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Address the epidemic of *p*-phenylenediamine sensitization and aid marginal farmers in a changing climate

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THE EFFECT ON THE HAIR DYE INDUSTRY OF THE EPIDEMIC OF *P*-PHENLYLENEDIAMINE SENSITIZATION

There is a global epidemic of sensitization to *p*-phenylenediamine (PPD) (1). The popularity of using black hair dye to create "black henna" temporary tattoos as vacation souvenirs for Westerners as well as for Muslim and Hindu weddings and social occasions has exposed millions of people to highly sensitizing doses of PPD. Of these people, 50% become allergic to oxidative hair dye and 20% become severely allergic (2). The most commonly used materials for black henna tattoos are 15–40% PPD black hair dye powders (3) as well as chunks of 90% + pure industrial PPD (4). The ornate black henna patterns cover large skin surface areas and the black henna paste is left in place for half an hour or more introducing a dangerously high dose of PPD to the body.

Substitution of PPD for safe traditional henna body art began in east Africa in the 1970s when Bigen and Peacock home hair dye kits were marketed in the region. This practice spread and became fashionable in Saudi Arabia, Egypt, Pakistan, and India by the early 1980s (5). Women used high PPD content black oxidative chemical hair dye powders for body art instead of henna because PPD produces black stains on skin quickly; the finely powdered chemical dye can be manipulated into more complex patterns than roughly sifted local henna. PPD was applied to skin of brides and their wedding guests, and was used for social celebrations. Many were sensitized by the first time their skin was painted with PPD; if they were not sensitized in the first application, subsequent celebrations with black henna for Eids, Karva Chauth, and Diwali sensitized them. Five or fewer applications of 10% PPD in a patch test will sensitize 100% of subjects (6); black henna contains 15–60% PPD. Some were unaware that PPD sensitization would affect their health in the future; others regarded the blisters that arose after application to be of little concern, regarded as "suffering for beauty." They felt black patterns were more beautiful on darker skin as well as more convenient. As these women mature, they may decide to dye their hair with oxidative hair dye. For these women, the hypersensitivity reaction can be severe; anaphylaxis may be fatal (7). Forty women have died in recent years in Libya from PPD sensitization (8), and officials have called for a ban on oxidative hair dye. There has been

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a similar call in Egypt and the United Kingdom (9). Khartoum (10) and Karachi (11) average hundreds of admissions to the main hospital per year from PPD sensitization. There is a solution to this problem: at the first sign of sensitization, immediately transition the person to pure henna, cassia, and indigo from oxidative hair dye. They cannot be transitioned to *compound henna or adulterated henna* without risking a destructive chemical reaction between the metallic salts in compound henna and the activators in oxidative dye: hair may break, turn an unexpected color, or in the worst case, incinerate.

Henna, cassia, and indigo.

Pure henna, cassia, and indigo, in differing proportions and techniques, can produce the complete range of natural human hair colors from blond through red, brunette, and black (12). These methods were used across Arabia, the Middle East, the Levant, South Asia, and Africa for centuries, but are now regarded as "old fashioned." It is going to require persistent marketing and education to dispel the notion that henna is inferior, that it destroys hair, is filthy, and can only make hair orange. Pure henna is not inferior to chemical dyes; it is simply a different technology. Pure henna does not harm hair; it strengthens hair, protects it from ultraviolet and desiccation. If skillfully applied, henna is no less tidy than chemical dye. Though the lawsone molecule is orange, it can be manipulated through a range of color, and with two other plants, can mirror the entire range of human hair and completely cover gray. Henna must be reframed as a safe, versatile, beautiful, and healthy approach to hair care. Salons and customers must be helped to adjust to and embrace the experience of a slow, nuanced art of women's self-care and beauty.

IMPROVING AND INCREASING THE PRESENT SUPPLY OF HENNA, INDIGO, AND CASSIA TO MEET RISING DEMAND

Improving the quality of henna products is crucial to gaining market acceptance and saving lives. It is entirely feasible to scale up production of henna and improve quality over the next 15 years to meet the demand of the epidemic of PPD sensitization. The present leader in the production of henna is Rajasthan, India. The government of India provides substantial support for the henna industry, partly to prevent the expansion of the eastern Thar Desert boundary into Punjab farmland (13). This support has made the Punjab the world's dominant henna producer. Henna production and exporting increased from 4500 to 7600 tons per annum during the period 1988–1993 to 24,000 tons in 2004 (14). In 2006, henna leaves (54,750 metric tons) were registered through Krishi Upaj Mandi, the government board of agricultural produce, in Sojat city, Rajasthan (15). Demand for Rajasthani henna production and export is strong and has a steady growth rate of 9% per year. About half of the crop is exported to the United States and Europe. Scaling up production requires time to plant and grow small trees, but with foresight, it is possible. Scaling up indigo and cassia production is more straightforward; these are tropical annual and perennial plants.

Areas suitable for growing henna, and centers of commercial henna production, 2009.

Henna presently in the marketplace is coarsely sifted; twigs and scraps often cling to hair through several washings. The dye content of henna decreases quickly when packaged in thin, single-walled cellophane envelopes. Henna, cassia, and indigo milling and sifting must be improved to 150 μm particle size to be acceptable to western consumers accustomed to easy-to-apply, easy-to-rinse hair dye. There must be no sand or plant debris in the leaf powder. Double-wall packaging is necessary for the powders to retain quality over several years. Indigo must be kept from moisture and freezing, or the dye will be spoiled. Henna must be kept under 32°C to maintain dye quality. Vacuum-packed henna, though it might seem to be an attractive way to preserve quality, adheres to itself and becomes barely breakable even with a hammer (Personal Experience).

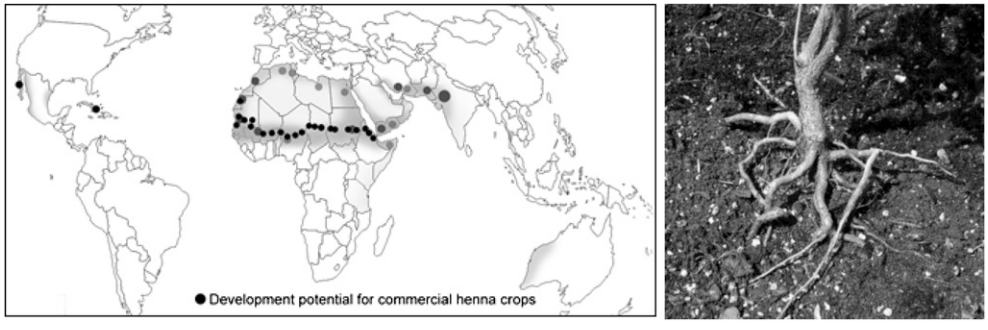
The Central Arid Zone Research Institute in Jodhpur, India, has conducted research on plant breeding, soils, and pests, enabling more reliable crops of higher quality. Improved milling and an improved supply chain has made Rajasthani henna cost more than henna from other countries (16). The supply is reliable and quality predictable, but the lawsone content varies from year to year. Based on my own lab testing and 25 years of experience, the highest lawsone content crops from Rajasthan occur during El Nino events when the plants are stressed by extreme heat and late onset of the monsoon. Lower lawsone contents in Rajasthani henna correlate with La Nina events. To obtain consistent lawsone content for marketing and formulation, more than one source will have to be developed to compensate for variation in crop quality. Other countries produce henna, but no other government has allocated resources to henna to the extent as has India.

On the western side of the Thar Desert, henna from Pakistan can be of high quality and the milling is usually excellent. LUKE II examinations of henna show Pakistani henna can be grown adjacent to other crops unlike Sojat henna where the main henna district is monocropped. I have found pesticide blow-over from both tomato and cotton crops in Pakistani henna; the amounts are negligible, but measurable. LUKE II tests of henna from the Sojat crops often reveal low levels of synthetic pyrethrin pesticide residue, probably from treating the castor semi-looper caterpillar (*Achaea janata*) that occasionally invades the monocrop (17), and occasional detectable DDT residue, probably drifted from mosquito treatments of nearby habitation. Henna from India often has green dyed sand and other adulterants added (18).

According to the independent certified laboratory tests (Alkemist Labs, Costa Mesa, CA) and my personal experience with henna over the last 25 years, Yemen produces some of the highest dye content and cleanest henna; I have never found pesticide residue in the LUKE II tests in the henna from Yemen. The milling from some producers is very fine though others have rough milling and sifting. At present the infrastructure in Yemen has been broken by civil war and suppliers are presently unable to export to the United States. Henna

is grown and milled from Iran but trade and banking restrictions have prevented direct importing into the United States for several years. Morocco has a reputation of perfectly sifted henna, but domestic production has fallen lower than domestic consumption levels; Morocco presently imports henna from India, cultivating more profitable crops and the seasonal farm labor migrates to Europe. In Mauritania, henna is grown as a domestic and export product. The samples of Mauritania henna I have tested are coarsely sifted, but are otherwise good henna. The Nigerian henna samples that I have tested contain sand. Sudan produces excellent henna, with high dye content and a more brownish tone than Iranian henna, but is coarsely sifted. All of the countries in the Sahel could be excellent henna producers, but the infrastructure necessary to raise henna production consistent with western market standard is not yet in place.

EXPANDING COMMERCIAL HENNA PRODUCTION IN THE SAHEL



Areas where commercial henna cultivation can be expanded and tenacious henna root growth pattern.

The most promising area for expansion and improvement of henna production is the southern boundary of the Sahel. Rajasthan's success with henna to secure farmland and soil at the eastern edge of the Thar Desert can be repeated in the "Green Wall" project, the international project to "green" the southern border of the Sahel, to reverse the Sahara's southward progression and to stabilize farming communities across the area. Henna is indigenous to the region. A small henna tree with its deep, gnarling, and spreading root base can stay in the ground and for up to 50 years. Henna is often planted as a "living fence" to keep livestock and wildlife out of vegetable gardens (19). In addition, henna tolerates soil that has become salinized from irrigation and climate warming (20). Henna thrives in fine, sandy, well-drained soil; hot, dry, sunny weather conditions promote higher lawsone content in leaves. In semi-arid areas with average annual precipitation of 250–450 mm, henna can be cultivated as a rain-fed crop (21).

Leaf harvesting from the henna trees is most productive during the first three decades, but henna plants that are not economically productive, even stumps, tenaciously hold soil in place acting as a living wall against desert encroachment and improving the land. Henna may be intercropped with legumes, further improving the soil (22). Henna leaves are harvested from the trees once or twice a year, and are a cash crop when all other crops fail from extreme weather events. No mechanical planting, harvesting, or any other fossil fuel–consuming equipment is necessary for tending henna; a hoe, pruning knife, and gloves are all that is necessary for crop maintenance and harvest. The cultural association

of henna with women may be advantageous; where populations have suffered genocidal conflict, women now dominate farming and entrepreneurial activity. As the market demand increases, as henna is bred for specific characteristics such as higher lawsone content, and as it is milled to higher quality standards, farmers who are smallholders in marginal areas with deteriorating conditions due to climate change will find they can more easily stay on their land and provide for their families.

MERGING HENNA, INDIGO, AND CASSIA INTO THE MODERN HAIR DYE INDUSTRY

The users of home hair dye kits are the most vulnerable consumer group; purchasers may be unaware that they are sensitized to oxidative hair dye, and the delayed hypersensitivity reaction to PPD may invalidate patch tests. Education of clients about the benefits of henna and ease of use is paramount. Henna is easily applied at home. If the safety, health, and naturalness of henna are marketed strongly, if educating clients about henna is made a priority, sensitized customers' reluctance to change may be overcome. There is no reason for a salon to not use henna on individual clients or for a salon to become "henna only" to serve many sensitized clients by stylists who have become sensitized. PPD sensitization is no less than an epidemic than human immunodeficiency virus (HIV) is, and they have many parallels. Recognition of the scope of the problem has been slow. A long latency period has exacerbated both, but the health effects are real, quantifiable, and inevitable in both. With HIV, there was great cultural resistance to acknowledging the epidemic, and great resistance to making the changes necessary to mitigate the risk. There is considerable resistance to henna in the cosmetology industry because of misinformation and inferior products. These problems can be corrected with education and improved product, and lives saved.

If, in the 15 years between now and the time when the estimated crest of sensitized population begins to go gray, and henna, indigo, and cassia are improved through rigorous testing, plant breeding, and infrastructure improvement programs, client base loss for the oxidative hair dye industry can be avoided. Henna product lines can be developed which will benefit not only the cosmetic industry: expanded henna, cassia, and indigo cultivation will stabilize farming in marginal regions and counteract desertification through climate change. If the global henna supply must be increased to meet rising demand, alternate growing areas and improved plant breeding should be developed as quickly as possible.

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