Sebum Reveals Hidden Differences in Foam Performance: Insights from FOAMSCAN™

INTRODUCTION

Soap products designed for public restrooms (offices, airports, and other public facilities) must provide effective hand hygiene while optimizing product consumption and user experience. Consequently, it is important for manufacturers to ensure the highest-performing formulations. Foamability tests are commonly used to differentiate formulations. However, soap products often exhibit similarly high foaming capacities, making performance differences difficult to identify. In practice, soap formulations should be evaluated in the presence of sebum, often acting as antifoaming agents.[1,2] Lipid droplets form oil bridges that promote film rupture. These coalescence events alter bubble size distribution, accelerate liquid drainage, and enhance foam coarsening.[3,4]The objective of this study is to demonstrate how the addition of synthetic sebum can reveal differences in the performance of foaming formulations that otherwise exhibit similar behavior in the absence of a lipid phase.

SAMPLE PREPARATION

Two liquid soaps intended for public restroom applications were evaluated. For confidentiality reasons, they are referred to as Soap A and Soap B. Soap A contains at least 94% naturally derived ingredients, while Soap B contains 99%. Both products were diluted to 1% (w/w) in tap water to reproduce typical use conditions. Part of each solution was analyzed directly, while the remaining aliquot was supplemented with commercial Artificial Sebum (ASTM D4265-14, non-stabilized) to a final concentration of 0.1% (w/w). The mixtures were then homogenized by magnetic stirring.

Product	*Soap A*		*Soap B*	
Product concentration	*1%*	*1%*	*1%*	*1%*
Sebum concentration	*0%*	*0.1%*	*0%*	*0.1%*

MEASUREMENT PROTOCOL

Foams were generated using the gas sparging method with a FOAMSCAN™ analyzer (TECLIS Instruments, France). Air was injected through a porous glass frit (pore size 40-100µm) at a controlled flow rate of 100 mL/min for 90 s. Foam volume and liquid volume were continuously monitored during both foam generation and foam decay. Images of the foam structure were acquired throughout the experiment and analyzed using TECLIS BubbleStatistics™ software to determine bubbles' size and distribution as a function of time. All measurements were performed in triplicate at room temperature.

FAOM CAPACITY & STABILITY PROPERTIES

The foam volume profiles (Fig1) are typical of foam analyses performed by gas injection. Foam volume increases during the sparging phase (0–90 s) and subsequently decreases as the foam destabilizes over time. The maximum foam volume is reached at the end of the gas injection period (90 s).

In the absence of sebum, both products exhibit similar foaming profiles, characterized by excellent gas capture efficiencies (R), indicating that nearly all injected gas is incorporated into the foam (Fig2)

In contrast, the presence of sebum reveals significant differences between the two formulations. While Soap A retains most of its foaming performance (R = 94%), the foam volume generated by Soap B is markedly reduced because of its much lower gas capture efficiency (R = 21%). Furthermore, the two formulations display clearly different foam decay kinetics in the presence of sebum.

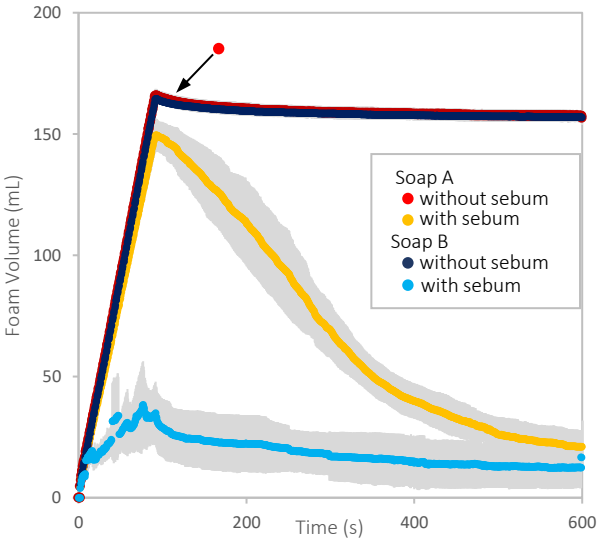


Fig1: Foam volume profiles

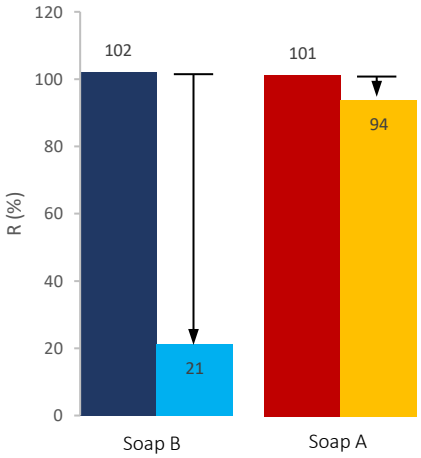


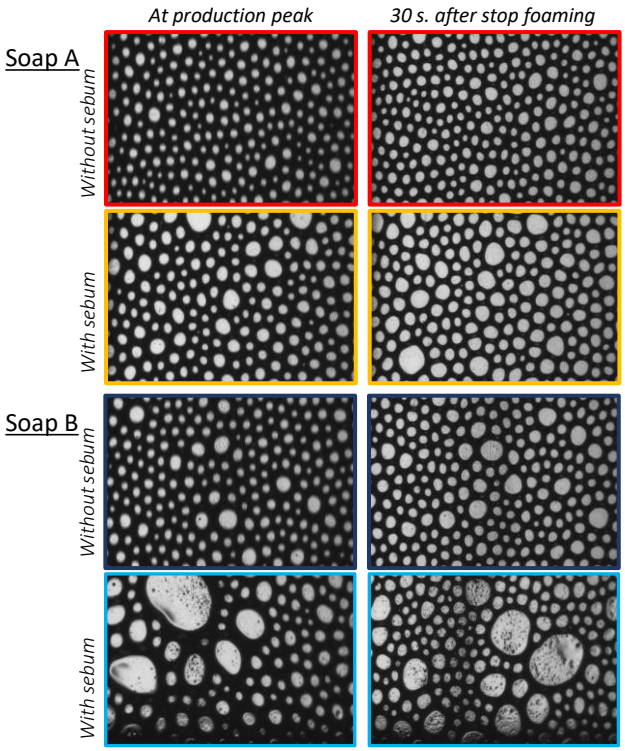
Fig2: gas capture efficiencies (R)

Sebum Reveals Hidden Differences in Foam Performance: Insights from FOAMSCAN™

FOAM STRUCTURE ANALYSIS

In the absence of sebum, the foam structures produced by Soap A and Soap B are highly similar (Fig3). The average bubble sizes are comparable, with Sauter mean radii (R32) of 313 µm and 372 µm, respectively. In addition, both foams exhibit highly homogeneous bubble size distributions, as reflected by their low polydispersity indices (PDI) of 0.33 and 0.35. Time-resolved analysis also shows similar foam stability dynamics for both formulations.

The addition of sebum significantly alters foam structure and stability. For Soap A, the Sauter mean radius (R32) increases gradually during the first 120 s before rising more rapidly. In contrast, Soap B exhibits substantially larger bubbles immediately after reaching maximum foam production. The evolution of foam heterogeneity, reflected by the PDI, follows the same trend. For Soap A containing sebum, the PDI remains relatively stable for approximately two minutes before increasing. Conversely, the foam generated from Soap B in the presence of sebum is highly heterogeneous from the outset and collapses rapidly. After only 45 s, the foam has decayed to such an extent that no further images can be acquired within the camera field of view.



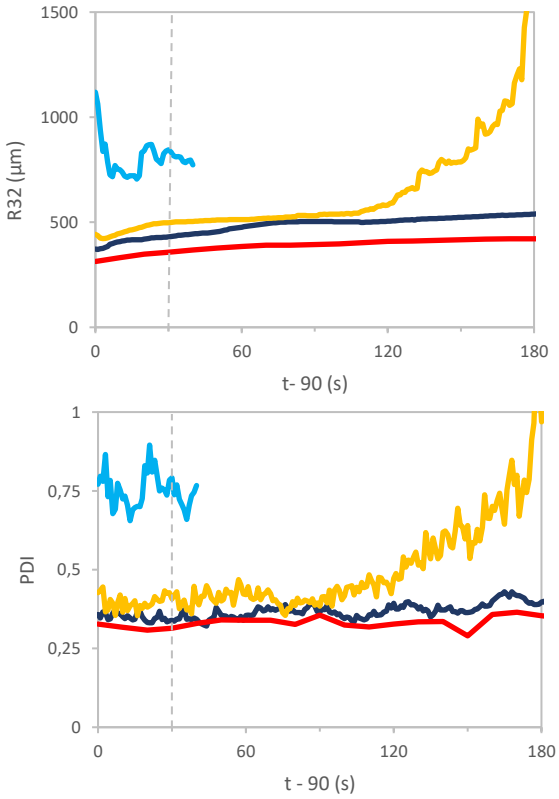


Fig3: Bubbles size and distribution statistical analysis

CONCLUSION

This study demonstrates that conventional foamability tests performed in surfactant-rich systems are often insufficient to discriminate between formulations because they generally exhibit similarly high foaming capacities.

The introduction of synthetic sebum as a lipid phase provides a more discriminating and application-relevant evaluation method.

Although both formulations show comparable foam behavior in the absence of sebum, their responses differ markedly when sebum is present. Soap A maintains relatively stable foam generation and structure, whereas Soap B exhibits reduced gas capture efficiency and faster foam destabilization. These differences are further reflected in the evolution of bubble size and foam heterogeneity over time.

Overall, the addition of sebum appears to be a key parameter for assessing foam stability under more realistic usage conditions and is likely to correlate more closely with consumer perception studies.

REFERENCES

1. Pappas, A., Epidermal surface lipids. *Dermatoendocrinol* **2009, 1 (2), 72-6.**
2. Draelos, Z. D., Essentials of Hair Care often Neglected: Hair Cleansing. *Int J Trichology* **2010, 2 (1), 24-9.**
3. Denkov, N. D., Mechanisms of foam destruction by oil-based antifoams. *Langmuir* **2004, 20 (22), 9463-505.**
4. Garrett, P. R., Defoaming: Antifoams and mechanical methods. *Current Opinion in Colloid & Interface Science* **2015, 20 (2), 81-91.**