OPINION EDITORIAL

Equal Access to Beneficial Microbes: A Tool for Reduced Malnutrition

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Microbes are intrinsic to human health. Communities of microorganisms within the gut, termed the gut microbiome, have been linked to healthy infantile development, reduced incidence of stunting, reduced incidence of infectious dysentery, and improved weight gain [1-4]. Despite proven benefits, healthy microorganisms are still considered a luxury in low-and middle-income countries (LMICs) [1]. Here, we review importance of the healthy microbes and methods that can promote its accessibility in low-and middle-income countries and help achieve the UN Sustainable Development Goals. With greater exposure to malnutrition and infectious disease, but limited buying power, access to diverse microbes in LMICs proves to be especially beneficial [1].

With recent innovation in the field of microbiology, microorganisms are being cast in a different light to better understand disease and nutrition. Microbes are involved in the development and functioning of the gastrointestinal, immune, endocrine, and metabolic systems [5]. As an integral component of the gastrointestinal system, the microbiome serves to induce vitamin absorption, improve digestion, and remove toxins and pathogenic microorganisms [5]. For optimal health, the microbiome must have sufficient diversity to provide an array of health benefits.

Probiotics, defined by the World Health Organization as "live microorganisms which when administered in adequate amounts confer a health benefit on the host," can be used to restore gut microbial diversity [6]. Infants of low birth weight experienced improved weight gain after probiotic treatment, and similar weight gain improvements have been observed in other groups [4]. Thus, the heavily disrupted gut microbiome in individuals with malnutrition can be counteracted by probiotic intake [2]. With such essential roles in human health, Ishaq et al. suggested that humans should have a right to the access and use of healthy microbes [7]. This right is analogous to the right of humans to access environmental resources necessary for life, and would reduce "microbial inequality" [7]. However, manufactured probiotics remain a luxury that can only be afforded by a select few, and cost remains a barrier for equal access to beneficial microbes [1].

Alternatively, the process of fermentation, a food preparation method that involves organic decomposition by microbes, is an accessible process for all [8]. Fermentation can cultivate microorganisms with probiotic-like effects that can be found in a variety of foods including milk, cereals, and fruits [1]. While fermented foods have been consumed around the world for thousands of years, their microbial benefits have only been discovered recently [8]. The lactic acid bacteria strain that exists in many fermented foods meet and exceed regulatory microbial standards to confer the same benefits as found in probiotics [3]. A study by Alou et al. reviewed several metagenomics studies that identified a depletion of gut microbes in individuals with severe malnutrition [9]. Another study, by Smith et al., indicated that improving the microbiota by fecal transplant or probiotics could replace missing strains in Malawian twin pairs [10]. Gastrointestinal disease and malnutrition are morbidities dominating child mortality worldwide

and may be alleviated through microbe supplementation. Fermentation provides a low-cost option to address the causal relationship between the gut microbiome and malnutrition. Thus, fermented foods can potentially be a solution to the nutrition crisis in LMICs.

Fermented foods are consumed globally, with at least some fermented foods being consumed by nearly every culture, but their health benefits are rarely promoted [8,11]. Thus, another method to improve access to beneficial microbes is through health policy and focus on health literacy. In Canada and the United States, food guides recommend yogurt and kefir as dairy products but do not provide further information about their benefits as fermented foods [8]. In Japan, fermented foods are only encouraged for "specified health uses" [8]. As of 2014, India was the only country to include fermented foods as a category in the national food guide, beginning in 2010 [8]. In India, children fed probiotic supplements experienced lower incidence of diarrhea and improve weight and height development compared to counterparts not receiving the supplement [12]. Further, stunting in India has decreased by 4% since 2015 [13]. With the exception of India, fermented foods are rarely promoted as a part of health literacy strategies such as food guides and recommendations. Inclusion of fermented foods or probiotics, where applicable, in health policy and food recommendations would encourage communities to consume traditional fermented foods with an increased understanding of their benefits. Further, inclusion of health-associated microbes in national health policy presents an opportunity to promote beneficial microbes that address health challenges specific to the location. Different gut microbiota compositions in different locations demonstrate the need for specific microbes tailored to these nations [1].

Improving the accessibility of healthy microbes is limited in LMICs, but locally sourced probiotics remain an exception. Today, many fermented foods are made using a starter culture to ensure reliability and reproducibility of microbes present in the food [8]. In 2004, Western Heads East (WHE) – a program established by staff, faculty, and students at Western University Ontario – collaborated with the Tukwamuane Women's Group to establish Africa's first probiotic yogurt called Fiti, which means 'Health' in Kiswahili. Local women from Mwanza, Tanzania were then taught how to produce yogurt supplemented with probiotic Lactobacillus rhamnosus GR-1 and how to start their own community kitchens. Through funding by the International Development Research Center (IDRC), the freeze-dried bacteria was made available in sachets improving the accessibility of the probiotics and allowing the program to grow to over 200 yogurt kitchens in Tanzania, Kenya, and Uganda. The Fiti Probiotic Initiative addresses the social inequality that propagates malnutrition by providing low-cost probiotics to LMICs, training women to make probiotic yogurt, and promoting community health. Such organizations that connect LMICs with the resources necessary to propagate microbe accessibility provide the social infrastructure necessary for improved accessibility to microbes, and the foundation for the inclusion of microbes in health policy.

The study of the microbiota presents an opportunity for immediate action to catalyze change to address the UN Sustainable Development goals of zero hunger, economic growth and industry, sustainable communities, and reduced inequalities [14]. To increase access to healthy microbes would also parallel the World Health Organization global target goals of reduced incidence of stunting, low birth weight, and wasting by 2025 [15]. To reduce social inequality, microbial inequality must first be reduced. International policy and social programming must recognize microbial availability as a right as important as access to healthcare or nutritious foods. To have access to microbes is to reduce the global burden of malnutrition; internationally, the world must understand microorganisms as such.

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REFERENCES

1. Sybesma W, Kort R, Lee Y. Locally sourced probiotics, the next opportunity for developing countries?. Trends in Biotechnology. 2015;33(4):197-200.

2. Saran S, Gopalan S, Krishna T. Use of fermented foods to combat stunting and failure to thrive. Nutrition. 2002;18(5):393-396.

3. Rezac S, Kok C, Heermann M, Hutkins R. Fermented foods as a dietary source of live organisms. Frontiers in Microbiology. 2018;9(1785).

4. Härtel C, Pagel J, Rupp J, Bendiks M, Guthmann F, Rieger-Fackeldey E et al. Prophylactic use of lactobacillus acidophilus/bifidobacterium infantis probiotics and outcome in very low birth weight infants. The Journal of Pediatrics. 2014;165(2):285-289.e1.

5. McVey Neufeld K, Mao Y, Bienenstock J, Foster J, Kunze W. The microbiome is essential for normal gut intrinsic primary afferent neuron excitability in the mouse. Neurogastroenterology & Motility. 2012;25(2):183-e88.

6. Mack D. Probiotics-mixed messages. Can Fam Physician. 2005;51(11):1455-1464.

7. Ishaq S, Rapp M, Byerly R, McClellan L, O'Boyle M, Nykanen A et al. Framing the discussion of microorganisms as a facet of social equity in human health. PLOS Biology. 2019;17(11).

8. Chilton S, Burton J, Reid G. Inclusion of fermented foods in food guides around the world. Nutrients. 2015;7(1):390-404.

9. Tidjani Alou M, Million M, Traore S, Mouelhi D, Khelaifia S, Bachar D et al. Gut bacteria missing in severe acute malnutrition, can we identify potential probiotics by culturomics?. Frontiers in Microbiology. 2017;8(899).

10. Smith M, Yatsunenko T, Manary M, Trehan I, Mkakosya R, Cheng J et al. Gut microbiomes of Malawian twin pairs discordant for kwashiorkor. Science. 2013;339(6119):548-554.

11. Marco M, Heeney D, Binda S, Cifelli C, Cotter P, Foligné B et al. Health benefits of fermented foods: microbiota and beyond. Current Opinion in Biotechnology. 2017;44:94-102.

12. Dinh D, Ramadass B, Kattula D, Sarkar R, Braunstein P, Tai A et al. Longitudinal analysis of the intestinal microbiota in persistently stunted young children in South India. PLOS ONE. 2016;11(5):e0155405.

13. Ministry of Health and Family Welfare. National family health survey. Mumbai: International Institute for Population Sciences; 2017. 671.

14. United Nations. Sustainable development knowledge platform [Internet]. 2020. Available from: https://sustainabledevelopment.un.org/

15. World Health Organization. Global targets 2025 [Internet]. 2020. Available from https://www.who.int/nutrition/global-target-2025/en/