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Biodegradable organic perfumes are eco-friendly and healthy compared to the synthetic perfumes

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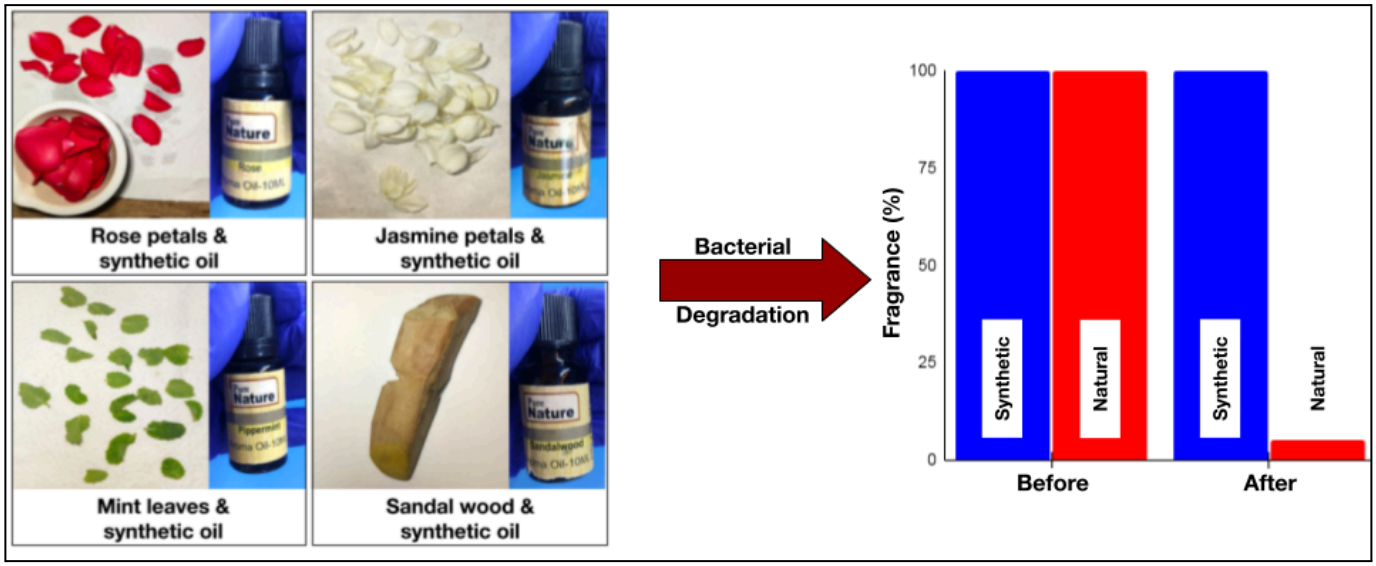
Perfumes and fragrances are one of the most important aspects of human life not only in India but also worldwide. Oftentimes perfumes are made of synthetic aromatic compounds that might be carcinogenic. Given the rising numbers of cancer patients in the world, if synthetic perfumes can be replaced by natural fragrances that are biodegradable then one could decrease those rising numbers. Synthetic perfumes are non-biodegradable hence they stay on to the fabrics and get washed away into the natural water streams during washing. Such accumulation will eventually affect the ecosystem. It has been proved before by scientists that the odor from armpits is due to the composition of different bacterial species in the skin microbiome. In this study we hypothesize that if biodegradable perfumes were used then, the skin microbiome would naturally degrade the molecules. In order to establish an *in vitro* proof of concept, we evaluated the bacteria-based biodegradation of natural and synthetic fragrances. Our results show that natural fragrances were completely degraded by the bacteria but not the synthetic perfumes thus supporting our hypothesis.



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Fragrances play a significant role in human behavior. Today, perfumes are used in various applications, including deodorants, laundry products, shampoos and conditioners, cleansers, etc. (1, 2). These compounds include two groups, natural and synthetic. Natural fragrances are derived from botanical sources such as flowers, fruits, herbs, and spices. These fragrances are obtained through various extraction methods, including steam distillation, solvent extraction, and cold pressing. Synthetic fragrances are artificial scents created in laboratories using various chemicals, often derived from petroleum or other sources. These fragrances are used in a wide range of products, including perfumes, cosmetics, cleaning agents, and air fresheners.

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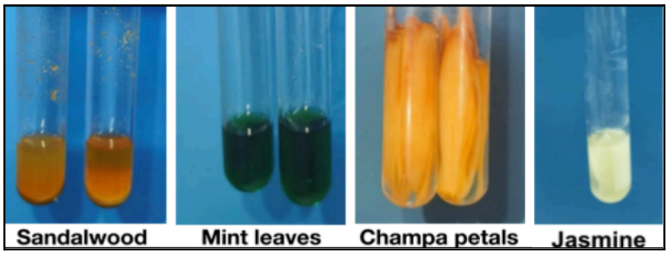

Figure 1. Ethanol/methanol extracts of natural fragrances.

These fragrances are non-natural scents and may contain a blend of both synthetic and natural compounds. However, some perfumes and colognes consist entirely of man-made ingredients. A typical name-brand perfume or cologne contains around 29 chemicals, although only half of these are required to be listed on the ingredients label. Overall, the fragrance industry utilizes over 3,100 synthetic chemical scent compounds, covering all scents naturally found in nature. One of the key advantages of synthetic fragrances is their versatility. Chemists can precisely control the composition of synthetic fragrances to achieve specific scent profiles, allowing for the creation of a wide range of unique and appealing fragrances. Additionally, synthetic fragrances tend to be more stable than natural fragrances, meaning they retain their scent for longer periods and are less susceptible to changes in environmental conditions. However, concerns have been raised about the potential health effects of synthetic fragrances. Some individuals may experience allergic reactions or sensitivities to certain fragrance ingredients, leading to symptoms such as headaches, dizziness, nausea, or skin irritation. Additionally, certain chemicals found in synthetic fragrances, such as phthalates and musk compounds, have been linked to adverse health effects and environmental pollution (3-8). Some of the chemicals used in making synthetic fragrances like beta-myrcene, benzophenone, and Di-2-ethylhexyl phthalate (DEHP) lead to different cancers in humans, with an increased risk of breast cancer, several concerns have been raised regarding the potential role of certain fragrance ingredients in cancer development (9, 10).

Efforts to reduce the use of non-biodegradable fragrance ingredients and promote the development of greener alternatives can help minimize their environmental impact and protect ecosystems and human health. Non-biodegradable fragrance ingredients may bioaccumulate in living organisms, meaning they can accumulate in tissues and organs over time. This bioaccumulation can occur through the food chain, with higher concentrations of fragrance chemicals. Non-biodegradable synthetic fragrances pose environmental risks due to their persistence and potential for accumulation in the environment. More eco-friendly fragrances are much needed.

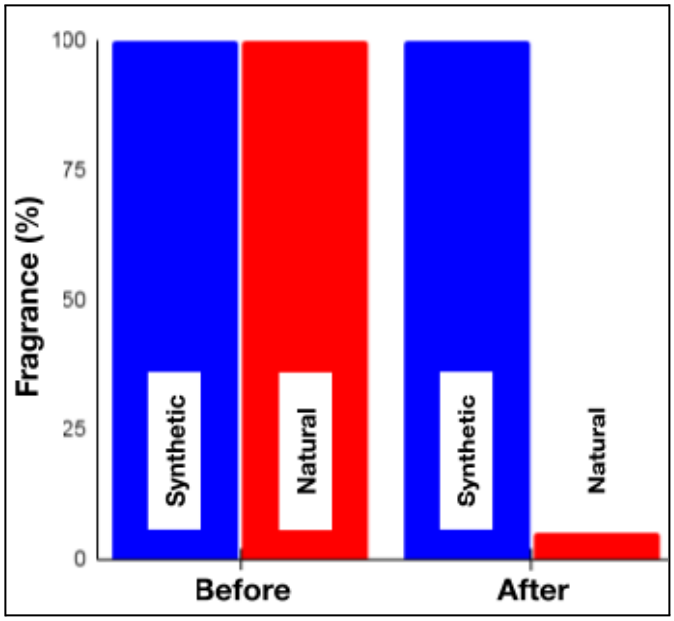

Figure 2. Fragrance levels before and after incubation with bacteria.

In this study we have taken the ethanol and methanol extracts of 6 different flavors using mint leaves, champa flower petals, jasmine flowers, sandalwood powder, rose petals and lemon peels along with their corresponding synthetic perfumes purchased from the a perfume shop to test their biodegradation by incubating them with bacterial culture. Filter papers were dipped into the natural and synthetic fragrances so that they were completely soaked in the fragrance overnight. These filter papers were quickly air dried to remove solvent and were placed in tubes containing 5 ml of *E. coli* culture. Tubes were incubated at 37 ℃ overnight. The fragrance of each flavor was manually recorded as 100% before incubation and the fragrance of the same was tested after incubation. These manually tested fragrances were then plotted as shown in Figure 2.

Our findings reveal that 2 out of the 6 natural fragrances tested in this study had some residual smell after incubating with bacteria overnight and the rest of the 4 fragrances had no residual fragrance after incubation. On the other hand, all the synthetic samples were consistently fragrant (100%) even after the overnight incubation with bacteria. As shown in Table 1, Mint, Champa and Rose natural extracts had zero fragrance after the overnight incubation with bacteria. Jasmine and Sandalwood natural extracts had some residual but not significant fragrance post incubation. Lemon peels extract yielded a different smell so was ruled out of the experiment. Among the synthetic samples, besides Champa (unavailable), all 5 samples retained 100% fragrance even after the overnight incubation with bacteria suggesting that they were not biodegradable compared to the natural ones.

Fragrances	Before Incubation		After Incubation	
	Synthetic	Natural	Synthetic	Natural
Jasmine	++++	++++	++++	+
Peppermint	++++	++++	++++	0
Lemon	++++	N.A.	++++	N.A.
Champa	N.A.	++++	N.A.	0
Sandalwood	++++	++++	++++	+
Rose	++++	++++	++++	0

Table 1. Fragrance before and after incubation with bacteria.

Based on the current results we believe that it is safe to think that the natural fragrances are easily degradable by the bacteria (not necessarily *E. coli* as tested in this study) present in the human skin microbiome but not the synthetic ones. If the natural perfume is degraded by the end of the day then there would be no concern of any unwanted chemicals entering the ecosystem through the cloth-washing process. However, synthetic perfumes would not only pose a threat to human health but also are environmentally not friendly. Hence we suggest that the usage of natural perfumes or perfumes prepared from natural extracts that are devoid of any organic solvents is an eco-friendly way to save the environment from getting polluted with artificial synthetic compounds that are hard to degrade.

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Conflict of interest: The authors declare no conflict of interest in this study.

Author contributions: P.V.S. performed all the experiments; S.A. and M.S. supervised P.V.S. R.S.Y. is the principal investigator who designed the project, trained P.V.S., S.A. and M.S., secured required material for the project, provided the laboratory space and facilities needed. R.S.Y. edited and finalized the manuscript.

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Full Figure/Table legends:

Figure 1. Ethanol/methanol extracts of natural fragrances. Natural fragrances were extracted by incubating the flower petals, minced leaves or Sandalwood powder with ethanol or methanol.

Figure 2. Fragrance levels before and after incubation with bacteria. Each of the natural and synthetic fragrance samples were incubated with *E. coli* at 37 ℃ overnight. The fragrance intensity (%) for all samples were manually tested before and after incubation. Considering the initial fragrance intensity as 100%, the fragrance of all natural samples decreased significantly overnight but not the fragrance of synthetic samples.