



# HANDCRAFTED SoapMaker

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## Superfatting and the Lye Discount

by Kevin M. Dunn

Handcrafted soap, whether hot- or cold-process, involves the addition of fats and oils to one of the caustic alkalis, sodium or potassium hydroxide. If excess alkali remains in the finished soap it will be harsh and perhaps even dangerous. To prevent this possibility soapmakers generally add more oil than can be saponified by the available alkali, or, conversely, they add less alkali than would be required to saponify the available oil.

The first practice is called superfatting and the second, lye discounting. While the two practices are similar, there may be subtle differences in emphasis and procedure between the two.

This past year my students and I have explored these differences and have tried to quantify them.<sup>1</sup>

### Saponification

There are many similarities between cooking and soapmaking. Fats and oils are combined in pots and melted on stoves. Stick blenders are used for mixing and measuring cups for measuring. It is not surprising that soapmakers with a cooking background often approach soapmaking as just another recipe.

In making the transition from cooking to soapmaking, however, the soapmaker must realize some important differences between cake recipes and soap recipes.

First and foremost, sodium and potassium hydroxide are far more hazardous than any ingredient employed by Betty Crocker and the soapmaker must be prepared to handle them cautiously and safely. A close second, however, is the concept that soap is not just a mixture of oil and lye.

When sugar, flour, and butter are combined, all three ingredients remain in the finished cake. If a cook uses more sugar than called for in the recipe, the cake will simply be sweeter than it would have otherwise been.

When oil and lye are combined, however, both are consumed in a chemical reaction called **saponification**. Each molecule of oil may react with as many as three molecules of sodium hydroxide to produce as many as three molecules of soap. This three-to-one ratio means that there is a definite relationship between the weight of oil used in a soap recipe and the amount of sodium hydroxide needed to turn it completely into soap. If the soapmaker adds “too much” lye, three molecules of sodium hydroxide react with each molecule of oil until the oil is completely consumed and turned into soap and the excess sodium hydroxide remains in the soap. Unlike the cake example, the soap is not simply a little more alkaline - it is caustic and potentially dangerous.

We cannot dole out lye and oil one molecule at a time, but because each molecule has a specific weight we can determine the weight of sodium or potassium hydroxide required to exactly saponify a given weight of oil. This is generally expressed as the number of milligrams of potassium hydroxide required to completely saponify one gram of oil. Because different oils contain different oil molecules, the saponification value (SAP or SV) for palm oil differs from that for coconut oil or olive oil. Worse than that, it may differ from one sample of palm oil to another; the values tabulated in soapmaking books are simply averages over many samples of each kind of oil. As a concrete example, consider the palm oil we used in the present study.

Our supplier lists the SAP value of palm oil as 203 mg KOH/ g oil. When we measured the SAP value of the oil we received, however, it turned out to be 196 mg KOH/ g oil, about 3% lower than the stated value. It would not be fair to blame the supplier - the SAP value of palm oil might be anywhere between 190 and 209 mg KOH/g oil.<sup>2</sup> The supplier simply reports an average value. The fact of the matter is that the SAP values of real-world oils may be higher or lower than the reported average values and the soapmaker must deal with this reality.

To cope with the fundamental uncertainty in the SAP value, soapmakers engage in two related practices, lye discounting and superfatting. While these terms are sometimes used interchangeably, there is a subtle distinction between the two. When a soapmaker discounts her lye, she generally uses the *average* SAP value to calculate the amount of lye required to completely saponify the oil to be used. She then deducts a percentage of the calculated lye as a safety precaution. If, for example, 100 oz of lye are indicated, she will use only 95 oz and will say that she “discounted the lye by 5%”. In the case of our palm oil, this discount would have been large enough to cover the (usually unknown) difference between the actual SAP value and the average one.

There is another way to look at the problem, however. A soapmaker might use the average SAP value to calculate the amount of lye needed to saponify the oil to be used, but instead of discounting the lye he could simply add more oil. The soapmaker who superfats might add 5% more oil than was used to calculate the lye portion and would say that he “superfatted by 5%”. So far, there is not much difference between discounting and superfatting and they both address the fundamental uncertainty in the SAP value.

A difference arises, however, when the soapmaker claims to have superfatted with some particular oil. He may, for example, make soap using 20% coconut oil, 60% palm oil, and 20% olive oil. He will calculate the lye needed for this oil blend and begin to make soap using the calculated lye amount. At trace, however, he adds 5% shea oil and believes that he has “superfatted with shea oil.” He is assuming that the last oil added to the soap is the oil which will remain unsaponified in the finished soap. It is this assumption that we set out to test. Let us call it the *superfatting hypothesis*:

**Hypothesis: In a superfatted soap some oil remains unsaponified. This unsaponified oil consists mostly of the last oil added, usually at trace.**

**If the superfatting hypothesis is true**, then the soapmaker can control the makeup of unsaponified oil by adding the superfatting oil at trace. This will generally be a relatively expensive oil whose presence in the finished soap is deemed desirable.

**If the hypothesis is false**, however, the soapmaker makes his life harder by attempting to incorporate the superfatting oil at a time when the clock is literally ticking. Not only would he work harder than he has to, but the superfatting oil may be incompletely mixed when the soap is poured. If this happens, some bars will contain more oil and others less. Those that contain less oil may, in fact, contain excess lye and one of the major benefits of superfatting will be lost.

## Analysis of Discounted and Superfatted Soaps

We addressed the superfatting hypothesis by making soaps which were identical in composition and differed only in the order in which the oils were added. In the discounted soaps, all of the oils were blended before adding the lye. In the superfatted soaps, one of the oils was held back when the other oils and lye were mixed. The superfatting oil was then added at trace, just before the soap was poured into the mold. The discounted and superfatted soaps were then held at  $160\pm F$  for 4 hours to ensure complete saponification. Samples of each soap were then boiled in ether to extract the unsaponified oils. The unsaponified oils were recovered and analyzed using NMR spectroscopy to determine their compositions. If the superfatting hypothesis were correct, we would expect to see a difference between the oils extracted from discounted and superfatted soaps.

The first combination of oils to be tested was 91% coconut oil and 9% olive oil. This rather peculiar combination was chosen because the oleic acid in olive oil is easily distinguished from the saturated fatty acids present in coconut oil. The discounted and superfatted soaps used identical quantities of the oils and lye, which was discounted by 5%. In the discounted soap the coconut and olive oils were mixed before the lye was added. In the superfatted soap the olive oil was added at trace. The soaps were extracted with ether and the extracted oils were analyzed by NMR spectroscopy, the details of which are beyond the scope of this report.

**Our analysis found that the oils extracted from the discounted and superfatted soaps were virtually identical.** The blend of coconut and olive oil used to make both soaps contained approximately 7% oleic acid, the remainder being saturated oils. The oils extracted from the discounted and superfatted soaps each contained 22% oleic acid. Thus the unsaponified oil contained more of the unsaturated oleic acid than did the original oil blend. We supposed that the unsaturated oils in olive oil react more slowly with lye than do the saturated oils which predominate in coconut oil. The resulting soap contained a higher-than-expected concentration of unsaturated oil, regardless of whether the olive oil was added at trace.

The second combination of oils was 90% palm oil and 10% castor oil. In this case, the unsaturated ricinoleic acid of castor oil is easily distinguished from the fatty acids present in palm oil. A 10% lye discount was taken to provide a greater quantity of unsaponified oil for analysis. While the original oil blend contained 9% ricinoleic acid, the unsaponified oils extracted from the discounted and superfatted soaps each contained 4% ricinoleic acid. We supposed

that castor oil reacts more rapidly with lye than palm oil, resulting in a lower percentage of unsaponified castor oil. As in the case of the coconut/olive combination it made no difference whether or not the castor oil was added at trace.

The third combination of oils studied was 90% palm oil and 10% grapeseed oil. The unsaturated linoleic acid of grapeseed oil is easily distinguished from the fatty acids present in palm oil. Again, a 10% lye discount was taken and the soaps were processed as in the previous combination. While the original oil blend contained 9% linoleic acid, the discounted soap contained 19% and the superfatted soap 17% linoleic acid. As in the case of the coconut/olive combination we supposed that the unsaturated olive oil reacts more slowly with lye than the saturated palm oil and so the finished soap contains a greater percentage of unsaturated oil than did the original oil blend. Once again it made little difference whether or not the grapeseed oil was added at trace.

## Conclusion

We have so far studied only three combinations of oils chosen for ease of analysis rather than as representatives of the kinds of blends usually chosen by soapmakers. These combinations have included oils containing oleic, linoleic, and ricinoleic acids. We will next study the hempseed/palm oil combination, adding linolenic acid to the list of included fatty acids. The results so far must be treated as preliminary but I think they are suggestive if not conclusive. In no instance was the superfatting hypothesis supported. For our continuing research we have adopted the kinetic hypothesis:

### **There appears to be no real difference between discounting lye and superfatting.**

The composition of unsaponified oil in finished soap does not depend on the order in which the oils are added. The oil component which reacts most slowly with lye will be more concentrated in the unsaponified oil than in the original oil blend.

What this means for the soapmaker is that you may discount or superfat your soap as you please. If you have been trying to incorporate superfatting oils at trace, however, you may have been working harder than you needed to. I would suggest that you thoroughly mix all of your oils before adding the lye. If you find that the quality of your soap is unchanged or improved, you will save yourself time and effort. If you do find a difference, however, between discounted and superfatted soap I would really like to hear about it. Send me your formulas and procedure and a sample of each soap. Who knows, your observations may point us toward our next research project. 🌿

1. *This material has been excerpted from a draft of the book, **Scientific Soapmaking** © 2007, Kevin M. Dunn. The research was performed at Hampden-Sydney College by students Mick Robbins, Robbie O'Cain, and Andrew McLeod under the direction of Kevin M. Dunn.*
2. *Physical and Chemical Characteristics of Oils, Fats, and Waxes, David Firestone (ed.), 1999.*