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Saponin Surfactants: Harnessing Soap Nut Saponins for Sustainable Cleaning Solutions

Background: The widespread use of synthetic surfactants in household detergents pose major environmental risks due to their persistence as toxic, non-biodegradable petrochemicals (Rai et al.). In Canada, over 3 billion loads of laundry are done annually (Tryon), exposing people and ecosystems to potential carcinogens often released into the environment without adequate treatment (Johnson). Soap nuts (*Sapindus mukorossi*) offer a natural alternative, as their pericarp is rich in saponins, plant-derived amphiphilic compounds with both polar and non-polar regions that mimic synthetic surfactants, acting as foaming and surface-active agents. Rural communities in South Asia, including my grandparents, traditionally used whole soap nuts for laundry and hair washing (Sochacki and Vogt), inspiring me to extract saponins for a detergent free of conventional surfactants. Reviewing detergent ingredients revealed a market gap for a saponin-based product.

Purpose: A novel, environment-friendly saponin extract ("Saponin Surfactants") was developed as an alternative to conventional detergents, that can be used the same way detergents are.

Method & Results: Innovation development and testing involved three phases:

Phase 1: Optimize Extraction	Phase 2: Antibacterial Test	Phase 3: Environment Effect
Tested four solvents (pure H2O, 50% EtOH, 80% EtOH and 100% EtOH) for saponin extraction. Quantified Total Saponin Content using vanillin-sulfuric acid assay. 50% EtOH yielded highest saponin content (Tukey's Test $p<0.01$).	Kirby-Bauer method tested saponin extract concentrations (3.25-100 mg/mL) against *Bacillus subtilis.* Antibacterial effect observed at 12.5 mg/mL, attributed to non-polar region embedding in membranes, causing lysis.	Lettuce and kale were irrigated for 2 months with saponin extract, water or detergent (Tide). Histology showed conventional detergent caused phytotoxicity, while saponin extract non-toxic to plant cells.

Conclusion: Saponin Surfactants offer a sustainable, eco-friendly alternative to conventional detergents, addressing health and environmental concerns. Unlike conventional and "green" products that still use harmful surfactants, Saponin Surfactants is functional and truly eco-safe.

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