Effect of Tallow-Coconut Fatty Acid Ratios on Properties of Bar Soaps

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Abstract

In this study, blends of tallow and coconut fatty acids prepared at ratios ranging from 95:5 to 75:25 were converted to sodium soaps, and were processed into soap bars through conventional milling and pressing techniques. Other minor ingredients were included in the bar to protect against rancidity and to provide color. The resulting bars were tested for lather, solubility, penetration, swell, slushing tendency, moisture and cracking. According to one mechanical method, the 85:15 tallow/coconut fatty acid blend yields optimum lather quickness. This does not agree with lather preference by an expert panel which preferred bars with increasing sodium cocoate content or with increasing levels of sodium laurate. Coincident with these effects was an increase in aqueous solubility. However, certain deleterious effects were observed with increase of sodium cocoate, namely: increased slushing and a higher erosion rate.

Introduction

Bar soap performance depends both on the method of manufacture and the chemical composition. Physical properties significantly affecting performance include solubility, hardness and slushing tendency. These characteristics as well as latherability, depend on composition variables such as fatty acid distribution, moisture content and the nature of various additives. Thomssen and other workers have reported that the use of minor additives such as salt and glycerine influence the gloss, cracking, texture, plasticity and moisture retention of bar soaps (1–3). Considering physical treatment of the soap, Ferguson and co-workers suggested that milling and plodding operations alter such characteristics as swelling, solubility and slushing tendency (4,5). Apparently very little has been published concerning the physical and performance properties of the various tallow/coconut fatty acid blends used in the manufacture of bar soaps. McCutcheon reported on the relationship of the chain length and unsaturation of fatty acids to performance properties. He found that detergency and micellar properties are related to the chain length of the soap. In particular, it was noted that longer chain length soaps, for example sodium stearate, are more effective cleansing agents, but only at elevated temperatures (6).

Experimental Procedures

Soap Manufacturing Procedure

The soap used in this study was manufactured from a blend of tallow and coconut fatty acids which is saponified with caustic soda. Further treatments involved vacuum drying of the resulting neat soap, blending of various additives into dried soap pellets and subsequent milling, plodding, slug cutting and pressing into the final soap bar. The equipment used in the plodding and slug trimming portion of the operation (7,8) included a triplex vacuum plodder in which the soap is forced through a series of three perforated plates. The soap was then extruded as a continuous cylinder. This cylinder was subsequently cut into slugs and conveyed to a press which stamped the slug to the desired dimensions.

Fatty Acid Derivation and Distribution

To derive fatty acids for saponification, stocks of tallow and coconut oil are hydrolyzed using conventional fat splitters. The split acids are distilled and the prime distillates are blended at the desired ratio. This study gives results for blends ranging from 95:5 to 75:25 ratios of tallow to coconut fatty acids. Figure 1 shows the major fatty acid components of these blends.

Lauric acid is found only in the coconut fraction and not in tallow fatty acids. Therefore, the most dramatic change observed is the increase of lauric acid content with increasing proportions of coconut acids. These variations in fatty acid content illustrate how the major components vary in blends ranging from 100% tallow fatty acids on the left to 100% coconut fatty acids on the right. The fatty acid distribution shown is somewhat idealized with respect to the omission of oleic and stearic acids in the coconut fraction. Most noticeable is the steep positive slope of the line representing the lauric acid content and the negative slope of the oleic acid level. Stearic, palmitic and myristic acid contents change to a lesser degree with the variation of blend ratio; however, these changes are regarded as significant. As the coconut acid ratio is raised, levels of stearic and palmitic acids decrease while the myristic acid content increases.

Performance Evaluation

Lather Quickness. The dipping apparatus was used according to the method described in the article by Becher (9). Mechanical erosion and concentration of soap required for the mechanical foam endpoint were taken at 85F with this method. In addition, the amount of mechanical work (strokes) necessary to induce a specific arbitrary foam was taken.

Hand Lather Preference. Fifteen to 20 persons are selected for this evaluation. Test bars are placed on the sink, one on the left and one on the right. One of the two bars is a control, the other a test bar. Each panelist washes his hands with the left bar, rinses his hands, then washes with the bar on the right. The panelist indicates by ballot whether he prefers the bar on the left or on the right. Panelists indicate their preference on the following basis; which bar is preferred with respect to lather quickness, lather consistency and lather volume of any combination of these factors. A second hand-washing (one during the midmorning followed by

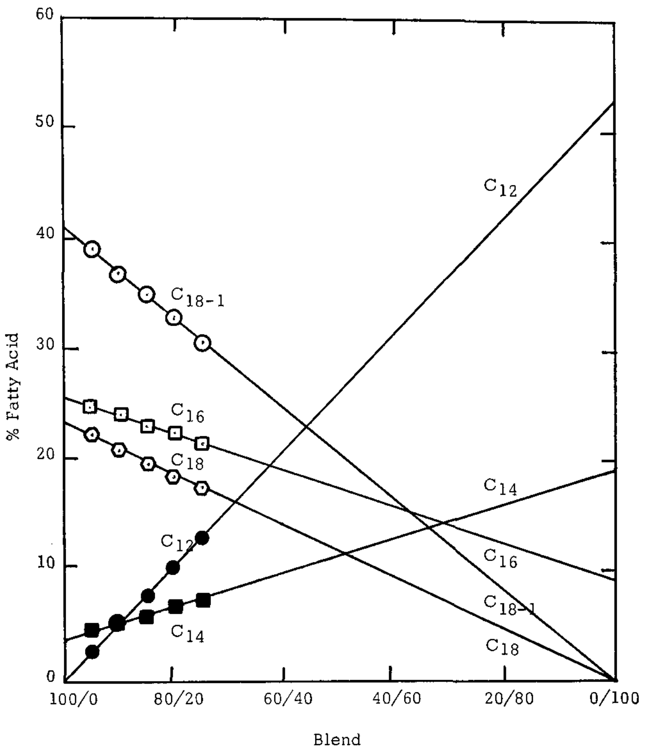

FIG. 1. Variation of major fatty acids with tallow/coconut blends.

one during midafternoon) is made with the position of the bars reversed, again starting with the bar on the left.

Erosion from Handwashing. The bars used in lather panels are weighed before use, then are allowed to dry (75F, 40% RH) 24 hr and reweighed. Results are reported as grams per handwashing.

Relative Bar Softness. Soap bars are shaved level with a carpenter's plane. Initial hardness is measured with a cone penetrometer using a 30 degree cone. The bar is then placed in water up to ¼ in. depth for 30 min and then measured 1 min after removal from the water. The bar is then allowed to dry (75 F., 40% RH) for a 2-hr period and the penetration is taken.

Slushing Tendency. A soap bar shaved to uniform dimensions is placed on end in 200 ml of water in a 600-ml beaker for 16 hr. At the end of this time the bar is removed from the solution and the resulting liquor is measured for solids content.

Swell. A soap bar is allowed to stand in water for 16 hr. At the end of this period the bar is removed from the water and left to stand in air 6 to 7 hr. The dimensions are then taken and compared to the original measurements.

Cracking. Soap bars are planed to achieve a level surface. They are placed in water up to ¼ in. depth Monday evening. Tuesday morning the water is drained from the soap dish. The bar is placed wet face upward in air (75 F., 40% RH) 24 hr. This process is repeated for the other face with the test ending Friday. Wednesday scoring is accomplished by measuring the volume of the cracks occurring on surface one; on Friday the second face is rated. The total volume of the cracks is a measure of the cracking.

The dipping apparatus in this study is designed for uniform abrasion of soap bars with cellulose sponges. With each stroke the sponge dips into a beaker of water and the abraded soap or lather is collected. Measurements of lather generation and erosion were carried out with this device under controlled conditions of water hardness and temperature. A similar apparatus was used by Becher (9) for the measurement of lather quickness. Determined in this study was lather quickness or number of strokes to generate a stable foam layer in water of known hardness and temperature; the concentration of soap at the lather quickness endpoint; and the mechanical erosion rate or use rate in grams per stroke.

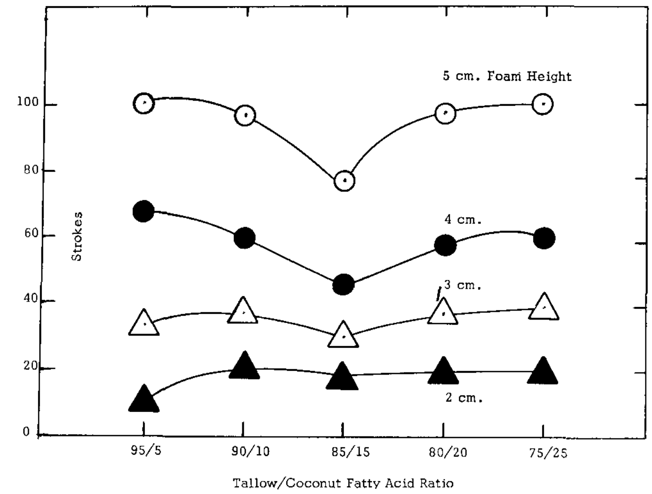

FIG. 2. Mechanical work to induce foam.

Results and Discussion

Among the most important properties of a bar soap is its ability to form a lather in the presence of hard water and sebum soil. Two foam measurements considered in this paper are the generation of a foam end point by the mechanical abrasion technique and a determination of the number of strokes necessary to achieve a given foam height. Figure 2 illustrates that fewer strokes are required for soap derived from the 85:15 ratio, suggesting optimum efficiency in promoting lather.

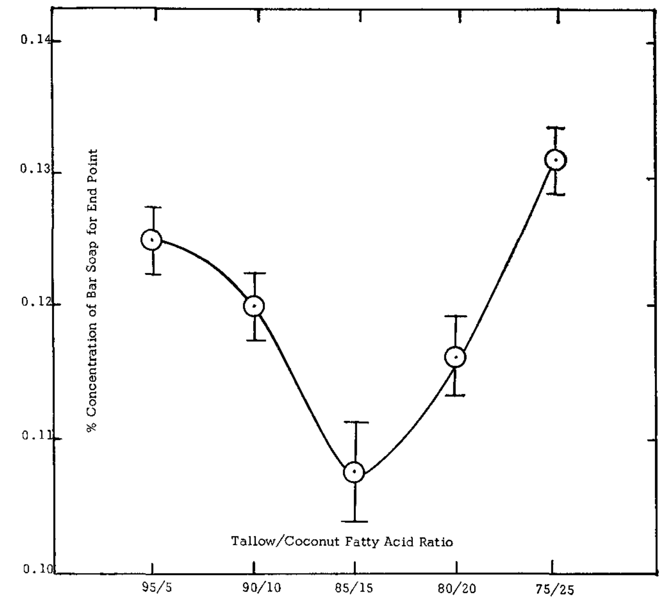

FIG. 3. Soap required for mechanical foam end point.

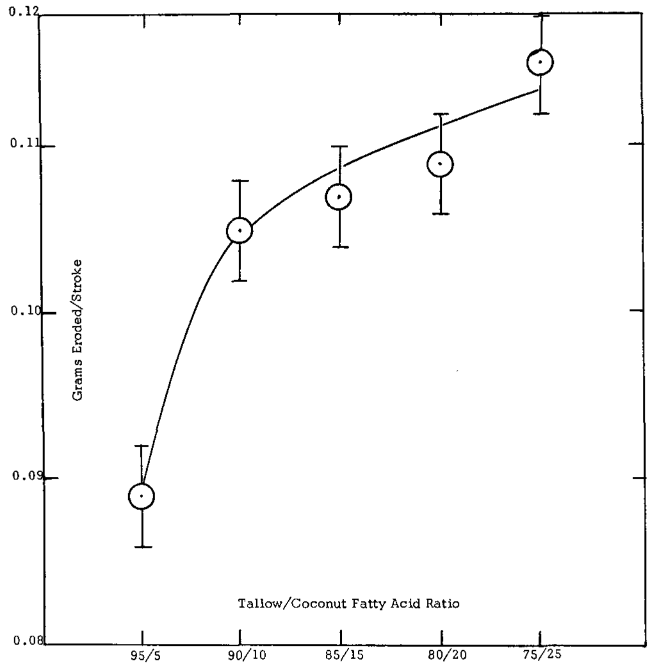

FIG. 4. Mechanical erosion.

Figure 3 shows the concentration of soap necessary to produce a layer of foam just covering the surface of the water in the beaker.

In this case a pronounced minimum was obtained for the 85/15 ratio, again suggesting optimum efficiency in promoting lather. Based on mechanical lather results, it might be concluded that an 85:15 tallow/coconut blend bar soap would show lather preference over bars prepared from other blends. However, this is by no means the case; lather quickness is not the only property which affects lather preference. Other factors such as volume and consistency of lather seem to be more influential when lather preference is measured subjectively.

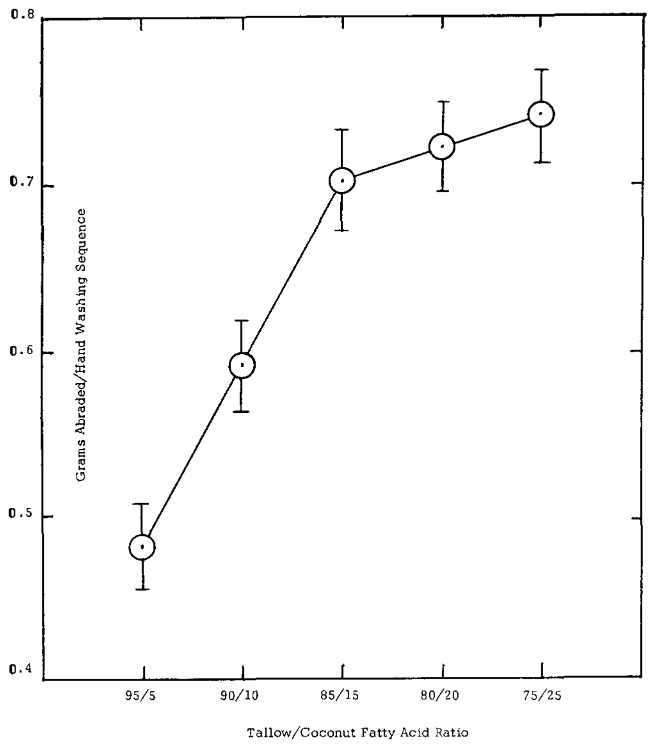

FIG. 5. Erosion from handwashing.

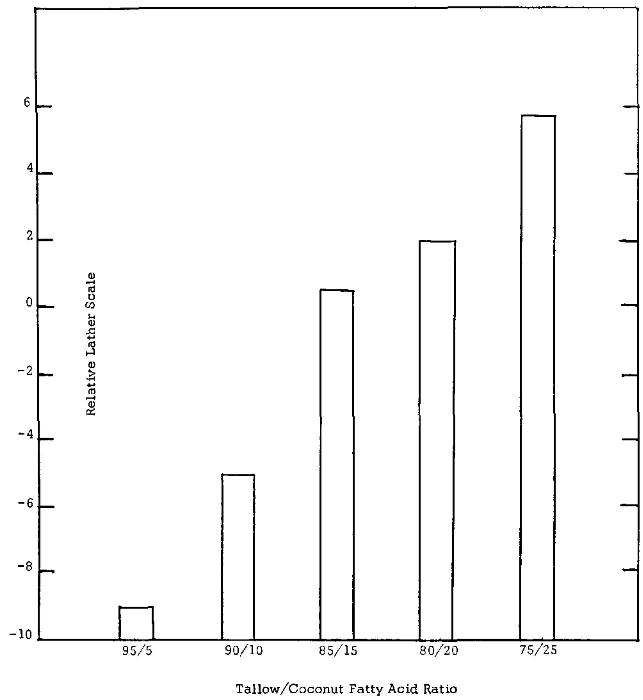

FIG. 6. Hand lather preference.

The use-life of a soap bar may be reflected in its tendency to be eroded through mechanical abrasion. Figure 4 gives such data as a function of blend ratio.

In this experiment the erosion data are given as grams per stroke measured at 85F, using 127 ppm water hardness. An upward trend is observed with increased Na-Cocoate in the bar soap; however, the most rapid increase in erosion occurs between the 95:5 and 90:10 blends. The total range varies from about 0.09 g/stroke for the 95:5 tallow/coconut blend to about 0.12 g/stroke for the 75:25 tallow-coconut blend bar soap.

Figure 5 gives data for erosion as measured by actual hand washing.

The same upward trend is shown with increased sodium cocoate in the bar soap. The amount of soap used by the panelists varied from approximately 0.5 grams per use for the 95:5 tallow/coconut blend to nearly 0.8 grams per use for the 75:25 tallow/coconut blend soap.

The tallow/coconut ratio soaps were subjected to an expert lather panel of approximately 40 participants (Fig. 6). The control bar used in this test was an 85:15 tallow/coconut ratio bar made at a different time than the test bars.

Statistical methods were used to determine whether one bar was significantly preferred over the control in this lather comparison test. Using an arbitrary scale showing the relative preferences, a score of 0.0 indicates that the test and control bars are equivalent. A number below 0.0 indicates that a bar was not preferred over the control bar, while a number above 0.0 shows that a test bar was preferred over the control bar. The distance between the numbers that is considered to be significant is approximately 1.5 units. Overall, the sodium cocoate content appears to be the most important contribution for lather preference. Results from the use of 85:15 and 80:20 ratios are very close (within 1.5 units), and this is consistent with findings in the field.

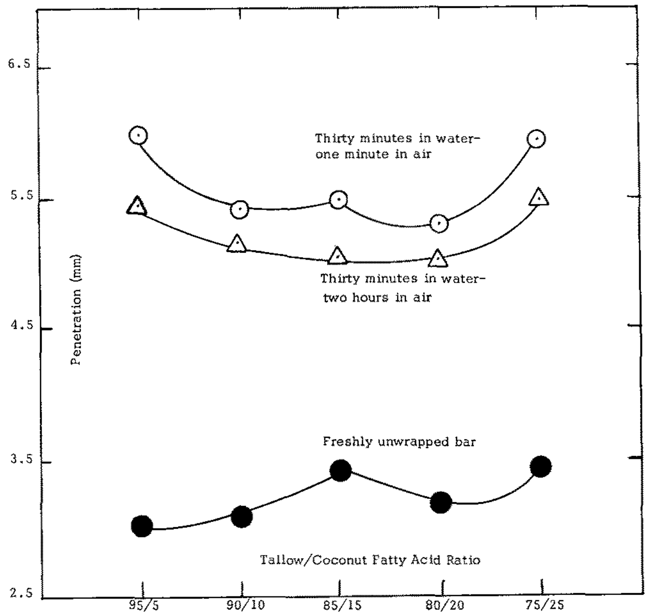

FIG. 7. Relative bar softness.

Figure 7 gives results for bar hardness as measured by the cone penetrometer.

Bar hardness is an inverse function of the depth of penetration of the metal cone impinging on the soap. Results were obtained for freshly unwrapped bars and for bars which had been immersed in water and allowed to dry for different periods of time. No simple relationship was observed between blend ratio and softness of the soap. After soaking, the 95:5 and 75:25 ratios, that is the extreme ratios studied, yield the softer bars. It seems evident from these results that softness depends upon several factors, including titer and relative solubility.

Slushing tendency data for tallow/coconut blend ratios are shown in Fig. 8.

Slushing tendency increased linearly with the proportion of coconut fatty acids in the blend. In this case solubility may be the most important factor. In addition to slushing tendency the use-life of a bar may be reflected in its tendency to be eroded through mechanical abrasion.

Other performance measurements made were swell tendency and cracking. No definite patterns appear to exist concerning the influence of tallow/coconut blend ratios on the tendency of soap to swell. Results from cracking studies were also not uniformly or clearly related to the blend ratio.

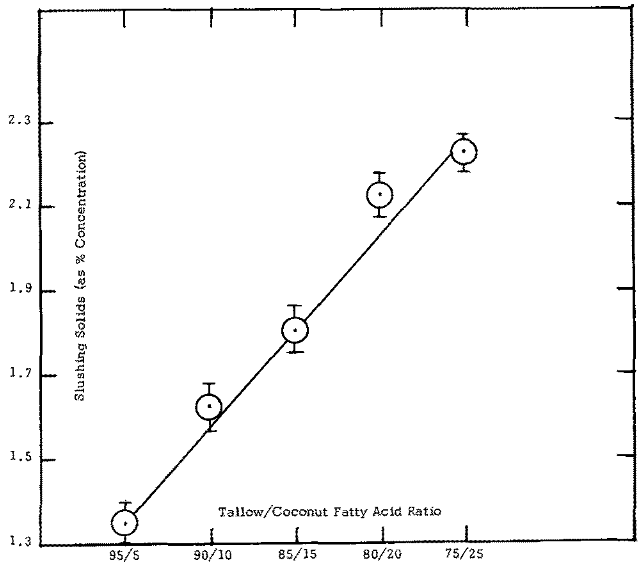

FIG. 8. Slushing tendency.

In conclusion, the following points should be noted: The tallow/coconut fatty acid ratios used in bar soap manufacture affect certain properties markedly and others to a lesser extent. Cracking, swelling and hardness properties are not as sensitive to variation of blend ratio as are slushing, erosion characteristics and lather. Slushing tendency increases linearly with increasing levels of sodium cocoate. Solubility as measured by both mechanical erosion and handwashing, increases with sodium cocoate content, and the increase is most rapid in the range between 95:5 and 85:15 blend ratios. While mechanical dipping data suggest an optimum lather quickness for the 85:15 ratio, actual hand panels indicate that lather preference increases with the level of sodium cocoate in the soap.

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