LIGNUM.
MARIAUD CONSULTING

UNDERSTANDING WOOD

SEASONING

Our PROGRAM

01 Wood stacking

02 The different seasoning methods

03 Seasoning mechanisms

04 Internal transformations of wood during seasoning

Understanding wood

Understanding wood

01

Wood stacking

Wood drying is **a fundamental step** in cooperage. It allows for the reduction of the wood's moisture content until it reaches an equilibrium with the environment. **Poorly dried wood works and deforms**. But beyond simple dehydration, drying is a genuine process of maturation and transformation that directly impacts the organoleptic quality of the barrels.

1. Dead stacking

- Used mainly **for transportation** or **short-term storage**.
- The pieces are stacked without battens, directly on top of one another.
- **Allows for no air circulation** → not suitable for seasoning.
- **Risk of mold** or **warping** in case of prolonged storage.

2. Stacking on battens

- The standard method for natural seasoning.
- **Battens are placed between** each layer of staves.
- **The battens are made of white wood** (poplar, fir) to prevent colored marks on the wood (tannins prominent wood species).
- **This method promotes natural watering by the rain** and**, most importantly, homogeneous air circulation.**

Understanding wood

01 **Wood stacking**

3. Open-air stacking

- **An improved variant** of stacking on battens.
- The staves are deliberately spaced apart within each layer, which **maximizes lateral air circulation**.
- Used for **wood that needs to dry faster** or in humid areas.

4. Tower stacking

- An artisanal method consisting of arranging the staves in circles, forming **a circular-section tower.**
- The center is left empty to ensure **vertical air circulation.**
- This method offers excellent natural ventilation and **homogeneous air exposure**.
- It is more difficult to stabilize and requires rigor and expertise.
- Still used by some traditional cooperages for exceptional woods.

5. Quincunx Stacking (for barrel heads)

- The short pieces are staggered every other one on each layer.
- This allows for better pile stability.
- It also provides a more homogeneous weight distribution.

Natural seasoning

Natural seasoning is the historical method and still the most widely used today in high-end cooperage.

Duration:

- Between 18 and 36 months, or even up to 48 months for certain lots intended for fine wines or spirits.

Method:

- The staves are stacked outdoors, on battens, in well-aerated piles, oriented towards the prevailing winds.
- The spacing between the battens allows for good air circulation between the boards.

Specific Characteristics::

- Exposure to natural cycles (rain, wind, frost, sun), which promotes the leaching of soluble tannins and the slow transformation of the material.
- The wood loses its moisture gradually, without internal stress.

Biological Process:

- Joseph & Marche (1972) observed a microbial flora in the deep layers of the oak during seasoning: lignin-degrading fungi and specific bacteria.
- These microorganisms participate in the partial degradation of certain tannins and the formation of aromatic compounds.

Oenological Effects:

- Roundness, aromatic finesse, less bitterness.
- Presence of lactones (woody notes), furfural (toasted notes), vanillin.

Natural seasoning

1. Ideal Weather Conditions

Natural seasoning is highly dependent on the local climate. Two phases must be balanced:

- An initial **humid phase** :
  - Allows for **the leaching of soluble tannins**.
  - Encourages the development of a **specific fungal flora**, useful for maturation.
- A **gradual dry phase** :
  - Ensures a **slow and even dehydration**.
  - Reduces the risk of abrupt shrinkage and cracks. Reduces the risk of abrupt shrinkage and cracks.

Regions that are too dry or too hot are unfavorable, as the wood dehydrates too quickly, leading to a notable loss in quality.

2. Phases of Natural Seasoning

- **Phase 1** (0 to 6 months): green wood → high water content.
- **Phase 2** (6 to 12 months): active drying, appearance of micro-cracks.
- **Phase 3** (> 12 months): gradual stabilization, tightening of the fibers.

Seasoning generally lasts 12 to 36 months, sometimes longer for wood intended for spirits.

3. Wood Leaching

During rain, water runs over the wood stacks. This phenomenon leads to the **extraction of water-soluble compounds** such as:

- **Ellagitannins,** responsible for a portion of the astringency.
- Phenolic acids.

Leaching is most effective in **the first 6 months**, when the wood is still rich in water. **Beyond 10 months**, the remaining tannins are more trapped within the wood structure.

💡 The tannins that are removed are more bitter than those that remain in the wood. This selective extraction therefore contributes to the aromatic balance of the wood.

Natural seasoning

4. Stack Sprinkling

To compensate for a climate that's too dry, some cooperages practice **controlled sprinkling:**

- It simulates regular rain, promoting leaching.
- It homogenizes the development of useful fungal growth.
- It regulates the wood's temperature.

⚠️ Excessive watering is harmful: it can eliminate interesting compounds (polysaccharides, extractable lignins, certain aromatic ellagitannins).
Sprinkling must therefore be adapted according to:

- The **local climate** (frequency, intensity).
- The **desired result** (more or less structure, woody aromas, etc.).

Maturation is the result of **a subtle balance** between water, sun, wind, and the wood's biological activity.

Natural seasoning

Open-Air Storage :

- The wood is **oriented in relation to the prevailing winds to limit the risk of checking** (surface cracks caused by drying too quickly).
- The top of the stacks is protected by sloped sheets or **plates to prevent rainwater from penetrating and to avoid direct sun exposure**.
- The storage area must be clean, healthy, and free of vegetation to **prevent stagnant moisture and fungal risks.**

Indoor Storage:

- This type of storage takes place in a wood shed, **a covered but ventilated structure.**
- The building's opening is ideally **oriented to the east** to protect the wood from prevailing rain and direct sunlight at the end of the day.
- **Louvered sides** (open, slanted slats) encourage transverse air circulation.
- An aisle is left between the stacks to create **a chimney effect**, improving vertical natural ventilation.

02

The different seasoning methods

Artificial (or Mechanical) Seasoning

Artificial seasoning is used as a complement, to stabilize the wood at the end of natural seasoning, or to meet faster production needs.

Duration:

- From a few days to 2 weeks, depending on the technology used and the desired moisture content.

Advantages :

- **Significant time saving.**
- **Reduction of storage space.**
- Ability to program cycles adapted to each wood species.

Disadvantages:

- **Does not allow for the aromatic evolution** obtained through natural seasoning.
- **Requires rigorous monitoring** of parameters (temperature, hygrometry, air speed).
- **Can cause internal tensions** if the wood is still too "green".

Reasoned Use :

- Many cooperages use the kiln **only to finalize the moisture content after natural seasoning.**
- For example, to go from 20% to 14% just before production, to ensure **dimensional stability** during machining.

Artificial (or Mechanical) Seasoning

1. Role and Limitations

Artificial seasoning primarily serves a single objective: **the loss of water** to achieve a moisture content compatible with manufacturing. This method allows for a rapid reduction of the wood's moisture content to a stable level.

However, unlike natural seasoning, artificial seasoning does not cause comparable biological or chemical maturation. **It does not leach out coarse tannins**, does **not promote beneficial** fungal flora, and does **not induce** the slow evolution of the volatile compounds responsible for the wood's enological quality.

Therefore, on its own, it cannot produce fully matured and refined wood suitable for aging fine wines. Its use remains frequent, however, for economic and technical reasons.

Artificial (or Mechanical) Seasoning

2. Reasons for use

Spirits (Bourbon, Whisky)

- Mainly produced from **American oak**, known for its desired aromatic qualities (vanilla, lactones).

- ***American oak*** *(Quercus alba) is favored for its high content of vanillin and lactones, which provide vanilla and fruity aromas (peach, coconut) highly sought after in bourbon and whisky.*

- *Americans use new "charred oak barrels":* ***the toasting/charring*** *allows for the* ***caramelization of the wood****, further enhancing the vanilla and sweet notes.*

- **Artificially seasoned wood** is perfectly suited to these aromas and tolerates the halt in aromatic evolution well, especially at high alcohol degrees.

- The market for spirits barrels is about **5x larger than** that for wine, which economically justifies the use of this type of seasoning.

The market for barrels for whisky and spirits (scotch + whisky + wines) is estimated at approximately $2.1 billion in 2024, with American barrels representing the majority ($1.49 billion).

Continuous Cooperage Production

- During each humid period, the ambient moisture can increase by **5 to 10%**, making the staves unusable.
- Drying kilns allow **for immediate manufacturing**, without needing to store large volumes in a shed.
- They are therefore essential in humid climates or during winter, to maintain the production rhythm.

Forced Convection Drying

Forced convection drying is the most widely used method in cooperage: a circuit of warm, humid air is propelled into a chamber for controlled drying.

🎯 System Components

- Fan: ensures **homogeneous air circulation.**
- Heating Exchangers: steam or hot water to heat the air.
- Humidifier: steam injection or water spraying to maintain the appropriate humidity.

🔁 Drying Phases (according to literature standards)

Warming-up Phase

- High temperature, humidity-saturated atmosphere.
- Objective: to homogenize the wood and prevent checking or surface cracks.

Capillary Migration Phase

- The wood, still above the saturation point, sees **free water migrating to the surface under the effect of capillarity.**
- This transfer is described by models (Fick's and Fourier's laws) in numerical drying research.

Critical Phase

- When the wood reaches the fiber saturation point (≈25–30% humidity), ventilation and temperature are reduced.
- Useful for **preventing internal stresses**: literature mentions the risks of deformation, collapse, or cracks.

Finishing Phase

- Ventilation is slowed or stopped.
- The wood enters the hygroscopic zone, and the residual moisture is controlled using **sorption charts**.

02

The different seasoning methods

Hot and Humid Air Kiln

- Air is blown by fans**, then heated by radiators.**
- It then passes over **humidification ramps** (water spray or steam injection).
- **The hot** and **humid air** passes through the wood stacks**, causing the water contained within the wood to evaporate.**
- As it becomes loaded with moisture, the air cools down.
- Part of the air is then vented outside via adjustable vents to remove the released water.
- **An intake of outside air replenishes the volume that was vented**, and the cycle begins again.

Condensation Kilns

- These kilns operate in **a closed circuit.**
- Moisture-laden air is directed towards a condenser (a cold surface), where the water vapor condenses.
- The air is then reheated and reinjected into the chamber.
- **Advantages:** Very low energy consumption, no venting of outside air.
- **Disadvantages:** Slower drying, limited power for large volumes.
- They are suitable for workshops with limited space or those looking for a gradual and consistent drying process.

02

The different seasoning methods

Vacuum Kilns

- During wood drying, **the internal circulation of water** is the limiting factor, much slower than evaporation: **100 to 1,000 times slower depending on the wood species.**
- By creating **a depression** (air vacuum), this circulation is accelerated by **5 to 6** times, allowing for much faster and more homogeneous drying.
- The process is based on the alternation of **vacuum and ventilation phases**:
  - Phase 1: Vacuum creation → lowers the pressure → water migrates more quickly to the surface.
  - Phase 2: Gentle ventilation with warm air to extract the moisture.
  - The cycle is repeated several times a day.
- This system also allows **water to evaporate at very low temperatures (30 to 50°C),** which limits the risks of cracks, overheating, or internal tension.
- It is highly suitable for fragile or high-value woods.

02

The different seasoning methods

Why It's Important

The wood drying method (open-air or in a kiln) directly influences the chemical composition of the oak. This modifies its impact on the wine or spirit: some chemicals contribute to bitterness, while others provide alluring aromas (vanilla, coconut, etc.).

Scientific Studies

A 2008 study by Martínez et al. (J. Agric. Food Chem., 56(9):3089–96) compared several drying methods (natural, artificial, and mixed) on American and European oak.
It concludes that natural seasoning allows for:

- **A greater reduction of ellagitannins** (tanins agressifs),
- **A better development of aromatic volatile compounds** (phenols, lactones, furans, etc.),compared to artificial drying alone.

A recent review (Bo Zhang et al., Int. J. Mol. Sci., 2015) confirms that natural leaching, slow oxidation, and enzymatic activity during slow drying **increase the aromatic richness of the wood**.

Key Highlights

Ellagitannins are more reduced in naturally seasoned wood:
Rain leaching, progressive oxidation, and microbial flora break down these aggressive tannins.
More pleasant aromas: Vanillin, eugenol, and lactones (coconut flavor) increase significantly with natural seasoning.
The aromatic profile is more balanced and better for wine; artificially seasoned wood remains more raw and bitter.

Artificial Seasoning as a Complement to Natural Seasoning

In cooperage, **artificial seasoning is often used after a long natural seasoning period**, with the goal of stabilizing the wood just before it enters production. This practice prevents the already-seasoned staves from re-absorbing moisture from the ambient air.

Why Do It?

- Even after 24 to 36 months of natural seasoning, wood remains **hygroscopic,** meaning it absorbs or releases water depending on the surrounding air.
- In humid periods (fall/winter) or in maritime climates, the wood's moisture content can **rise by 5 to 10%**.

What Does Artificial Seasoning Allow in This Case?

- Bring the wood back to a target moisture content (12–16%).
- **Standardize the moisture content** in the heart of the staves.
- Speed up production, **without having to store huge volumes under cover.**

What types of water are found in wood?

Wood contains two types of water:

- **Free water:** Like a sponge, it fills the small tubes of the wood.
- **Bound water: I**t is attached to the walls of the wood's cells and is more difficult to remove.

The process of drying starts by first removing the free water, and then the bound water. This second step is slower and more delicate.

The Major Stages of Drying

Evaporation of Free Water

- Hot, dry air draws the water towards the outside of the wood.
- The wood remains stable (with no deformation).

The Saturation Point

- The wood is now free of free water.
- It begins to contract, and this is where cracks can appear.

Stabilization

- The removal of bound water continues.
- The wood reaches its hygroscopic equilibrium, making it stable and ready to be used.

What Happens Inside the Wood

How does water exit?

- By capillarity: water rises to the surface like in a straw.
- By diffusion: it slowly passes through the walls of the wood.

Shrinkage (the wood tightens)

- The wood shrinks a little when it loses water.
- If it goes too fast, it can split.

Internal Tensions

- The center of the wood remains wet while the outside dries, which creates tensions.
- This can cause deformations or breakages.

What Changes in Wood (Chemistry and Microbes)

Oxidation

- Air causes certain compounds to react (like tannins).
- This changes the color and future aromas of the barrel.

Leaching

- When it rains on the wood, certain components (bitter tannins) are washed away.
- This is beneficial for the final taste.

Useful Fungi

- Certain microscopic fungi grow on the wood during natural drying.
- They gently degrade the wood's walls and release aroma precursors.
- Example: Aureobasidium pullulans, Trichoderma.

Influence of Fungal Flora on Chemical Composition 🧪

🌱 Fungal Development

- A very large diversity of fungal spores quickly settles on the surface of the staves. However, only **3 to 6%** of these spores germinate and form an **active mycelium**, capable of colonizing the wood.

- Only three fungi are truly capable of establishing and developing durably:
  - Aureobasidium pullulans
  - Trichoderma harzianum
  - Trichoderma koningii .

Mechanism of Action

- Fungi penetrate via micro-fissures present on the surface of the staves.
- After **one month**, a mycelium visible in culture forms; after **12 months** of drying, this mycelium can extend up to **10 mm deep into** the wood.
- This mycelium produces **exo-cellular enzymes** (such as β-glucosidases) that partially digest the wood's cell walls

Chemical and Organoleptic Effects

- Enzymatic activity releases **aromatic precursors:** lactones, furfural, vanillin, etc.
- The wood gains roundness and finesse and loses astringency.
- Although the **mycelial biomass remains low** (not visible), its chemical effect on the wood extracts is significant.

04 Internal transformations of wood during seasoning

🌍 Importance in Cooperage

- The presence of this **specialized microflora** (rather than a random fungal colonization) is not only **normal**, but also **desirable** for wood maturation.
- **A flora that is too diversified** or invasive can lead to the production of **aggressive cellulases** (Trichoderma, Penicillium…), which **consume the lignin or tannins,** altering the wood structure and reducing the organoleptic qualities.

✅ Technical Summary

- **3–6% of spores germinated** → 10 mm of mycelium
- Main agents: A. pullulans, T. harzianum, T. koningii
- Effects: gentle enzymatic digestion → **improved aromas**
- Desirable control: controlled natural drying promotes these fungi **without excessive growth.**

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Wood is a noble material because it comes from a long cycle. It's up to us to respect it.

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