APISARA

OXIDATION, RANCIDITY AND DOS IN SOAPMAKING

Understand the mechanisms, identify the causes and prevent defects

A DEFECT TO UNDERSTAND, NOT TO HIDE

Orange spots, commonly called DOS or “Dreaded Orange Spots”, are not a mysterious disease of soap. They are generally associated with oxidation and rancidity of the lipid fraction. Understanding the factors that accelerate oxidation makes it possible to reason about formulation, storage and preventive measures.

This guide covers: oxidation mechanisms • sensitive fatty acids • oxygen, light, heat and metals • raw materials • superfat • curing and storage • antioxidants • chelators • vitamin E • ROE • spot diagnosis • prevention • quality control.

Eric Bertrand for Apisara Free knowledge base for hobbyists, artisans, professionals and trainers.

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1. Oxidation, rancidity and DOS: three concepts to distinguish

Lipid oxidation is a group of chemical reactions affecting mainly unsaturated fatty acids. It can begin long before a defect is perceptible. Oxidative rancidity is a stage at which oxidation products have accumulated sufficiently to alter odour, colour or other characteristics of the fat or soap.

The term DOS is widely used in craft soapmaking to describe yellow-to-orange spots that appear locally on some soaps during storage. They are strongly associated with oxidative rancidity, but orange colour alone is not proof: colourants, botanicals, fragrances or contamination can create similar appearances.

ESSENTIAL POINT

Soap can begin oxidising without visible DOS. Conversely, not every orange spot is necessarily DOS. Diagnosis should combine appearance, odour, evolution over time, formulation, raw materials and storage conditions.

2. How lipid oxidation progresses

In a simplified model, lipid auto-oxidation is a chain reaction. Initiation creates lipid radicals; these react with oxygen and propagate the reaction, forming hydroperoxides among other products. These primary products can then decompose into numerous secondary compounds responsible for odours and other deterioration.

Stage	What happens	Practical consequence
Initiation	Radicals form under initiating factors such as heat, light, metals or pre-existing peroxides.	Deterioration may begin without any visible sign.
Propagation	A chain reaction with oxygen forms peroxides/hydroperoxides.	Oxidation can sustain itself while favourable conditions remain.
Decomposition	Hydroperoxides break down into more odorous and coloured secondary products.	Rancid odour and visible defects may appear.
Termination	Radicals react with one another and the chain slows locally.	This does not restore lipids that have already deteriorated.

The realistic objective is therefore not to make a soap “impossible to oxidise”, but to slow the reactions sufficiently to maintain acceptable quality throughout the intended product life.

3. Why oils are not equally sensitive

Sensitivity to oxidation generally rises with the degree of unsaturation. Double bonds make fatty-acid chains more vulnerable to certain radical reactions. All else being equal, lipids rich in polyunsaturated fatty acids therefore require more attention than those rich in saturated fatty acids.

Dominant profile	Relative sensitivity	Formulation consequence
Saturated fatty acids	Rather low	Relatively good oxidative stability, without implying absolute stability.
Oleic acid (monounsaturated)	Intermediate	Often more stable than oils very rich in linoleic/linolenic acids.
Linoleic acid (polyunsaturated)	Higher	Monitor freshness, storage and proportion in the formula.
Alpha-linolenic acid (more unsaturated)	High	Requires particular attention to oxidation and storage duration.

This table describes a chemical tendency, not an absolute ranking of oils. Actual stability also depends on naturally occurring antioxidants, refining, initial quality, packaging, storage and possible contamination with pro-oxidant metals.

4. Major accelerators of oxidation

Factor	Mechanism / effect	Practical measure
Oxygen	A reactant required for auto-oxidation.	Avoid unnecessarily long storage and excessive exposure; use suitable oil packaging.
Light	Can promote photo-oxidation and initiation.	Store oils and soaps away from intense, direct light.
Heat	Accelerates many chemical reactions.	Avoid hot storage and unnecessary temperature fluctuations.
Iron / copper	Transition metals can catalyse hydroperoxide decomposition and accelerate radical chains.	Avoid contamination from water or equipment; use a chelation strategy where justified.
Existing peroxides	A partially oxidised oil enters the process with a head start.	Check freshness, odour, date, supplier and storage conditions.
High unsaturation	Provides more oxidation-sensitive sites.	Consider the overall fatty-acid profile rather than one oil in isolation.

5. Oil quality before soapmaking even begins

An excellent recipe cannot correct a fat that is already deteriorated. Prevention therefore begins at receiving. An oil may have experienced heat, light, oxygen or prolonged storage before reaching the workshop.

- Buy from suppliers able to provide traceability and coherent storage conditions.
- Record batch, receiving date and, where available, production date and shelf life.
- Check odour and appearance when opening; compare with a reference batch where possible.
- Close packaging promptly and limit unnecessary transfers.
- Match container size to actual consumption: a large drum left open for months is not always economical.
- Apply FEFO stock rotation — “first expired, first out” — where durability dates are available.

A COMMON TRAP

An oil that does not yet smell clearly rancid may already contain primary oxidation products. Smell is useful, but it does not replace supplier specifications or, when justified, quality analysis.

6. The role of superfat

Superfatting deliberately leaves a lipid fraction unsaponified or reduces the amount of alkali available. This can improve certain use characteristics, but it also means that a lipid fraction remains susceptible to oxidation. Increasing superfat is therefore not neutral for stability.

This does not mean that a superfatted soap will automatically become rancid. Risk depends on the oil profile, initial oil condition, overall formulation and storage. However, a very high superfat combined with a high proportion of oxidation-sensitive oils deserves stability validation rather than confidence based solely on a recipe.

7. Curing, drying and soap storage

- Cure in a clean, ventilated environment protected from excessive humidity.
- Avoid prolonged contact with metal surfaces that could contaminate the soap.
- Avoid direct sunlight and excessive heat.
- Do not package soap that is still too moist in packaging that traps moisture unless the choice has been validated.
- Retain reference samples from every batch to observe changes over time.

- Record production date, formula, oil batch numbers, additives and unusual conditions: without traceability, diagnosis becomes guesswork.

8. Antioxidant ≠ preservative ≠ chelator

These three functions are frequently confused, yet they address different problems.

Family	Main function	What it does not guarantee
Antioxidant	Interrupts or slows certain radical oxidation reactions.	Does not replace good-quality oil or proper storage; is not automatically antimicrobial.
Chelator	Binds certain metal ions and reduces their ability to catalyse undesirable reactions.	Does not stop every oxidation pathway and is not, strictly speaking, a radical-scavenging antioxidant.
Antimicrobial preservative	Limits microbial growth in systems that require such preservation.	Does not necessarily prevent lipid oxidation.

> REMEMBER Adding vitamin E does not “preserve” a product against bacteria and moulds. Conversely, an antimicrobial preservative does not automatically protect an oil against rancidity.

9. Vitamin E / tocopherol: useful, but not magic

Tocopherol is a lipid-soluble antioxidant capable of reacting with radicals involved in the propagation of lipid oxidation. Its effectiveness nevertheless depends on the system, concentration, initial state of the oil, oxygen and other factors. Scientific literature shows that the effect of tocopherols does not necessarily increase linearly with dose and that pro-oxidant behaviour can occur in some experimental systems.

For craft practice, this leads to two rules: do not regard vitamin E as universal insurance against DOS, and avoid arbitrarily high doses on the assumption that “more antioxidant = more protection”.

An experiment published by the Handcrafted Soap & Cosmetic Guild using an accelerated olive-oil soap model did not observe a notable preventive effect from vitamin E under the conditions tested. This result is useful, but it should not be turned into a universal rule for every formulation.

10. Rosemary oleoresin extract (ROE)

ROE is used to improve the oxidative stability of oils and fats. It is most relevant when added before the fats have become substantially oxidised. It does not “repair” rancid oil.

In the accelerated craft experiment cited above, ROE clearly delayed the appearance of oxidation signs under the experimental conditions. As with any antioxidant, actual performance nevertheless depends on the commercial product, active-compound content, dosage and system studied.

11. Chelators: acting on pro-oxidant metals

Iron and copper can strongly accelerate oxidation by catalysing hydroperoxide decomposition. A chelator forms complexes with certain metal ions and can reduce their catalytic activity.

In soapmaking, EDTA and some citrates are often discussed. Their effectiveness is not interchangeable and depends on pH, concentration, metals present and the system. In the accelerated Handcrafted Soap & Cosmetic Guild experiment, EDTA showed strong protection against DOS, whereas sodium citrate alone did not show a notable benefit under those specific conditions. This illustrates why absolute claims should not be drawn from a single experiment.

A chelator may also provide other formulation benefits, particularly regarding ions that contribute to insoluble soap deposits in hard water. This function is distinct from oxidation prevention.

12. Can an antioxidant and a chelator be combined?

Yes. The strategy is chemically coherent: the antioxidant acts on certain radical reactions, while the chelator reduces the activity of catalytic metals. Complementary effects are therefore possible. However, a combination is not automatically synergistic. In accelerated tests, some combinations perform better than either ingredient alone, while others offer no gain or may perform less well.

GOOD PROFESSIONAL PRACTICE

Choose a stabilisation system from the actual formula, actual raw materials and intended product life. Then validate it by comparing control batches rather than stacking several additives “just in case”.

13. Mistakes that encourage rancidity

Mistake	Why it is a problem	Correction
Using old oil because it “still smells fine”	Primary oxidation may precede a rancid odour.	Check history, storage and specifications; reduce open stock.
High superfat + highly polyunsaturated oils without validation	Increases the sensitive lipid fraction.	Rebalance the formula or test stability.
Storing oils near heat/light	Accelerates oxidation.	Use cool, dark, suitable storage.
Equipment or water introducing metals	May catalyse oxidation.	Identify the source; use compatible equipment; chelate where justified.
Adding lots of vitamin E “for safety”	Effect is not proportional to dose.	Follow supplier data and testing.
Confusing antioxidant and preservative	Addresses the wrong risk.	Define the mechanism to control first.

14. My soap has orange spots: step-by-step diagnosis

Step	Question	Interpretation / action
1. Observe	Localized spot or general discoloration? Surface or depth?	Photograph, date and retain a sample.
2. Smell	Rancid, waxy, oxidised-oil odour, or normal?	A rancid odour strengthens the oxidation hypothesis, but may be absent early on.
3. Check the formula	Highly unsaturated oils? High superfat? Colouring additives?	Assess intrinsic risk factors and possible false positives.
4. Check batches	Oil near end of life? Packaging open for a long time?	Compare with other products made from the same raw-material batch.
5. Check storage	Heat, light, humidity, metal contact, poor airflow?	Compare the location of affected and unaffected soaps.
6. Look for local contamination	Contact point with shelf, metal wire, tool or surface?	A localized pattern may point to an external factor.
7. Compare batches	Same formula, different dates or oils: same defect?	Helps isolate formula, raw material or environment.
8. Document	When does the defect appear and how does it progress?	Build a usable history to correct the cause.

> DO NOT JUMP TO CONCLUSIONS An orange spot caused by a botanical colourant, fragrance or external contamination can resemble DOS. Diagnosis becomes far more reliable when reference samples, oil batch numbers and dated photographs are available.

15. What should be done with a suspect batch?

Soap showing perceptible rancidity is a product whose quality has deteriorated. In professional activity, it should not be placed on the market as though no defect exists. Isolate the batch, document the defect, identify shared raw-material batches and assess any products already distributed according to the company's quality procedures.

Do not attempt to hide a rancid odour with additional fragrance. Once lipids have oxidised, adding an antioxidant later does not return them to their original state.

16. Ten-point prevention plan

- 1. Design a formula whose lipid profile is compatible with the intended product life.
- 2. Buy fresh, traceable oils.
- 3. Match purchasing volumes to actual consumption.
- 4. Protect oils from heat, light and air as far as reasonably practical.
- 5. Control possible sources of iron and copper.
- 6. Reason the superfat level rather than automatically maximising it.
- 7. Choose antioxidant and/or chelator for a defined function, not from habit.
- 8. Organize clean, dry, ventilated curing and storage without excessive heat.
- 9. Keep reference samples and complete traceability.
- 10. Compare batches and learn from defects: a stable formula is a formula observed over time.

17. Building a small comparative workshop test

Without replacing laboratory testing, an artisan can greatly improve knowledge of a formula with a simple comparative protocol. The aim is not to “scientifically prove” a shelf life, but to compare variants under identical conditions.

Element	Good practice
Control batch	Make an unchanged version to serve as the reference.
One variable only	Change one factor at a time: antioxidant, chelator, oil, superfat, packaging…
Identical samples	Same size, same initial cure, same location.
Dated observations	Colour, odour, surface, mass if useful; photographs under similar conditions.
Normal conditions + controlled stress	Observe real storage; an accelerated test may help compare samples but cannot be directly converted into real shelf life.
Replication	A single bar is not representative: use several samples where possible.

18. Analytical indicators: going further

Professionals working with oils and fats have analytical tools that can help characterize oxidation. The peroxide value mainly reflects certain primary oxidation products; the anisidine value and other measurements can provide information on secondary products; accelerated induction tests such as Rancimat assess stability under defined conditions.

No single indicator tells the whole story. Peroxide value, for example, can fall as hydroperoxides decompose even while overall oxidation continues. For a professional specification, suitable methods should be selected for the material and several pieces of information interpreted together.

19. What can reasonably be said — and what is too simplistic

Reasonable statement	Over-simplified statement
More polyunsaturated oils are generally more oxidation-sensitive.	“Every oil rich in linoleic acid causes DOS.”
Transition metals can strongly accelerate oxidation.	“Metal is always the cause of DOS.”
Antioxidants can slow certain oxidation reactions.	“Vitamin E prevents rancidity.”
Chelators can reduce the catalytic action of some metals.	“Citrate always prevents DOS.”
Good traceability helps identify the cause of a defect.	“DOS is random and impossible to understand.”

20. Summary: a multi-barrier strategy

The best prevention usually does not depend on a miracle ingredient. It combines several coherent barriers:

- Raw materials: freshness, traceability and suitable storage.
- Formulation: fatty-acid profile and superfat compatible with the intended stability.
- Process: avoid contamination and unnecessary exposure.
- Stabilisation: antioxidant and/or chelator where their function is justified.
- Curing and storage: limit heat, excessive light, humidity and problematic contact.
- Control: retained samples, dated observations, batch comparison and analysis where necessary.

THE KEY IDEA

DOS is rarely solved sustainably by adding a random ingredient. The most robust approach is to identify where oxidation begins — oil, formula, contamination, process or storage — and then act on the cause.

21. References and level of evidence

Handcrafted Soap & Cosmetic Guild — “Dreaded Orange Spot”. Educational experiment on soap oxidation, the influence of oxygen and comparison of several additives. Useful for craft soapmaking, but it should be interpreted as a specific experiment rather than a universal standard.

Scientific literature on lipid oxidation. General auto-oxidation mechanisms describe initiation, propagation and termination; light, heat and metal ions can accelerate the phenomenon.

Literature on tocopherols. Tocopherols are important lipid antioxidants, but effectiveness depends strongly on concentration and the system; several studies show that increasing the dose does not necessarily produce greater protection.

Literature on transition metals. Iron and copper can accelerate hydroperoxide decomposition and promote radical reactions, explaining the potential value of chelation strategies.

22. Disclaimer

This guide is an educational resource. It does not replace laboratory analysis, an SDS, supplier specifications, a cosmetic safety assessment, suitable stability testing, or the regulatory obligations applicable to the product and country concerned.

APISARA RESOURCES

In addition to the soap recipe calculator, apisara.org provides Apisara technical guides and reference sheets. Additional educational articles are also published on Substack and Facebook.

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