# APISARA

# SOAP HARDNESS, SOLUBILITY AND LONGEVITY

Understanding what really makes a bar of soap last

Apisara technical and educational guide For hobbyists, artisans, professionals, trainers and learners.

> Core idea. A soap that feels “hard” is not necessarily a soap that wears away slowly. Bar longevity results from a combination of the soaps formed, bar structure, water content, curing, conditions of use and drying between uses.

This guide separates three concepts that are often confused: mechanical hardness, solubility/erosion in contact with water, and longevity in actual use. This distinction helps formulators work methodically instead of treating a calculator's hardness indicator as a verdict on soap quality.

### Apisara resources

In addition to the saponification calculator, technical guides and reference sheets are available at apisara.org. Complementary educational articles are also published on Substack and Facebook.

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## 1. Three different concepts

Hardness describes a bar's resistance to deformation, penetration or crushing. It depends on factors including soap composition, residual water, crystalline structure and processing.

Solubility describes how readily soap components enter the aqueous phase. In a real bar, however, use is not simply equilibrium dissolution: wetting, swelling, formation of organised phases, friction and mechanical removal also contribute to material loss.

Longevity in use is the observable outcome: how many washes or days does a bar remain usable? It depends on formulation, but also strongly on how the soap is used and allowed to dry.

> **Key point:** hardness ≠ low solubility ≠ long service life. These properties are related, but they are not synonymous.

## 2. Why fatty-acid composition matters

Saponification converts fatty acids from oils and butters into fatty-acid salts. With sodium hydroxide (NaOH), the main products are sodium soaps, suitable for solid bars. Chain length, degree of unsaturation and molecular organisation influence the soap's physical properties.

| Family | Typical contribution in a sodium soap | Point to watch |
|---|---|---|
| Lauric / myristic (C12-C14) | Can contribute to a firm bar and rapid dissolution/lathering. | A firm bar can nevertheless wear away quickly in water. |
| Palmitic / stearic (C16-C18 saturated) | Generally promote firmness, structure and denser, more stable lather. | Very high levels can alter texture, processability and user feel. |
| Oleic (C18:1) | Produces soaps with properties distinct from saturated soaps and contributes to the overall balance of many formulas. | Its role should not be reduced to simplistic labels such as “soft” or “mild”. |
| Linoleic / linolenic | Contribute to soaps derived from polyunsaturated oils. | High unsaturation mainly increases the formulation's oxidative-stability challenge. |

Research on soaps shows that chain length affects molecular organisation and dissolution behaviour. In practical soapmaking, it is therefore more useful to reason from the overall fatty-acid profile than from a simple “hard oil versus soft oil” classification.

## 3. The paradox of a hard soap that disappears quickly

A soap rich in lauric raw materials such as coconut or palm-kernel oil can become firm quickly. Yet shorter-chain soaps are generally more readily mobilised by water than long-chain saturated soaps. Initial firmness alone therefore does not predict wear rate.

Conversely, simply increasing palmitic and stearic fractions is not a universal solution. Texture, lather, processing, manufacturing temperature and sensory performance must remain balanced.

> **Common mistake:** trying to maximise the “hardness” number in a calculator. A formulation indicator is useful for comparing recipes, but it does not directly measure how long a bar will last in the shower.

## 4. Water: the invisible longevity variable

Two bars with identical composition can behave differently if their water content differs. During curing, some water evaporates. The bar loses mass, becomes firmer and its physical structure evolves. Lower available water generally reduces the amount of material readily removed during the first wettings.

This is why comparing soaps only at 24 hours, or merely by pressing them with a finger, is not very informative. To compare formulations, standardise soap age, sample dimensions and curing conditions.

## 5. Does curing always improve longevity?

Adequate curing is generally beneficial for cold-process soap: among other effects, it permits water loss and evolution of the physical structure. But curing cannot correct an intrinsically highly soluble formulation or poor conditions of use.

In other words, allowing a highly soluble soap to dry for a few extra weeks may improve its behaviour, but it will not turn it into an inherently low-erosion soap. Formulation and curing work together.

## 6. Superfat: do not attribute every effect to it

Superfat changes the final product by leaving an unsaponified lipid fraction or by deliberately creating an alkali deficit. It can influence texture and use, but longevity cannot be predicted from the superfat percentage alone. Fatty-acid profile, water, additives and processing remain important.

## 7. Additives that may affect firmness or erosion

Some additives alter texture or water availability without fundamentally changing the fatty-acid profile. They should be regarded as adjustment tools, not substitutes for a coherent formulation.

| Additive / lever | Possible intended effect | Limitations |
|---|---|---|
| Sodium chloride (salt) | Can firm some soaps and alter their behaviour in water. | Can reduce or change lather; the effect depends strongly on dosage and formulation. |
| Sodium lactate | Often used to aid unmoulding and increase early firmness. | Should not be confused with a guarantee of longevity in use. |
| Reduced formulation water | Can speed early firming and reduce the amount of water that must evaporate. | Changes reaction speed and trace behaviour; requires process control. |
| Fillers / powders | May modify texture, slip and mechanical resistance. | Effects depend on material, particle size and amount; some may increase mechanical wear. |

## 8. Real use: the soap dish matters more than it seems

A bar left in standing water or in a persistently wet shower remains hydrated at the surface. The outer layer softens and is more easily removed during the next wash. With the same formulation, a soap that dries on a draining, ventilated support can therefore last considerably longer.

- Promote drainage: use an open support with no standing water.
- Promote drying: allow air circulation between uses.
- Avoid immersion: do not leave the bar under running water or sitting in water.
- Standardise tests: same wetting time, same rubbing cycles and same drying time.

## 9. How to measure longevity without a laboratory

For a small workshop, mass tracking is a simple, reproducible approach. It does not replace a standardised laboratory method, but it can compare prototypes under defined conditions.

### Simple comparative protocol

- Prepare at least 3 bars per formulation, with dimensions as similar as possible.
- Cure them under the same conditions and test them at the same age.
- Weigh each dry bar before the first cycle (m0).
- Apply an identical cycle: wetting, rubbing or agitation, rinsing and draining.
- Allow to dry for a fixed period under identical conditions.
- Weigh again after drying (m1), then repeat for several cycles.
- Mass loss (%) = [(initial mass - mass after n cycles) / initial mass] × 100.

The lower the mass loss under an identical protocol, the better the bar resists that particular use scenario. The result is comparative and should not be presented as a universal consumer service life.

## 10. Going further: separate hardness from wear rate

To avoid misleading conclusions, a workshop can track two separate indicators:

- Firmness index: instrumental measurement when available (penetrometer, texture analyser), or a strictly standardised internal protocol.
- Wear rate: mass loss after a defined number of water/rubbing/drying cycles.

Four profiles may then appear: hard and long-lasting; hard but rapidly eroded; less hard but long-lasting; less hard and rapidly eroded. This framework is more informative than a single “hardness” number.

## 11. A teaching example

Imagine three prototypes. The purpose is not to provide recipes, but to show how results can be interpreted.

| Prototype | Observation | Interpretation to test |
|---|---|---|
| A | Very firm on unmoulding, high mass loss during wet cycles. | Initial firmness does not necessarily protect against strong removal by water. |
| B | Moderate initial firmness, low loss after full cure. | Final structure and soap profile may promote better resistance in use. |
| C | Good test resistance, but softening reported by some users. | Check soap dish, humidity, time between uses and bar geometry before reformulating. |

## 12. What calculators can - and cannot - tell you

A saponification calculator is essential for correctly determining alkali and analysing a recipe's composition. Property indices are primarily comparison and formulation-aid tools. On their own, they do not reproduce bar microstructure, actual water content, process, cure or user habits.

Good practice: use the calculator to build a hypothesis, then confirm it with standardised physical tests and observations in use.

## 13. The most common mistakes

- Confusing a soap that is difficult to cut with one that will last a long time.
- Maximising a hardness index without considering lather, use, processing and stability.
- Comparing soaps of different ages or water contents.
- Changing several variables at once and losing the ability to identify the cause.
- Ignoring storage and soap-dish conditions in consumer tests.
- Drawing conclusions from one bar instead of repeating trials.
- Turning formulation trends into absolute rules.

## 14. Practical diagnostic sheet

| Observed problem | Questions to ask | Test directions |
|---|---|---|
| Soap is soft after unmoulding | Water? age? composition? temperature? superfat? weighing error? | Check calculations and process first; compare at equal age; do not infer longevity yet. |
| Soap is hard but disappears quickly | Lauric/myristic profile? immersion? soap dish? very frequent use? | Measure mass loss; test drying conditions and targeted reformulation. |
| Pasty surface between uses | Standing water? ventilation? high humidity? | Improve drainage/drying before changing the formula. |
| Good durability but weak lather | Has the formula been pushed toward long-chain saturated soaps at the expense of balance? | Rebalance by changing one variable at a time. |
| Inconsistent results between batches | Are weighing, temperature, water, cure, dimensions and raw materials standardised? | Implement batch records and a control protocol. |

## 15. Formulation checklist

- Have I defined the intended use before looking for an “ideal hardness”?
- Is the fatty-acid profile balanced for that use?
- Have I separated unmoulding firmness from erosion resistance?
- Are water amount and lye concentration controlled?
- Is cure standardised before comparisons?

- Does each additive have a precise, documented purpose?
- Have I planned a reproducible mass-loss test?
- Have I tested several bars and several cycles?
- Are drying conditions between uses controlled?
- Have I recorded every variable in the batch record?

## 16. Summary

Soap longevity cannot be reduced to hardness. A successful bar is a compromise between soap composition, water content, structure, cure, lather, user experience and drying conditions. The most useful approach is to formulate from the fatty-acid profile and then measure firmness and actual wear separately.

The useful question is therefore not “Is my soap hard enough?” but “Under defined conditions of use, do its structure and formulation allow it to resist water while delivering the properties I want?”

## 17. References and further reading

The references below support the physicochemical principles discussed here. Some concern model systems or industrial soaps and should be interpreted cautiously when applied to a complete handcrafted soap.

Kuntom, A. et al. (1996). Chemical and physical characteristics of soap made from distilled fatty acids of palm oil and palm kernel oil. Journal of the American Oil Chemists' Society.

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Processes (2025), 13, 2770. Towards a Deeper Understanding of Simple Soaps: Influence of Fatty Acid Chain Length on Concentration and Function.

Soap formulation study (2014). The Use of D-Optimal Mixture Design in Optimising Okara Soap Formulation for Stratum Corneum Application.

### DISCLAIMER

This guide is an educational resource. It does not replace laboratory analysis, a Safety Data Sheet (SDS), supplier specifications, a cosmetic safety assessment, or the regulatory requirements applicable to the product and country concerned.

### LICENCE

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