

A LONG TERM STORAGE EXPERIMENT, YEAR 1

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About a year ago, an article was published in a Dutch trade journal, Greenity, about [long term Ultra Low Oxygen \(ULO\) storage of peonies](#). It stated that a few cut flower growers had been successful keeping peony flowers for several months without losing (too much) quality. We were very interested in this from a commercial point of view as it seemed our own efforts of keeping them for a longer time always failed miserably. A few weeks never was a problem, but after two to three weeks the omnipresent fungus botrytis always appeared rendering the flowers useless. Some other growers are definitely better at keeping them in storage than we do, but some four weeks after the main season, the peonies I could see at the flower auction were not particularly impressive. There's good reason why fresh peonies from Alaska are such a growing business as they are that late in the season simply far superior in quality to longer stored ones. They will open better, have a longer vase life and will be less infected with botrytis.

But apart from growing peonies in regions far north (the Baltic states (Lithuania, Estonia, Latvia) or some Scandinavian countries (Norway, Sweden, Finland)) would keeping them in ULO not be a viable option we thought? So we have bought a dozen ULO-storage boxes from [Janny MT](#). In one of those boxes there's room for some 700-800 stems and it is theoretically possible to keep them for several months. Dreams of selling peony flowers at Halloween come to mind, but we'd be glad if we got them until August or early September.

The boxes arrived here in April. Nothing special about them, they are plastic boxes of the standard pallet size, about one metre high. A special cover is placed over them which closes them from the outside air. There are several membranes that let the CO₂ (carbon dioxide) out and less O₂ (oxygen) in. Flowers in the dark use up O₂ and change it into CO₂, so the O₂ decreases naturally within the boxes. The membranes can be individually closed with some caps so that the speed and depth of the ULO-process can be managed. There's an instrument to measure the oxygen content within the boxes as well.

There's little point in keeping the flowers from greenhouses for later storage as the early ones are usually the most expensive ones, but we still did try with some Coral Charm because at least we had a chance to try it once before the main season was in full swing. So the first ones were placed in the box around April 20th, and taken out of them May 5th, some two weeks later just before Mother's Day. They had been harvested, placed in water, then taken out and left for a few hours to dry before being placed into them. They looked perfectly fine afterwards, but of course two weeks isn't a real challenge to be honest. There was some frost damage which we didn't expect. Apparently during the cooling down process the cold wind froze some of the foliage (anyone will surely know the phenomenon that the same cold temperature feels a lot more chilling when the wind blows). There was some condensation, but not too much and we were able to sell them all to a few local florists who told us they were perfectly fine. We hadn't reached O₂ contents below 5% however, which is the stated goal. That resulted from our faulty understanding of how the membranes work. We left five of the six membranes open, because we thought that would make the oxygen contents decrease fastest. Wrong, the more membranes you close, the faster O₂ decreases. When fully closed O₂ decreases very fast, but at the end no oxygen will remain and all living things in it shall die. That's why the membranes are there, to let some O₂ in, but only very little.

Measuring the oxygen content

frost damage

At the beginning of June we filled all the boxes. This time they were placed in a cold room where we also placed an air-dryer to get a low Relative Humidity (RH) below 70% to start with (the log results from the first trial with Coral Charm showed that we started at around 85% RH, which seemed rather high). They were harvested, sorted, bunched, placed in water for a few hours, taken out, left to dry for several hours in a cold room and then placed into the boxes. They were cooled down to some 5-7°C after which the boxes were closed and placed into a cold room that was kept at around 2°C for the rest of the time. Caps were

placed on them and this time we got the O2 below 5%. So all we had to do then was wait...

I must also add that there's a project, Atmo-flor, running at a local research centre in cooperation with the university of Ghent. Some (very) large growers of other ornamental crops and one small one (me) are part of this and the project will run for 4 years. You can read more about it in the green box, but they are also testing the same ULO-boxes with peonies as part of the project. They have provided me with loggers to log temperature and humidity within the boxes and have visited several times to take air samples and analyse both gas contents and ethylene levels. They have used their own Sarah Bernhardt plants for the test, but I've also provided them with The Fawn so there would be more than one variety.

Their results have been more or less the same as mine. It's an ongoing project, thus there's still room for improvement the following years. The results are still to be discussed within the team and some minor remarks may still be made, but I've received the results in a handy presentation where I've simply changed the Dutch language into some English and I think it's easy to simply show it to you with some personal remarks next to it.

As has been said before, the aim is to have peony flowers available over a longer period without loss of quality.

Here's an image of one of those ULO boxes with a close-up of a membrane and next to it showing that it releases CO2 but only lets in a small amount of O2.

At the research centre, they have proceeded the same way we suggested. Harvesting, placing into water, drying, into the box, cooling, closing. They also placed some in a cardboard box with some plastic inside to compare with. With the plastic inside it was assumed they would not dry out. The only difference was

“ATMO-FLOR: Preservation technologies for maintaining quality throughout the ornamental plant production chain”

Suboptimal preservation and transport conditions of plantlets, cuttings, flowers and whole plants in the ornamental production chain leads to big annual losses for several growers. To avoid as much losses as possible, both transport and preservation time is kept as short as possible to guarantee high quality products. However, for a better production spreading and to reach a larger export area, longer preservation and transport is necessary.

Plants or plant parts are alive. This means that they respire and transpire. Both respiration and transpiration rate have an important influence on the quality and regrowth after preservation and transport because they affect the energy and water reserves of the plants and plant parts. When one or both of these parameters increases, the quality of the material will decrease.

The aim of my research is to prolong the preservation and transport time without additional loss of quality. To reach this goal, I will look into the current preservation and transport conditions in the sector together with the PCS. Next to this, I will study the respiration of several plant species and in close cooperation with the UGent Department of Food Technology, Safety and Health, I will examine the potential of the application of equilibrium modified atmosphere packaging. This research is funded by VLAIO-LA.

Source: [Ghent University](https://www.ghent.ac.be/en/research-and-innovation/peony-project)

assumed to be the oxygen level then.

With the benefit of hindsight (see the results further down) we should never have placed the peonies in water beforehand. A short while ago a scientific paper was published where it was clearly demonstrated that dry storage is far superior to wet storage. But at the time of the experiment I hadn't read it. My reasoning was that when cutting during hot weather the petals are easily dried up and damaged. Thus I assumed some rehydration and then drying again would mean there was sufficient water in the stems whilst the flowers and foliage would be dry. Besides, one cannot always cut during dry weather, it does rain from time to time...

As mentioned before, two cultivars were used. The ubiquitous Sarah Bernhardt and my favorite pink The Fawn. Sarah Bernhardt is the most widely available thus results for this would be interesting for every grower. The peony plot at the research station is more or less organically grown, that is they don't spray any fungicides nor insecticides. Herbicides hadn't been used either as there was an experiment with different mulches to see which one best kept weeds at bay. On the other hand, I was convinced that my peonies needed spraying as I didn't want any problems with botrytis. I used some of the best and newest fungicides available nowadays ('signum' which has boscalid and pyraclostrobin as active ingredients). The Fawn was cut at a fairly soft bud stage, which I usually do because I want them to open well. At that stage The Fawn has an open 'rose' bud, unlike Sarah Bernhardt which has closed buds. A closed bud will probably keep better in storage and the inner petals are better protected of course.

These are the measurements from the boxes at the research station. They are comparable to mine. My 'tiempo tester' which measure the O₂ and CO₂ gave the same results as theirs, so at the very least we know it's a reliable instrument. In the cardboard box the oxygen levels remained at normal levels. Within the ULO box the oxygen decreased to below 5%. CO₂ levels first went up in the ULO box, but then stabilized, whereas in the cardboard box nothing changed. What you see is that ethylene levels rose dramatically within the ULO box. That is a dangerous thing is assumed, but in fact no detrimental effects have been noticed afterwards.

After 6 weeks the first ULO box was opened, the second one after 10 weeks. As you can see from the image, after six weeks the results were more or less ok. After 10 weeks however there was a lot of botrytis. The foliage was 'fresh' as were the flowers, but there was a lot of condensation inside the box and nearly all of the flowers were wet to some degree. The constant wetness was obviously the root of all problems here. The loggers all showed the same thing, although Relative Humidity started around 70%, it gradually rose to 100%. Temperatures however had remained

fairly constant, around 1,5-2°C with no spikes at all (the loggers recorded data every five minutes).

And here's the cardboard box. At 6 weeks it was manageable, at 10 weeks all could be thrown away.

Here's an important result: all flowers were graded according to botrytis damage. 0 being none and 3 being fully rotted. Peonies graded 1 could be used if you carefully peeled off one outer petal. Grade 2 would be too much as the botrytis would continue destroying the flower. Ideally we should only see grade 0, but we all know the world isn't perfect.

At 6 weeks some 80-90% of Sarah Bernhardt was still fit to be sold. But only some 15% was totally free from botrytis. Clearly ULO storage is not fit for organically grown peonies. At 10 weeks, results were even poorer, with half of them ready to be composted.

The Fawn did better, some 90% showed zero botrytis at 6 weeks, with the remainder some slight infections. At 10 weeks however the situation was different, a quarter had to be thrown away.

Mention also that the cardboard box at 6 weeks wasn't too bad either. Results were more or less comparable. At 10 weeks however the ULO boxes are clearly the better option.

Botrytis isn't the only quality issue. Important for the end user of course is whether they will open well and how long they will remain fresh in a vase. Thus we've also measured that.

So here are some more quality measurements. As you can see keeping peonies in storage does decrease vase life, although the results aren't too bad. When placed in a vase right after cutting you can see a customer has a long time to enjoy them. It must be said that Sarah Bernhardt has such a long vase life because they were cut at an earlier stage and they took several days before starting to open, whilst The Fawn opened much faster.

After 6 and 10 weeks The Fawn had a better vase life than Sarah Bernhardt, suggesting some cultivars will be better fit for ULO treatment than others. I've trialled several other varieties and concluded the same.

As you can see Sarah Bernhardt which is reputed for being a difficult opener had a large part not getting past flowering stage 3

and 4. The Fawn was a better opener as nearly all of them opened completely. At 10 weeks for both cultivars it can be seen that opening quality decreased, although I'd say that buyers of The Fawn wouldn't be disappointed.

All in all, the results are thus mixed. 6 weeks seems to be ok, at 10 weeks we have some more experimenting to do. It is obvious that spraying against botrytis is necessary. And next year they'll be placed directly into the ULO boxes without placing them in water first. We'll also put some silica-gel into the boxes to get some moisture out of the air. According to the supplier of the boxes we should keep temperature fluctuations very very low (although the loggers didn't log much difference). We'll also cool them down much deeper before closing the boxes and we'll try to get the temperature closer to zero. We'll see next year with these changes if we have more success.

Some other growers had good results with the boxes, others not so, so there's still some work to be done.

If it all works well, in a few years time peonies should be available over a longer period of time. But then the question remains whether it's all worthwhile? From the prices growers fetched this year there's little to support doing it large-scale. Look at the chart showing the numbers sold and prices fetched of peonies at the auctions of Royal Flora Holland. The blue bars show the numbers this year, clearly the numbers are still rising, at peak time some 4 million stems are sold weekly at the auctions (without the 'direct sale' of flowers that don't pass before a 'clock'). The blue line shows the prices this year, and the red one last year in the same weeks. As can be seen, growers didn't receive a premium for keeping them in storage and would have been better off selling them during the peak season itself. If quality rises, then a market can be formed, but we might assume it's an uphill struggle.

The Fawn with water droplets on them

Madame Claude Tain was also tested, the outer petals were fine but inside several petals were also infected

The stems didn't dry out in the ULO boxes whereas dry storage did result in dehydration, here's Coral Charm from ULO (left) and dry storage (right)