LAGERING
WITH THE
CONICAL FERMENTER & GLYCOL CHILLER

THE GRAINFATHER
ALL GRAIN BREWING

What is a lager fermentation profile?

Lager yeasts enjoy lower fermentation temperatures and as a result, produce fewer fruity esters during fermentation than ale yeasts. Therefore a higher expectation is held for lagers.

Lagers should most often taste 'clean' - this means that lagers should have a clean malt character with minimal off flavours from esters, diacetyl, acetaldehyde and fusel alcohols. At lower temperatures, especially for lager yeasts, there is a slow growth rate of the yeast cells and also a slower reduction of diacetyl and acetaldehyde during fermentation. At lower temperatures, lager yeasts also tend to produce more sulphur compounds. As a result, steps are needed to achieve the expected 'clean' lager flavour profile.

In any fermentation, a large healthy pitch of yeast is very important, this is especially important for lagers for the reduction of off flavours;

1. It is ideal to pitch at 3°C (4°F) below your target fermentation since there will be a natural rise in temperature over the first stages of fermentation, then ramp up to your fermentation temperature over the first 18-36 hours of fermentation.
2. Conduct a diacetyl rest when the beer is 0.5-1°P (SG: 0.002-0.004) above calculated terminal gravity by raising the temperature of fermentation to 18-20°C (65-68°F) until fermentation has finished.

Lager comes from the German word 'lagern' which means 'to store' where the beer was stored cold to preserve and condition the beer for consumption later in the year. The process of long cold storage became known as 'lagering'.

The objectives of lagering were published by Jean De Clerck in 1957, and these are still the objectives for lagering today;

1. To allow yeast and turbid matter to settle out.
2. To carbonate the beer with artificial (forced) carbonation or secondary fermentation.
3. To improve flavour.
4. To precipitate chill haze, to prevent haze formation when the beer is chilled after filtration.
5. To avoid oxygen pickup to prevent oxidation.

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Traditional Lagering

As the fermentation slows and yeast begins to flocculate; the brewer starts to slowly cool the beer at 0.5-1°C (1-2°F) per day until they reach about 4°C (40°F.) Beer is then transferred into lagering tanks where it is held at this temperature for months.

Now that fermentation is complete, including the diacetyl rest, we need to start lowering the temperature. This encourages any remaining yeast in solution to flocculate out. However, this cooling needs to be conducted at a rate that keeps the yeast active for as long as possible, continuing the conditioning process. Rapid (within 6 hours) changes in temperature of more than 3°C (5°F) (up or down) at the end of fermentation can force the yeast to release esters and shock proteins rather than retaining them within the cell. Therefore, slow decreases in temperature of 1-2°C (2-4°F) per day are recommended.

Below 4°C (40°F) there is very little activity from the yeast to clean up the beer. Therefore, the lagering time is much longer. The main benefit of going below 4°C (40°F) is the removal of chill haze, but the availability of well modified malts and fast-acting finings have removed the need for long cold storage.

Traditional lager conditioning times:
- 3-4 weeks at 7°C (45°F)
- 5-6 weeks at 4°C (40°F)
- 7-8 weeks at 2°C (35°F) – Mostly unneeded due to and low yeast activity.

Note: longer lagering times are needed for higher alcohol lagers.

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Grainfather Conical Fermenter & Glycol Chiller

Recommended lagering method

For lagering using the Grainfather Conical Fermenter in conjunction with the Glycol Chiller, we recommend setting the fermenter target temperature to 6°C (43°F). The reasons for this are:

- 6°C (43°F) is a low enough temperature to achieve optimum lagering results.
- Setting the target temperature lower than 6°C (43°F) increases the required lagering time.
- Although setting the target temperature lower than 6°C (43°F) helps remove more chill haze, it is unnecessary assuming finings (chill haze removing type) have been used.
- Setting the target temperature lower than 6°C (43°F) may result in a non-uniform temperature distribution within the fermenter and cause the cooling signal from the digital temperature controller to stay on indefinitely.

See below for explanation.

How the Grainfather Conical Fermenter maintains a uniform temperature distribution

While maintaining a lower-than-ambient target fermenter temperature, the cooling signal that the digital temperature controller sends to the chiller cycles on and off. While the signal is on, cold glycol is pumped through the glycol jacket. Intuitively, this first cools the beer closest to the jacket.

Like water, as a beer's temperature decreases, its density increases. Because the glycol sleeve is in the upper region of the beer, the upper region is cooled first. It follows that this region also becomes denser than the lower region.

Subject to gravity, this cooler beer sinks, and the warmer beer below rises to take its place. This warmer beer, now located in the upper region, gets cooled by the jacket and in turn sinks to be replaced by the lower region... and so on and so forth.

This phenomenon is a natural convection current and is the method by which "cooling" is distributed evenly within the fermenter.

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THE GRAINFATHER ALL GRAIN BREWING

Nonuniform temperature distribution at target temperatures lower than 6°C

As stated above, when a beer's temperature decreases, it's density increases. The problem arises if we set a target temperature lower than 6°C. Also, like water, there is a temperature for beer which corresponds to its maximum density, at which if its temperature is decreased further, its density will decrease instead of increasing.

The temperature at which the temperature-density relationship inverts is the inversion point, and it is somewhere around 1-4°C (34-40°F) for beer. If a target fermenter temperature below 6°C (43°F) is set, the fermenter may first reach that temperature and even maintain a reasonably uniform temperature distribution for some time. However, it is likely that at some point, while the cooling signal is on, the beer directly adjacent to the jacket (in the upper region) drops below the inversion point.

If this occurs, the beer in the upper region no longer increases in density and instead of sinking it remains buoyant, stopping the natural convection current from distributing the beer evenly inside the fermenter.

While the upper region continues to receive cooling from the jacket, due to the absence of the natural convection current, the lower region is deprived of cooling. This results in the lower region staying relatively warmer than the upper region i.e. creating a non-uniform temperature distribution. In extreme circumstances the beer directly adjacent the jacket can freeze.

Note: The time of the onset of inversion will vary depending on the beer style and ambient conditions. Also, the lower the target temperature, the sooner the beer inversion may occur.

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THE GRAINFATHER ALL GRAIN BREWING

Lager Fermentation - Cheat Sheet

1. A larger healthy pitch of yeast is needed than for ales.
2. Pitch yeast 3°C (5°F) below fermentation temperature as there will be a natural rise in temperature.
3. Raise your temperature slowly to fermentation temperature over 18-36 hours.
4. Allow fermenting until 0.5-1°P (SG: 0.002-0.004) above estimated final gravity.
5. Raise temperature to 18-20°C (65-68°F) for diacetyl rest.
6. Hold at diacetyl rest temperature until final gravity has been reached and is stable for 2 days.
7. Decrease temperature no more than 3°C (5°F) per day until lagering temperatures are reached.
8. Hold at one of the lagering temperatures below for conditioning.
   a. 3-4 weeks at 7°C (45°F)
   b. 5-6 weeks at 4°C (40°F)
   c. 7-8 weeks at 2°C (35°F) Unneeded due to finings and very low yeast activity.

Note: longer lagering times are needed for higher alcohol lagers.

FOR FURTHER READING ON FERMENTATION AND LAGERING, WE RECOMMEND THE FOLLOWING LITERATURE;

- **Yeast:** The Practical Guide to Beer Fermentation (Brewing Elements) – by Chris White and Jamil Zainasheff

- **How to Brew:** Everything You Need To Know To Brew Beer Right The First Time – by John J. Palmer

- **New Brewing Lager Beer:** The Most Comprehensive Book for Home and Microbrewers – by Gregory J. Noonan