily, they are therefore very suitable for vacuum cooling. Mushrooms have an open structure, allowing for fast vacuum cooling. The perfect vacuum cooler for mushrooms is designed to cool down pallets with an average 200-300 kg of mushrooms within 15 minutes, down to 1-3 °C.

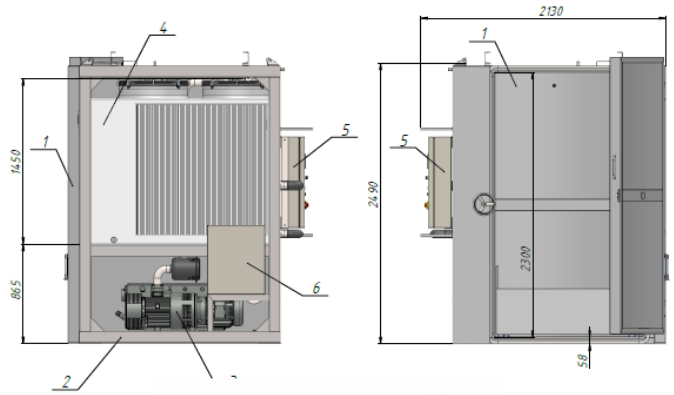
Weber COMPACT ONE

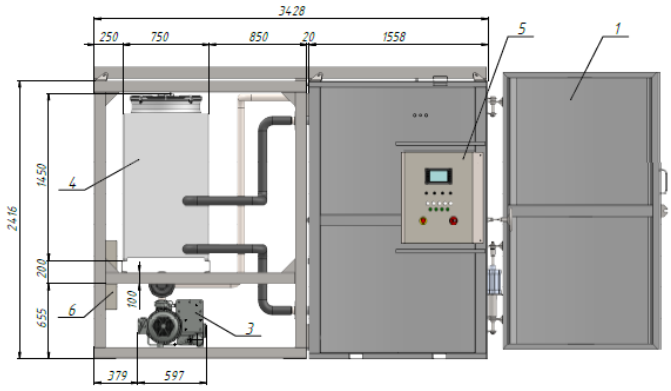
Smaller farms can work with smaller vacuum coolers; with a one pallet system, you can achieve highest cooling speeds, of 12-15 minutes. With the Weber Compact ONE you will cool three to four loads per hour, or up to 32 pallets on an eight-hour working day! Available in different configurations, you will always find a system perfect for you.

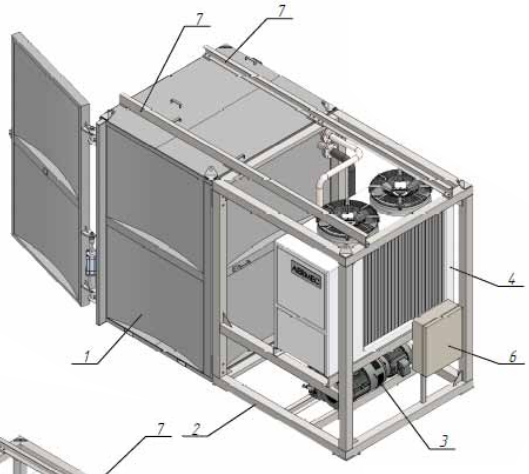


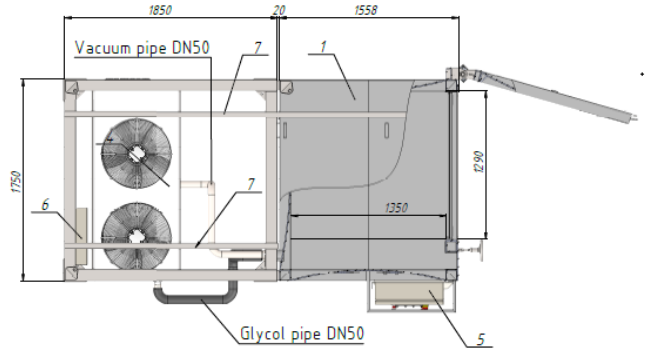


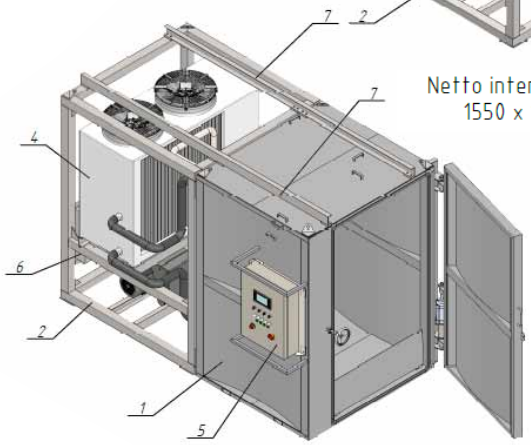








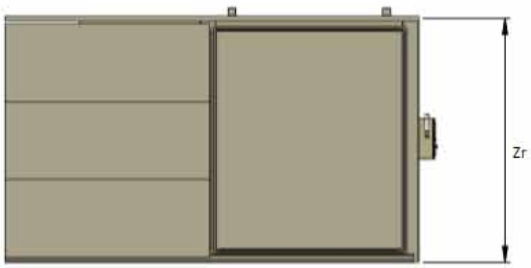


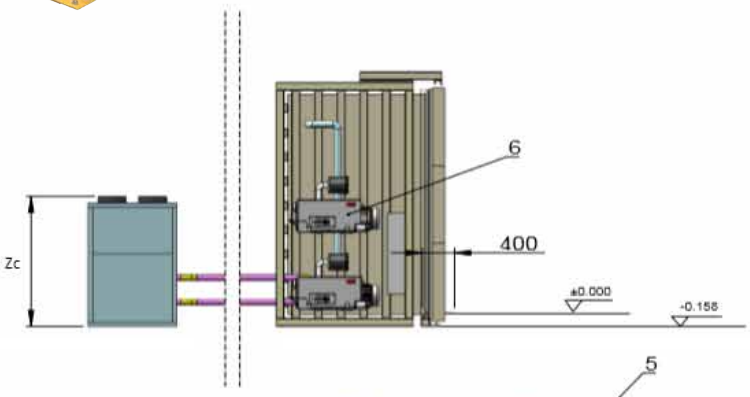


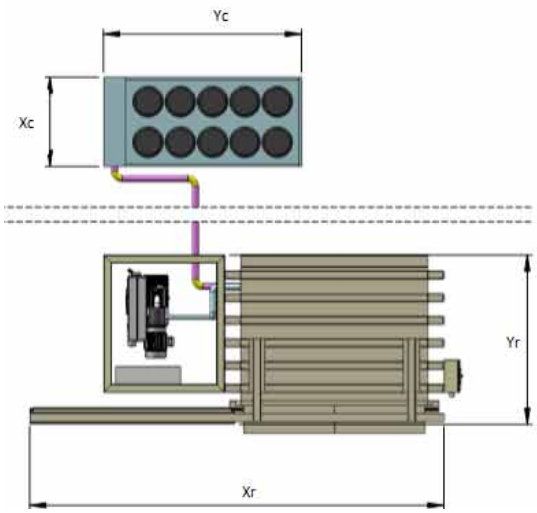
Netto interior dimensions:
1550 x 1350 x 2300

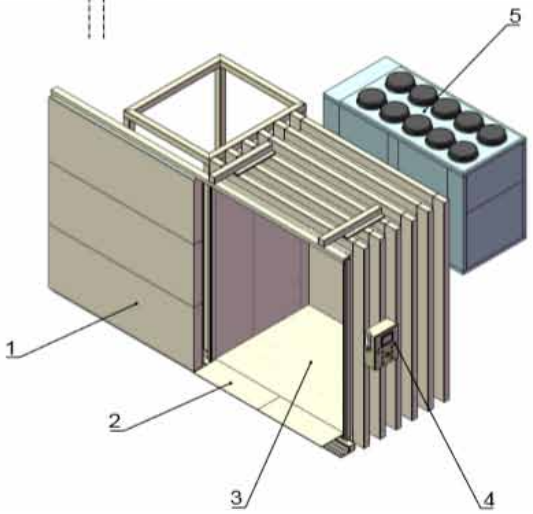
Weber
COMPACT TWO

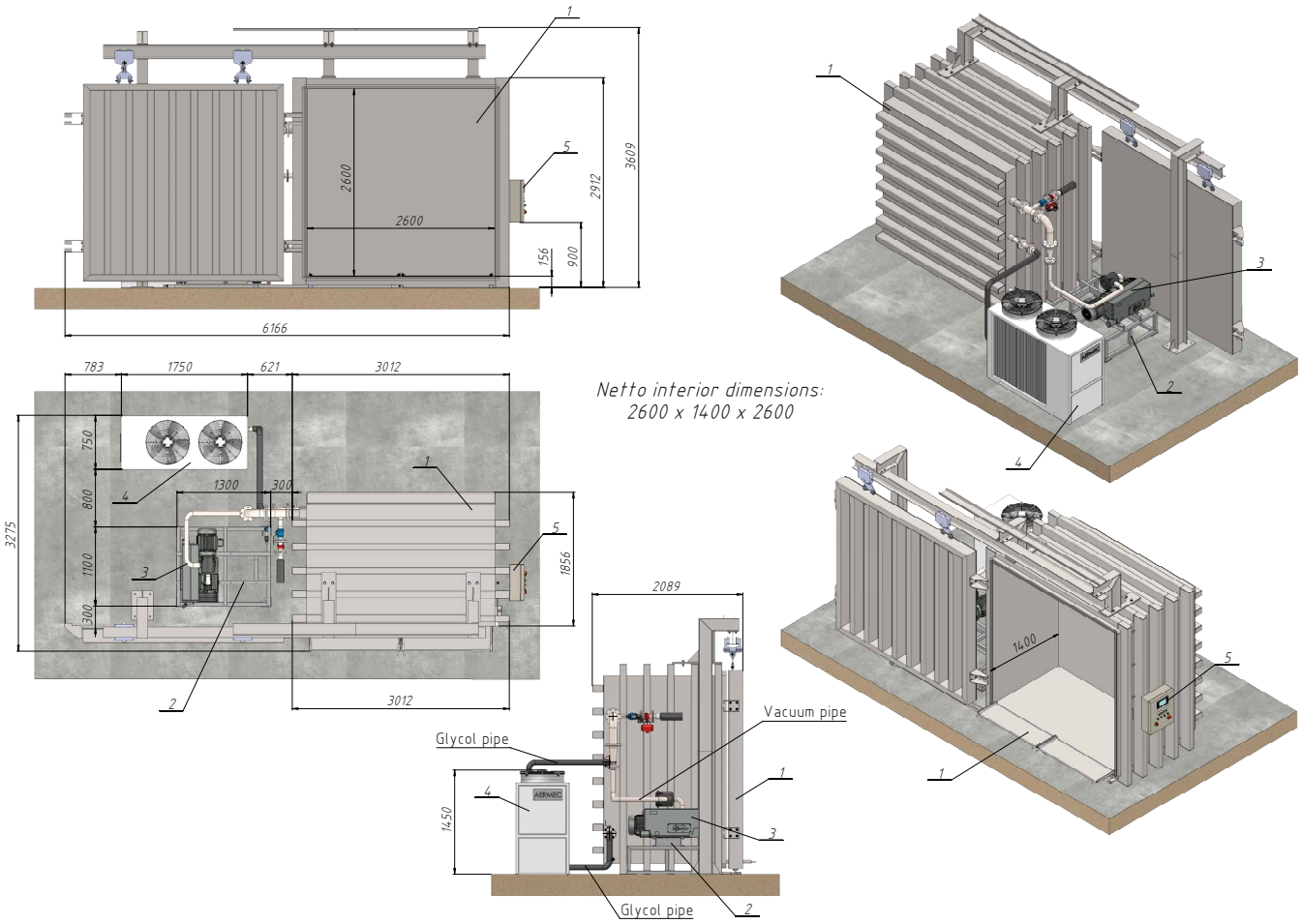
With the Weber Compact TWO you will achieve cycle times of around 15 minutes. Including logistics, you will cool up to three loads per hour, or **up to 48 pallets on a normal day!** Also available in different configurations, you will always find the perfect fit.



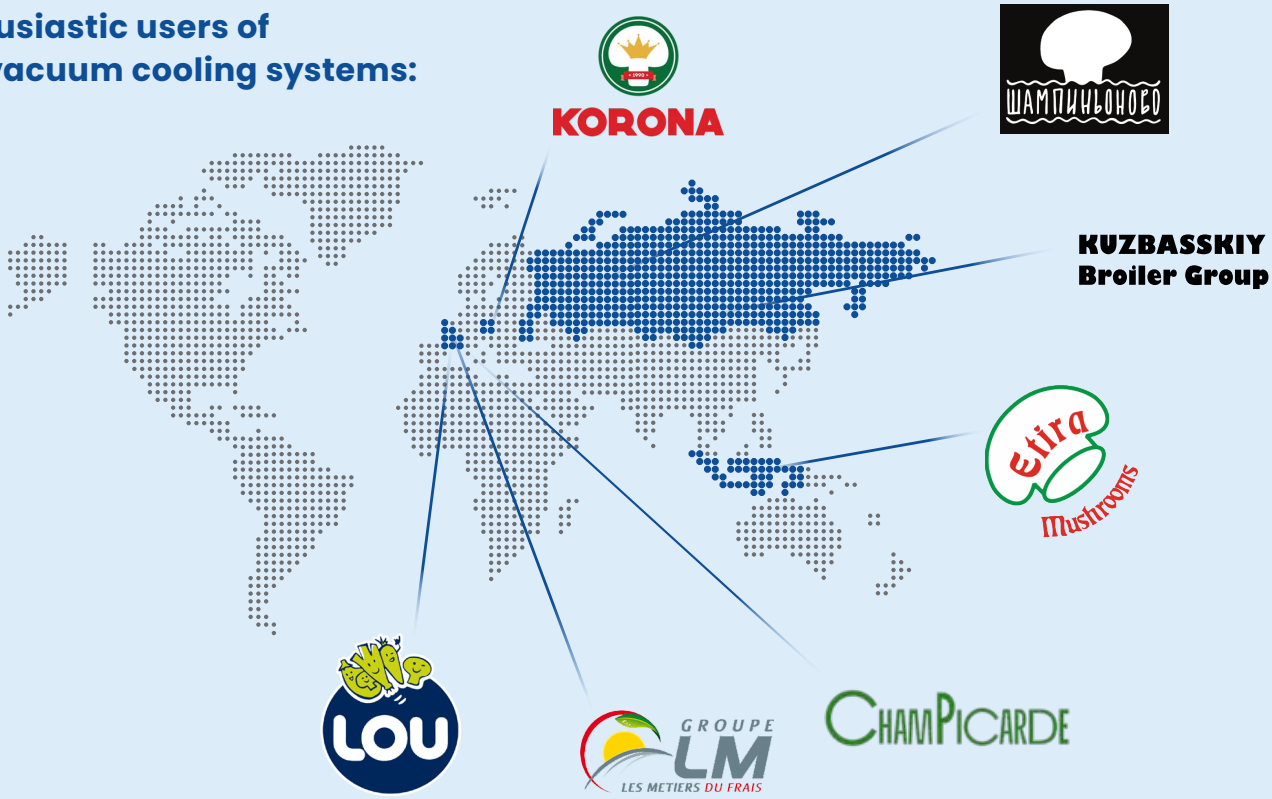








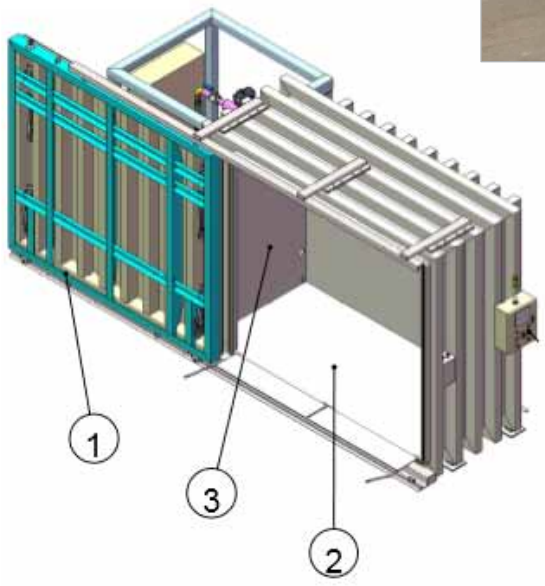
Enthusiastic users of our vacuum cooling systems:

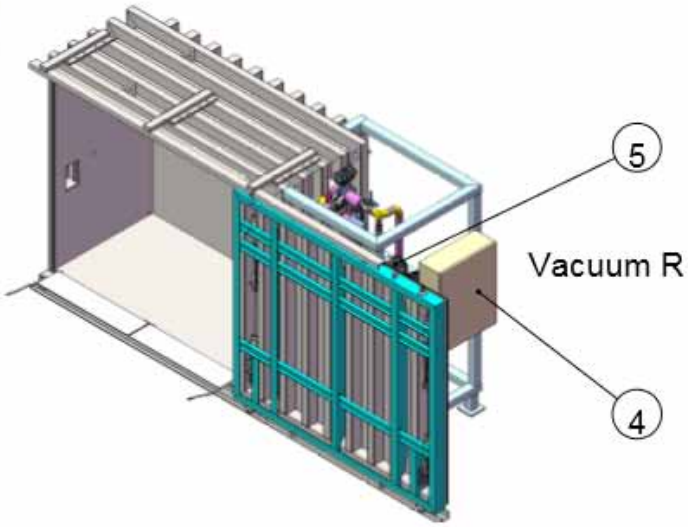


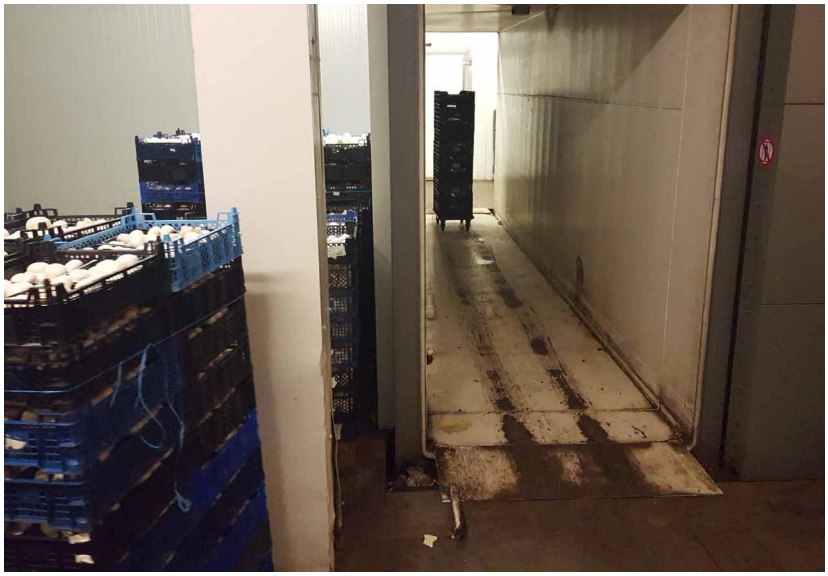
Weber
BASE GEN & NEXT GEN

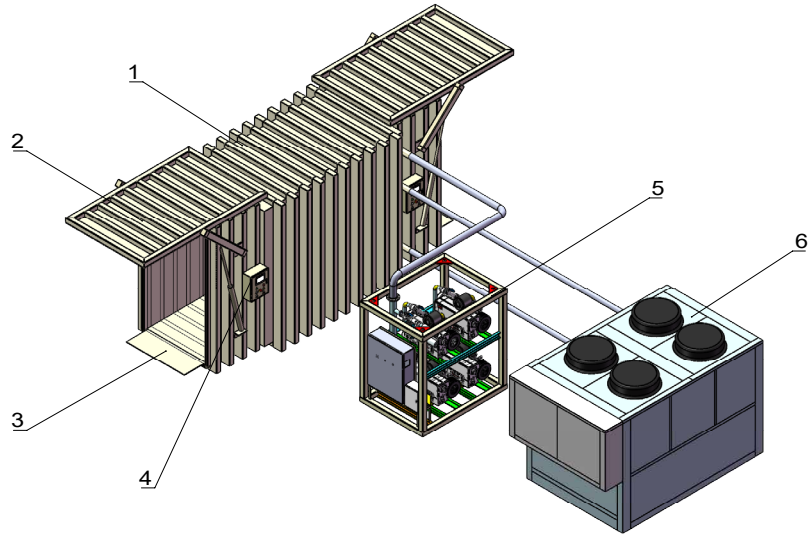
The Weber Base Gen & Next Gen models offer standardized solutions for three up to ten Standard pallets (1.000 × 1.200 mm), and for up to twelve Euro pallets double rows of Euro pallets (800 ×1.200 mm). It is easy to achieve a capacity of **well over 200 pallets per eight-hour shift**. Available with electric sliding or hydraulic swing door – upon your request.

Vacuum L









We can build solutions for each demand!

Should you require higher capacities, or have special requirement, we can supply! Some recent examples include multiple room vacuum cooling systems, in standard configuration, and with ultra-wide rooms.

Videos on vacuum cooling of mushrooms

CLICK ON
the pictures!

Mushroom cooling demo

Vacuum Cooling | Mushrooms (FR)

Vacuum Cooling | Mushrooms (CN)

Showcase Compost (HU)

Some online articles about vacuum cooling of mushrooms

Vacuum cooling mushrooms:
the quickest pre-cooling technique
www.freshplaza.com

Vacuum cooler technology delivers better shelf life and returns for mushroom growers
www.goodfruitandvegetables.com

Postharvest Atmosphere Management
www.frutas-hortalizas.com

INTERMEZZO

Vacuum cooling **of mushroom compost**

At the end of phase 3, in the composting process, the bed of compost is loosened and removed from the tunnel. When the compost is loosened the branched mycelium hyphae network is disturbed and broken. This causes wounds at the ends of the mycelium hyphae and triggers the mycelium's repair mechanisms to heal the wounds and to restore the hyphae network.

As a result, the microbiological activity (respiration) increases significantly, causing additional heat production on top of the inherent high specific respiration heat of compost. At temperatures above 30 °C the mycelium will die and is no longer able to produce mushrooms. Therefore, the loosened compost must be cooled, e.g. using CO_2-snow to allow transportation to further destinations is the conventional way of cooling. However, this is a very expensive process because high quantities of CO_2 are required.

Vacuum cooling is a rapid and cost efficient cooling alternative, with which you can save 90 % on your operational cost. Your compost – either loose or compressed in bales – can be cooled down to the core within normally 20-30 minutes. Both pallets as well as full trailers can be cooled with vacuum; the size of the room is made to specification. The technology is being used worldwide. One of the leading users here is Shasta, who has also patented the technology for this application in several (European) countries.

Based on the cost savings you can achieve, it is simple to calculate that your payback time is short (2-3 years can be expected). Based on the customers using this technology it's simple to prove that vacuum cooling is the most clever, effective and cost efficient way of cooling mushroom compost.

All parties involved profit by good and fast pre-cooling!

Weber Cooling
Your FIRST choice for vacuum cooling!

Weber Cooling is worldwide leading in vacuum cooling solutions. We ONLY produce vacuum coolers, and supply tailored solutions for all six application areas where vacuum is being used for cooling.

FOOD APPLICATONS
Bread & Pastry
Food & Kitchen | Rice & Sushi

FRESH APPLICATONS
Vegetables & Herbs
Flowers & Cold Chain | Turf & Compost

Weber Cooling ONLY builds vacuum coolers – this is where we excel. All vacuum coolers are designed by our Dutch engineering team and built using premium (European) components. As a result of our economies of scale (we produce up to 100 systems/year), our intelligent design and strategically, positioned and highly efficient production locations in Europe and Asia, we are able to offer a premium price/performance level.

Our global presence ensures our availability for maintenance and service worldwide. No other supplier has more knowledge and experience on (pre-)cooling than Weber Cooling.

For our Next Gen range we exclusively work using **"Hydronic Technology"**, with which cooled water (generated by a chiller) is used in a secondary cooling system for the "Cold Wall" inside the vacuum cooler. Hydronic Technology offers many advantages: It gives you faster cooling, it reduces the amount of refrigerant in the system and it minimizes maintenance and TCO.

For our export markets we also offer the conventional Base Gen range, using **DX (direct expansion) technology**, in which you cool the "Cold Wall" directly with your refrigerant. Simple & effective. Requiring minimum installation, and at lowest cost (especially for smaller systems).

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