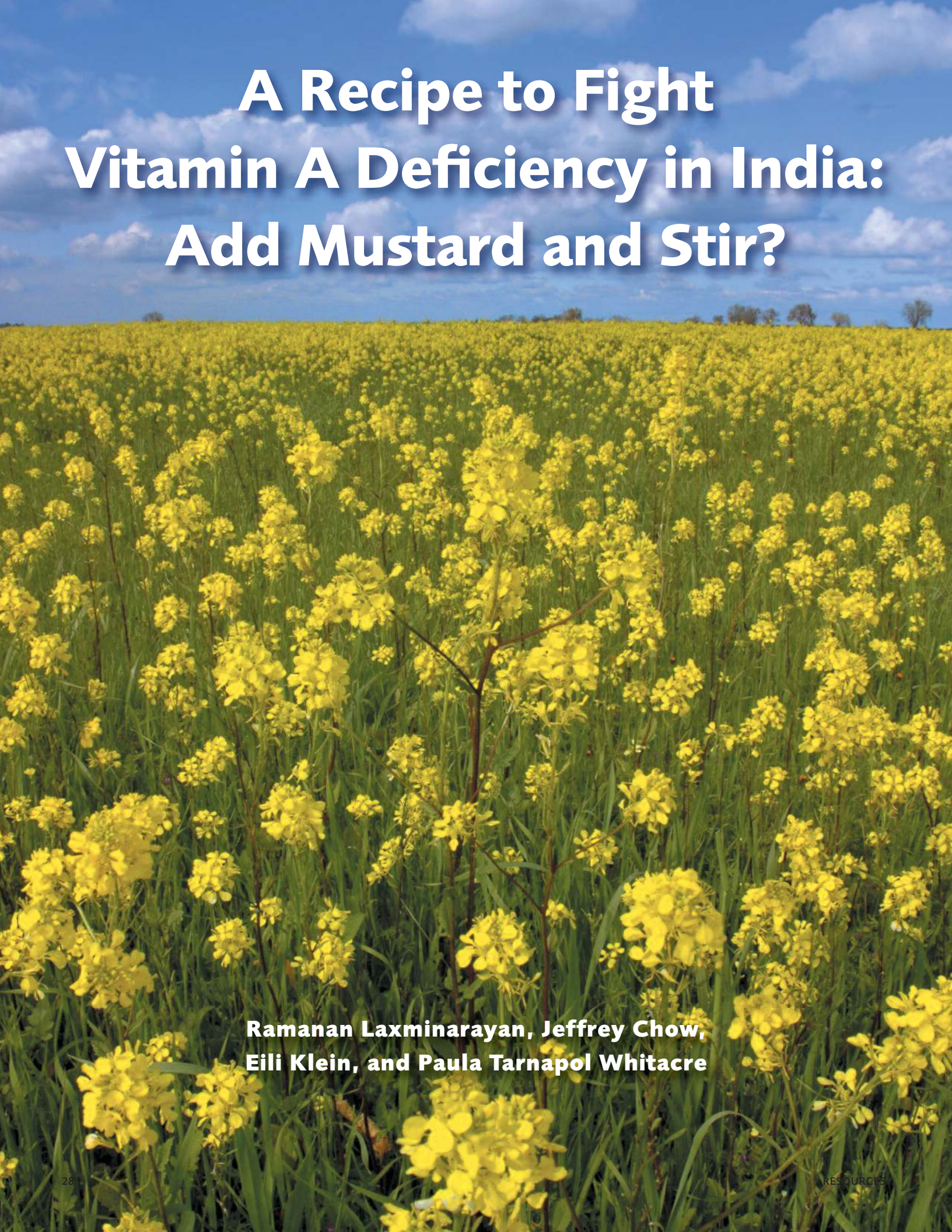
A Recipe to Fight Vitamin A Deficiency in India: Add Mustard and Stir?



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Have you had your vitamin A today? You need it for such essential processes as growth, vision, and resistance to infectious disease. Chances are, you don't have much to worry about. Most adults who consume dairy products, meat, and vegetables on a regular basis are okay, as these products either contain or are fortified with vitamin A or beta-carotene, a precursor to vitamin A.

But worldwide, the situation is quite different. Vitamin A deficiency (VAD) is a significant cause of blindness and death, especially for children and pregnant and lactating women. According to the World Health Organization, an estimated 250 million preschool-age children in more than 100 countries are vitamin A deficient. Of these, between 250,000 to 500,000 lose their sight each year as a result, and more than half die within 12 months. VAD also increases the risk of dying from diseases such as malaria and measles: estimates suggest that it contributes to the deaths of 1.2 to 3 million children annually. Approximately 7.2 million pregnant women in developing countries also suffer from VAD, which means their infants are likely born in an already compromised state.

Beyond the immediate impact on families, VAD also has a financial impact on a country. Poor nutritional status can reduce a country's gross domestic product by 2 to 3 percent annually, according to the World Bank. In addition, VAD and other nutritional deficiencies can result in significant outlays when treatment of otherwise preventable illnesses strains overburdened health systems. Conversely, improving a person's nutritional status can increase his or her lifetime earnings by at least 10 percent, which can make a considerable difference to a country's economy as a whole.

India has some of the highest rates of VAD in the world. Each year, it is associated with the deaths of 330,000 children in India alone. Although vitamin A status has improved in the past few decades, a survey by the National Nutrition Monitoring Bureau indicates that 57 percent of Indian children—35.4 million children—were vitamin A deficient in the late 1990s. Data also suggest that while VAD affects both rural and urban households, it generally results from malnutrition.

Getting Public Health Programs Working

Over the past few decades, as the link between VAD and mortality and morbidity have become better understood, countries and international organizations have developed three main approaches to boost vitamin A levels: periodic supplementation of young children with high dosages of vitamin A; fortification of commonly eaten foods with vitamin A, often with other micronutrients; and other food-based approaches such as nutrition education and promotion of home vegetable gardens.

These approaches have had results, but, as the numbers show, they have not solved the problem. Moreover, supplementation, the most commonly used intervention, is on the decline, because it has often been implemented alongside polio immunization campaigns that are winding down in many countries.

Experiences in India with these three interventions illustrate how difficult it is to get public health programs working on the ground. Although the country launched one of the world's first supplementation programs to fight blindness in 1970, only a small percentage of children now receive the recommended twice-yearly dosages of vitamin A, and coverage varies greatly by state and by income level.

Supplementation programs in India also suffer from a lack of support from India's medical establishment—which, despite widespread evidence—has not uniformly endorsed vitamin A's link to mortality, and has displayed a preference for fortification and food-based approaches over supplementation. Unfortunately, India's highly decentralized food-processing systems and varied diets hamper these other approaches, as well. Despite many innovative attempts and pilot projects with foods that range from rice, to tea, to fortified candies, less than one percent of food in India is fortified with vitamin A or any other micronutrient. India's low meat and dairy consumption increases the likelihood that people, especially the poor, will get enough vitamin A from their diet alone.

New advances in biotechnology have generated the possibility that foods genetically modified to express excess amounts of vitamin A may be an alternative. To assesses the potential of this approach, the U.S. Agency for International Development and the International Center for Tropical Agriculture asked RFF to look at one potential option: biofortification of mustard seed with vitamin A. (This article is based on a new RFF report, *Closing India's Nutrition Gap: The Role of Golden Mustard in Fighting Vitamin A Deficiency,* by the authors. See ▸ www.rff.org/rff/goldenmustard.)

Why mustard? Cooking oil from pressed mustard seed is commonly used in northern India where VAD is most widely prevalent, especially among poor rural families that are often underserved by supplementation programs. Another advantage is that vitamin A is more easily digested when consumed with a moderate amount of fat, such as edible oil. In recent years, the Monsanto Company and The Energy and Resource Institute (TERI) in India—building on Monsanto's experience biofortifiying canola oil, a close genetic relative to mustard, with vitamin A—succeeded in expressing high levels of beta-carotene in mustard seeds. The technology involved is similar to that used to develop the better-known "golden rice." Once pressed, the biofortified mustard oil retains high levels of beta-carotene, which is what gives the oil, like rice, its dark golden color. The fortified oil can provide far more vitamin A per serving than through traditional means.

However, after several years of laboratory work and very limited field trials, efforts to commercialize the technology have stalled,

despite a pledge from Monsanto to license the technology without cost. RFF was asked to help determine whether further investment in the technology should continue. Two main questions were addressed: first, whether mustard production and consumption indicate its appropriateness as a vehicle to increase vitamin A intake; and second, whether biofortification costs, particularly compared with existing interventions, justify further investigation. If VAD-affected individuals do not consume mustard in sufficient quantities, especially children and women, or if the costs are unreasonably high, it is not worth exploring further.

The study did not take into account the political, social, and environmental questions that have been central in the debate about genetically modified foods worldwide, issues that policymakers cannot ignore. But it provides a piece to the puzzle as new ways are sought to improve nutrition worldwide.

Mustard from Mela to Mouth

As with many crops in India, mustard is grown primarily on a small scale, with most of the country's 40 to 50 million mustard farmers planting about five acres annually. Production, like consumption, is concentrated in the north. Farmers generally purchase new seed each year, typically at melas (farm fairs), which also serve as a source of agricultural information. A number of public and private institutions also support producers and processors and are potential avenues to introduce information about "golden" mustard or even distribute seed.

About 90 percent of the mustard seed grown in India goes to make oil. Large manufacturers process the highest volume of oil (about 75 percent of the total annual production of about 2 million metric tons); small-scale facilities are more inefficient, although far more numerous. Although no reliable data exist about the extent of home production, anecdotally it is believed to be high.

Studies on similar types of oil show it must be stored in dark containers, as vitamin A breaks down in light, and for a limited amount of time (nine months in lab conditions, probably less in situations of extreme heat or cold). Therefore, the feasibility of biofortified mustard as a reliable vehicle to increase vitamin A intake depends in large part on proper packaging and storage. In India, mustard oil is purchased in small quantities from bulk suppliers or in bottles or cans as branded oil—in either case, opaque packaging would be needed. While it has a shelf life of up to a year, it is typically distributed far more quickly from processor to consumer.

Mustard oil is prized for its pungency and is a staple in many households, regardless of income, in both urban and rural areas. Although not all states with VAD problems are mustard consumers (again, keeping in mind regional preferences), it is consumed in a significant number of states where VAD is also prevalent. Assuming that all mustard oil was biofortified and none of the vitamin A was lost during storage or cooking—admittedly very optimistic assumptions—a child would need less than one teaspoon a day to get their recommended daily allowance, assuming no other source of the vitamin was available.

Consumption among the poor is closely tied to household production of mustard oil, especially in rural areas. Households with no cash income still consume small amounts, which suggests the need to get biofortified seed to home-based producers. On the other hand, some states with a high prevalence of VAD consume mustard oil shipped in from other states, most likely from one of the few large processors. In other words, both large commercial producers and small producers would need to buy or grow biofortified seed in order to reach all the people suffering from VAD.

Is It Worth It?

An economic-based analysis of biofortified mustard to fight VAD does not provide the whole answer. However, the RFF analysis creates a framework against which to explore other issues. If biofortified

VITAMIN A

The ancient Egyptians and Greeks were on to something when they treated ocular problems with a piece of liver consumed or placed on top of the eyes. Centuries later, doctors recognized that meat and milk could cure night blindness, a symptom of vitamin A deficiency (VAD). By the early part of 20th century, the role that vitamins and other nutrients play in human health was firmly established, and VAD was generally eliminated from developed nations.

Vitamin A is consumed as retinol in animal foods, such as meat, dairy products, and eggs, or as carotenoids (principally beta-carotene) in many fruits and vegetables, such as dark green leafy vegetables, mangoes, and squash. Because the body absorbs retinol far more efficiently than carotenoids, adequate vitamin A intake requires more "retinol activity equivalents" from vegetable sources than from animal products—in other words, far larger amounts of fruits and vegetables must be consumed to reach the recommended daily allowance for vitamin A. Absorption of vitamin A also depends on a person's fat intake (because it is a fat-soluble vitamin, more fat is better in this instance), how the food is prepared and stored, and the presence or absence of parasites in the body.

The bottom line is that a person, especially a child, cannot realistically get sufficient vitamin A from diet alone if he or she consumes little or no animal products, even with lots of beta-carotene rich foods.

mustard can't meet the vitamin A needs of vulnerable populations—or would do so at a cost that makes it unfeasible on a wide enough basis to solve anything—then these other questions become moot.

The cost-effectiveness analysis compared supplementation, traditional fortification of processed mustard oil, and biofortification of mustard seed. The economic burden of avoiding diseases was calculated using disability-adjusted life years (DALYS), which is an adjusted measure of years lost due to premature death or disability, where different forms of disability are given different weights. The comparison is based on the cost per DALY averted (cost-effectiveness ratio) for each of the three interventions over a 20-year time frame.

Costs for supplementation include those associated with dosing children twice annually through existing health centers; training, promotion, and monitoring; and an additional amount to reach areas without functioning health centers. Costs of traditional fortification include processes to ensure product quality and to promote consumption, as well as to fortify the oil with beta-carotene. Biofortification costs include the same quality-related costs, as well as a one-time cost to account for research and development and licensing of the seed (estimated at $5.6 million). Additional seed costs for farmers were not factored in, nor were potential costs related to uncertain environmental impacts of genetically modified crops.

The RFF analysis shows that the most cost-effective intervention remains supplementation, followed by biofortification and traditional fortification. Despite less favorable economic numbers, biofortified mustard has the potential to avert a greater burden of childhood and maternal death than both traditional fortification and supplementation, particularly in areas with weak coverage by the health care system.

No matter the analysis, mustard farmers must be willing to plant the biofortified varieties, and consumers must be willing to consume sufficient quantities of it. As traditional fortification efforts show, both a "push" strategy to increase the attractiveness to growers and oil producers and a "pull" strategy to increase consumer demand for fortified oil would be needed. These challenges are not novel to biofortification, but their successful resolution remains unknown.

Experience shows that Indian farmers are willing to adopt new technologies when they recognize tangible benefits, such as improved yield, higher revenues, lower price of inputs, or some combination. The RFF study looked at several strategies to provide incentives, from a full-scale plan to subsidize costs at all levels of production to a market-based approach that would target seed production alone. The latter is less resource-intensive and would probably yield comparable results. A program could offer free seeds or targeted seed subsidies, especially in areas where production and consumption are high so that demand could also be stimulated. While all seed would not have to be biofortified to accrue nutritional benefits, a significantly high amount would.

The challenge for biofortified mustard oil, as for other health practices that do not result in immediate, visible benefits, is to educate consumers to want to use the enhanced product. Given some well-publicized cases with food adulteration in India, a campaign to reliably identify the enhanced product would be needed, reinforced by public health messages from credible sources such as the medical establishment and nonprofit organizations.

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In short, a wide-scale attempt to introduce biofortified mustard would have to overcome hurdles to technology adoption by growers and gain acceptance by consumers to ensure that the projected benefits are achieved. The challenge is no less daunting than other health campaigns, including other methods of increasing vitamin A intake, but would have to be considered and planned for.

Wider Implications

A biofortification strategy can play an important role as part of a broader approach to reducing the prevalence of VAD in India. Such strategies can be cost-effective, feasible, and implemented under conditions where supplementation and fortification are currently disadvantaged. However, there are significant barriers. Perhaps foremost of these is that recognition of the importance of VAD as a public health problem in India is low. Without this recognition, all strategies to address VAD are doomed. Even with it, supporters would have to overcome many operational challenges. Additional concerns specific to biotechnology also cannot be ignored, as they remain a continuing barrier to adoption of mustard or any other genetically modified foods.

So, to biofortify or not to biofortify? Golden mustard is not the proverbial silver bullet to solve vitamin A or other micronutrient deficiencies. Yet, with evidence that millions of children and women in India and worldwide can benefit from even modest increases in consumption of the vitamin, it deserves a closer look.■