Cabbage and fermented vegetables: from death rate heterogeneity in countries to candidates for mitigation strategies of severe COVID-19

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meta-analysis found that the intake of probiotics resulted in minor but consistent improvements in several metabolic risk factors in subjects with metabolic diseases, and particularly in insulin resistance.[101] Another recent meta-analysis found that an oral supplementation with probiotics or synbiotics has a small effect in reducing waist circumference but no effect on body weight or body mass index (BMI).[102] Kefir, a fermented milk product, was not found to be more effective than yoghurt in the glycemic control of obesity, possibly because there are insufficient differences between both.[103]

8.3.3 | Lactobacillus and Nrf2

Nrf2 may be involved in diseases associated with insulin resistance.[73–75] "Ancient foods," and particularly those containing *Lactobacillus*, activate Nrf2.[72] The microbiome is highly related to insulin resistance. In mice, several strains of *Lactobacillus* were found to regulate Nrf2 in models of aging,[104] in cardioprotective effects,[105] and in nonalcoholic fatty acid liver disease.[106] *Lactobacillus plantarum* CQPC11—isolated from Sichuan pickled cabbages—antagonizes oxidation and aging in mice.[107] Lactobacillus protects against ulcerative colitis by modulation of the gut microbiota and Nrf2/Ho-1 pathway.[108] The sugary kefir strain, *Lactobacillus mali* APS1, ameliorates hepatic steatosis by regulation of Nrf2 and the gut microbiota in rats.[109] In vitro studies have also found an effect of *Lactobacilli* mediated by Nrf2.[110–112] Interestingly, the symbiotic combination of prebiotic grape pomace extract and probiotic *Lactobacillus* sp reduces intestinal inflammatory markers.[113]

8.3.4 | Coronavirus disease in animals and lactic acid bacteria

The porcine epidemic diarrhea virus (PEDV) and the transmissible gastroenteritis coronavirus infection (TGEV) are worldwide-distributed coronaviruses. Low levels of *Lactobacillus* were found in the intestine of piglets infected by TGEV[114] or PEDV *Lactobacillus* inhibits PEDV or TGEV effects in vitro.[115,116]

8.4 | 7-4-Nrf2 and COVID-19

Nrf2 can act on the endoplasmic reticulum stress and the AT1R pathway. A putative mechanism may be proposed for the AT1R pathway (Figure 5). SARS-CoV-2 downregulates ACE2 inducing an increased insulin resistance associated with oxidative stress through the AT_1R pathway. This may explain risk factors for severe COVID-19.

Fermented vegetables are often made from cruciferous (Brassica) vegetables that release glucoraphanin converted by the plant or by the gut microbiome into sulforaphane which activates Nrf2 and subsequently reduces insulin intolerance by its potent antioxidant activities. Fermented vegetables contain a high content of *Lactobacillus* that can activate Nrf2 and impact on the microbiome. [117] Sulforaphane and LAB both therefore have the ability to reduce insulin resistance.

Other putative actions on COVID-19 severity may be postulated. The downregulation of ACE2 reduces the Ang-1,7 antioxidant activity that was found to activate Nrf2.[118,119] Nrf2 protects against hallmarks of severe COVID-19. It has anti-fibrotic effects on various organs including the lungs,[120] and protects against lung injury and acute respiratory distress syndrome,[121] and endothelial damage.[78] Finally, Nrf2 can block IL-6 in different models of inflammation[122] and might play a role in the COVID-19 cytokine storm.

These different mechanisms may explain the importance of fermented cabbage in preventing the severity of COVID-19. It is clear that other nutrients, vitamin D,[123] and many different foods act on NRF2 and that mechanisms other than Nrf2 may be operative.

It is not yet known whether sulforaphane and/or LAB may act on the infectivity of SARS-CoV-2. Disulfide bonds can be formed under oxidizing conditions and play an important role in the folding and stability of some proteins. The receptor-binding domain of the viral spike proteins and ACE2 has several cysteine residues. Using molecular dynamics simulations, the binding affinity was significantly impaired when all of the disulfide bonds of both ACE2 and SARS-CoV/CoV-2 spike proteins were reduced to thiol groups. This computational finding possibly provides a molecular basis for the differential COVID-19 cellular recognition due to the oxidative stress.[124]

It is likely that foods with antioxidant activity can interact with COVID-19 and that fermented or cruciferous vegetables represent one of the possible foods involved. If some foods are found to be associated with a prevention of COVID-19 prevalence or severity, it may be of interest to study their LAB and/or sulforaphane composition in order to eventually find some common mechanisms and targets for therapy.

9 | MAY DIETARY MODIFICATIONS CHANGE THE COURSE OF COVID-19?

9.1 | Fermented vegetables and Kimchi

It is tempting to propose that countries where traditional LAB-fermented vegetables are largely consumed are those showing lower COVID-19 death rates and that fermented vegetables represent one possible preventive approach. Other nutrients are found in these products that may enhance their effect (eg, vitamin K[125]). Kimchi fermented from many vegetables including cabbage has several effects on insulin resistance-associated diseases: anti-diabetic properties,[126,127] cardiovascular diseases,[28] dyslipidemia,[128] or aging.[129] Kimchi, when fermented for a long time, reduces insulin intolerance to a greater extent than fresh kimchi,[126] indicating that newly formed products during fermentation are important. In particular, Kimchi from cabbage and Chinese cabbage contains several glucosinolates[60,130,131] that can be transformed in sulforaphanes either in the plant itself or by the human microbiome.[60] In central European countries, raw and fermented cabbage is commonly consumed.

In sub-Saharan Africa although young age is an important factor, people commonly eat fermented foods, mainly cereal-based foods like sorghum, millet and maize, and roots such as cassava, fruits, and vegetables. Fermented cassava products (like *gari* and *fufu*) are a major component of the diet of over 800 million people and, in some areas, these products constitute over 50% of the diet.[16]

It is clear that sauerkraut is consumed in Alsace (France) where a COVID-19 outbreak has been identified, but it is not a regular meal.

9.2 | Westernized diet

Westernized diets contain a reduced amount of fermented vegetables[43,132] and may be prone to increasing insulin resistance[44,133] and diseases associated with it,[134] and thereby severe COVID-19.

In the Mediterranean diet, well known for reducing insulin resistance,[135] Nrf2 appears to play an important role.[71,136] The COVID-19 death rate differences in Italian (Figure 2) and Spanish[3] regions suggest a role for Mediterranean diet and short-chain food supply. This also indicates that many foods can have an effect and that cabbage and fermented foods represent a proof-of-concept. Nrf2 is also involved in the Okinawan-based diet,[71] active on insulin intolerance.[137] Taken altogether, it is possible that diet is partly involved in the COVID-19 death clusters found in large Western cities where traditional diet is often replaced by long-chain food supply.

It is clear that diet is not the only risk factor and should be considered in the context of COVID-19 in a given setting. For example, Nordic/central European people socialize less than the Mediterraneans and simultaneously may consume more fermented vegetables.

9.3 | The COVID-19 slum paradox

It was expected that the COVID-19 pandemic will be catastrophic if it reached deprived areas of low- and middle-income countries, in particular informal settlements (slum areas) where social distancing and lockdown are almost impossible to set up.[138]

In the United States, highly populated, regional air hub areas, minorities, and poverty had an increased risk of COVID-19-related mortality.[139] It was proposed that the inequality might be due to the workforce of essential services, poverty, access to care, or air pollution.[140] These are common risk factors in mortality observed in deprived areas of the United States.[141] Moreover, in the United States and the UK, there are unique health issues facing black, Asian, and minority ethnic communities.[142,143] This greater risk of hospitalizations in these populations was not explained by socioeconomic or behavioral factors.[144] Social distancing is an important factor to be considered[145] but diet may also be involved.

On the other hand, a recent report of the Municipal Corporation of Greater Mumbai (Public Relation Department, 28-07-2020) found that 57% of subjects tested in the slum area had antibodies against SARS-CoV-2 but only 16% in the nonslum areas. The fatality rate in slum areas was very low (0.05%-0.1%).[146] Although precise data are lacking, in Brazilian favelas the spread of COVID-19 is not noticed.[147] Temperature does not seem to be an important factor to contain the pandemic. Young age of the population may be important. Fermented foods are popular throughout the world, and in many regions, they represent a widespread tradition as well as they make a significant contribution to the diet of millions of individuals.[16] This is the case in slum areas, and it is possible that fermented foods explain, at least partly, the paradox.

10 | CONCLUSION

Cabbage contains precursors of sulforaphane, the most active natural activator of Nrf2. Fermented vegetables contain many lactobacilli, also potent Nrf2 activators. It is proposed that fermented cabbage is a proof-of-concept of dietary manipulations that may enhance Nrf2-associated antioxidant effects helpful in mitigating COVID-19 severity.

Mainstream COVID-19 control strategies including social distancing, confinement, and intensive case finding, testing, tracing, and isolating are so far not enough to provide a SARS-CoV-2-free environment and restore a safe social life. There are hopes for a safe and effective vaccine, but this is unlikely to become rapidly available. So, there is a need to explore other potentially useful strategies. An area that has not been sufficiently considered is diet, both as a preventive and as therapeutically useful intervention, encouraging people to eat more traditional foods containing fermented vegetables (Figure 6). We have suggested that fermented vegetables could be associated with a lower COVID-19 mortality due to their potent antioxidant effect among which sulforaphane and LAB are important. However, many other foods may have a similar activity. It should be noted that dietary supplements that overactivate Nrf2 may have side effects.[148]

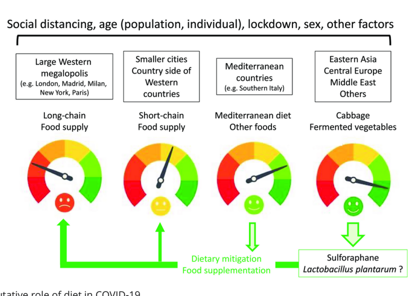

FIGURE 6. Putative role of diet in COVID-19

Robust evidence from observational studies would be helpful to formally investigate associations between fermented foods and clinical outcomes in COVID-19. State-of-the-art methods, including the use of DAGs (directed acyclic graphs), may be needed to help assess whether the associations seen are likely to represent causal relationship.[149] A faster approach would be to develop large clinical trials in the appropriate populations. Interventions based on diets with a high intake of fermented foods like Kimchi or other fermented foods are unlikely to present ethical difficulties. Furthermore, the fact that a precise mechanism has been proposed would facilitate adding reliable biomarkers to the relevant clinical outcomes. Moreover, new drugs based on the components of these fermented foods may be of interest.

If the hypothesis is proved, COVID-19 will be the first infectious disease outbreak associated with a loss of "nature"[150] and to be ascribed as a disease of the Anthropocene.[151] Imbalance in the gut microbiota is responsible for the pathogenesis of various disease types including allergy, asthma, rheumatoid arthritis, different types of cancer, diabetes mellitus, obesity, and cardiovascular disease.[152] Fermentation was introduced during the Neolithic age and was essential for the survival of humankind. When modern life led to eating reduced amounts of fermented foods, the microbiome drastically changed,[153] allowing SARS-CoV-2 to spread or to be more severe.[154] It is time for mitigation.[155]

CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

REFERENCES

1 Stafford N. Covid-19: Why Germany's case fatality rate seems so low. *BMJ*. 2020;369:m1395.

2 Bousquet J, Czarlewski W, Blain H, Zuberbier T, Anto J. Rapid Response: Why Germany's case fatality rate seems so low: Is nutrition another possibility. *BMJ*. 2020. https://www.bmj.com/content/369/bmj.m1395/rr-12

3 Bousquet J, Anto JM, Iaccarino G, et al. Is diet partly responsible for differences in COVID-19 death rates between and within countries? *Clin Transl Allergy*. 2020;10:16.

4 Iddir M, Brito A, Dingeo G, et al. Strengthening the Immune System and Reducing Inflammation and Oxidative Stress through Diet and Nutrition: Considerations during the COVID-19 Crisis. *Nutrients*. 2020;12(6):1562.

5 Cena H, Chieppa M. Coronavirus Disease (COVID-19-SARS-CoV-2) and Nutrition: Is Infection in Italy Suggesting a Connection? *Front Immunol*. 2020;11:944.

6 Infusino F, Marazzato M, Mancone M, et al. Diet Supplementation, Probiotics, and Nutraceuticals in SARS-CoV-2 Infection: A Scoping Review. *Nutrients*. 2020;12(6):1718.

7 Adams KK, Baker WL, Sobieraj DM. Myth busters: dietary supplements and COVID-19. *Ann Pharmacother*. 2020;54:820-826.

8 Sunyer J, Jarvis D, Pekkanen J, et al. Geographic variations in the effect of atopy on asthma in the European Community Respiratory Health Study. *J Allergy Clin Immunol*. 2004;114:1033-1039.

9 Kissler SM, Tedijanto C, Goldstein E, Grad YH, Lipsitch M. Projecting the transmission dynamics of SARS-CoV-2 through the postpandemic period. *Science*. 2020.

10 Rosenthal PJ, Breman JG, Djimde AA, et al. COVID-19: Shining the Light on Africa. *Am J Trop Med Hyg*. 2020;102(6):1145-1148.

11 Fonseca S, Rivas I, Romaguera D, et al.Association between consumption of fermented vegetables and COVID-19 mortality at a country level in Europe MEDRXIV/2020/147025; 2020.

12 Fonseca S, Rivas I, Romaguera D, et al. Association between consumption of vegetables and COVID-19 mortality at a country level in Europe. *MedRix*. 2020.

13 Baker P, Friel S. Food systems transformations, ultra-processed food markets and the nutrition transition in Asia. *Global Health*. 2016;12:80.

14 Santulli G, Pascale V, Finelli R, et al. We are What We Eat: Impact of Food from Short Supply Chain on Metabolic Syndrome. *J Clin Med*. 2019;8(12):2061.

15 Peters A, Krumbholz P, Jager E, et al. Metabolites of lactic acid bacteria present in fermented foods are highly potent agonists of human hydroxycarboxylic acid receptor 3. *PLoS Genet*. 2019;15:e1008145.

16 Azam-Ali S. Fermented fruits and vegetables. A global perspective; 1998.

17 Marco ML, Heeney D, Binda S, et al. Health benefits of fermented foods: microbiota and beyond. *Curr Opin Biotechnol*. 2017;44:94-102.

18 Rhee SJ, Lee JE, Lee CH. Importance of lactic acid bacteria in Asian fermented foods. *Microb Cell Fact*. 2011;10(Suppl 1):S5.

19 Patra JK, Das G, Paramithiotis S, Shin HS. Kimchi and other widely consumed traditional fermented foods of korea: a review. *Front Microbiol*. 2016;7:1493.

20 Jung JY, Lee SH, Jeon CO. Kimchi microflora: history, current status, and perspectives for industrial kimchi production. *Appl Microbiol Biotechnol*. 2014;98:2385-2393.

21 Chen YS, Otoguro M, Lin YH, et al. Lactococcus formosensis sp. nov., a lactic acid bacterium isolated from yan-tsai-shin (fermented broccoli stems). *Int J Syst Evol Microbiol*. 2014;64:146-151.

22 Han X, Yi H, Zhang L, et al. Improvement of fermented Chinese cabbage characteristics by selected starter cultures. *J Food Sci*. 2014;79:M1387-M1392.

23 Yoon KY, Woodams EE, Hang YD. Production of probiotic cabbage juice by lactic acid bacteria. *Bioresour Technol*. 2006;97:1427-1430.

24 Slattery C, Cotter PD, O'Toole PW. Analysis of health benefits conferred by Lactobacillus species from Kefir. *Nutrients*. 2019;11(6):1252.

25 Shiby VK, Mishra HN. Fermented milks and milk products as functional foods–a review. *Crit Rev Food Sci Nutr*. 2013;53:482-496.

26 Sanders ME, Merenstein DJ, Reid G, Gibson GR, Rastall RA. Probiotics and prebiotics in intestinal health and disease: from biology to the clinic. *Nat Rev Gastroenterol Hepatol*. 2019;16:605-616.

27 Sanlier N, Gokcen BB, Sezgin AC. Health benefits of fermented foods. *Crit Rev Food Sci Nutr*. 2019;59:506-527.

28 Lavefve L, Marasini D, Carbonero F. Microbial ecology of fermented vegetables and non-alcoholic drinks and current knowledge on their impact on human health. *Adv Food Nutr Res*. 2019;87:147-185.

29 Melini F, Melini V, Luziatelli F, Ficca AG, Ruzzi M. Health-Promoting Components in Fermented Foods: An Up-to-Date Systematic Review. *Nutrients*. 2019;11(5):1189.

30 Azam M, Mohsin M, Ijaz H, et al. Review - Lactic acid bacteria in traditional fermented Asian foods. *Pak J Pharm Sci*. 2017;30:1803-1814.

31 Dimidi E, Cox SR, Rossi M, Whelan K. Fermented foods: definitions and characteristics, impact on the gut microbiota and effects on gastrointestinal health and disease. *Nutrients*. 2019;11(8):1806.

32 Riggioni C, Comberiati P, Giovannini M, et al. A compendium answering 150 questions on COVID-19 and SARS-CoV-2. *Allergy*. 2020.

33 Ruokolainen L, Lehtimäki J, Karkman A, Haahtela T. Holistic view on health : two protective layers of biodiversity. *Ann Zool Fennici*. 2017;54:39-49.

34 Septembre-Malaterre A, Remize F, Poucheret P. Fruits and vegetables, as a source of nutritional compounds and phytochemicals: Changes in bioactive compounds during lactic fermentation. *Food Res Int*. 2018;104:86-99.

35 Kok CR, Hutkins R. Yogurt and other fermented foods as sources of health-promoting bacteria. *Nutr Rev*. 2018;76:4-15.

36 De Filippis F, Pasolli E, Ercolini D. The food-gut axis: lactic acid bacteria and their link to food, the gut microbiome and human health. *FEMS Microbiol Rev*. 2020;44(4):454-489.

37 Mobeen F, Sharma V, Tulika P. Enterotype Variations of the Healthy Human Gut Microbiome in Different Geographical Regions. *Bioinformation*. 2018;14:560-573.

38 Bibbo S, Ianiro G, Giorgio V, et al. The role of diet on gut microbiota composition. *Eur Rev Med Pharmacol Sci*. 2016;20:4742-4749.

39 Tian S, Liu X, Lei P, Zhang X, Shan Y. Microbiota: a mediator to transform glucosinolate precursors in cruciferous vegetables to the active isothiocyanates. *J Sci Food Agric*. 2018;98:1255-1260.

40 Segata N. Gut Microbiome: Westernization and the Disappearance of Intestinal Diversity. *Curr Biol*. 2015;25:R611-R613.

41 Vangay P, Johnson AJ, Ward TL, et al. US Immigration Westernizes the Human Gut Microbiome. *Cell*. 2018;175:962-972.

42 Zuo T, Kamm MA, Colombel JF, Ng SC. Urbanization and the gut microbiota in health and inflammatory bowel disease. *Nat Rev Gastroenterol Hepatol*. 2018;15:440-452.

43 Wilson AS, Koller KR, Ramaboli MC, et al. Diet and the human gut microbiome: an international review. *Dig Dis Sci*. 2020;65:723-740.

44 Yamashita M, Okubo H, Kobuke K, et al. Alteration of gut microbiota by a Westernized lifestyle and its correlation with insulin resistance in non-diabetic Japanese men. *J Diabetes Investig*. 2019;10:1463-1470.

45 Angelakis E, Yasir M, Bachar D, et al. Gut microbiome and dietary patterns in different Saudi populations and monkeys. *Sci Rep*. 2016;6:32191.

46 Mitsou EK, Kakali A, Antonopoulou S, et al. Adherence to the Mediterranean diet is associated with the gut microbiota pattern and gastrointestinal characteristics in an adult population. *Br J Nutr*. 2017;117:1645-1655.

47 Saad MJ, Santos A, Prada PO. Linking Gut Microbiota and Inflammation to Obesity and Insulin Resistance. *Physiology*. 2016;31:283-293.

48 Chen X, Devaraj S. Gut microbiome in obesity, metabolic syndrome, and diabetes. *Curr Diab Rep*. 2018;18:129.

49 Lee CJ, Sears CL, Maruthur N. Gut microbiome and its role in obesity and insulin resistance. *Ann N Y Acad Sci*. 2020;1461:37-52.

50 Zuo T, Zhang F, Lui GCY, et al. Alterations in Gut microbiota of patients with COVID-19 during time of hospitalization. *Gastroenterology*. 2020.

51 Xu K, Cai H, Shen Y, et al. Management of Corona Virus disease-19 (COVID-19): The zhejiang experience. *Zhejiang Da Xue Xue Bao Yi Xue Ban*. 2020;49.

52 Finucane FM, Davenport C. Coronavirus and obesity: could insulin resistance mediate the severity of Covid-19 infection? *Front Public Health*. 2020;8:184.

53 Guzik TJ, Cosentino F. Epigenetics and Immunometabolism in Diabetes and Aging. *Antioxid Redox Signal*. 2018;29:257-274.

54 Miedema MD, Maziarz M, Biggs ML, et al. Plasma-free fatty acids, fatty acid-binding protein 4, and mortality in older adults (from the Cardiovascular Health Study). *Am J Cardiol*. 2014;114:843-848.

55 Hurrle S, Hsu WH. The etiology of oxidative stress in insulin resistance. *Biomed J*. 2017;40:257-262.

56 Wen H, Gwathmey JK, Xie LH. Oxidative stress-mediated effects of angiotensin II in the cardiovascular system. *World J Hypertens*. 2012;2:34-44.

57 Bhatt SR, Lokhandwala MF, Banday AA. Vascular oxidative stress upregulates angiotensin II type I receptors via mechanisms involving nuclear factor kappa B. *Clin Exp Hypertens*. 2014;36:367-373.

58 Dalan R, Bornstein SR, El-Armouche A, et al. The ACE-2 in COVID-19: Foe or Friend? *Horm Metab Res*. 2020;52:257-263.

59 Sarzani R, Giulietti F, Di Pentima C, Giordano P, Spannella F. Disequilibrium between the classic renin-angiotensin system and its opposing arm in Sars-Cov-2 related lung injury. *Am J Physiol Lung Cell Mol Physiol*. 2020;319(2):L325-L336.

60 Bousquet J, Anto J, Czarlewski W, et al. Sulforaphane: from death rate heterogeneity in countries to candidate for prevention of severe COVID-19. *Allergy*. 2020.

61 Ren H, Yang Y, Wang F, et al. Association of the insulin resistance marker TyG index with the severity and mortality of COVID-19. *Cardiovasc Diabetol*. 2020;19:58.

62 Jain S, Buttar HS, Chintameneni M, Kaur G. Prevention of cardiovascular diseases with anti-inflammatory and anti- oxidant nutraceuticals and herbal products: an overview of pre-clinical and clinical studies. *Recent Pat Inflamm Allergy Drug Discov*. 2018;12:145-157.

63 Razmpoosh E, Javadi M, Ejtahed HS, Mirmiran P. Probiotics as beneficial agents in the management of diabetes mellitus: a systematic review. *Diabetes Metab Res Rev*. 2016;32:143-168.

64 Serino A, Salazar G. Protective role of polyphenols against vascular inflammation, aging and cardiovascular disease. *Nutrients*. 2019;11(1):53.

65 Zabetakis I, Lordan R, Norton C, Tsoupras A. COVID-19: The inflammation link and the role of nutrition in potential mitigation. *Nutrients*. 2020;12(5):1466.

66 Tonelli C, Chio IIC, Tuveson DA. Transcriptional regulation by Nrf2. *Antioxid Redox Signal*. 2018;29:1727-1745.

67 Yamamoto M, Kensler TW, Motohashi H. The KEAP1-NRF2 system: a thiol-based sensor-effector apparatus for maintaining redox homeostasis. *Physiol Rev*. 2018;98:1169-1203.

68 XXXXXXXX.

69 Wardyn JD, Ponsford AH, Sanderson CM. Dissecting molecular cross-talk between Nrf2 and NF-kappaB response pathways. *Biochem Soc Trans*. 2015;43:621-626.

70 Jimenez-Osorio AS, Gonzalez-Reyes S, Pedraza-Chaverri J. Natural Nrf2 activators in diabetes. *Clin Chim Acta*. 2015;448:182-192.

71 Pall ML, Levine S. Nrf2, a master regulator of detoxification and also antioxidant, anti-inflammatory and other cytoprotective mechanisms, is raised by health promoting factors. *Sheng Li Xue Bao*. 2015;67:1-18.

72 Senger DR, Li D, Jaminet SC, Cao S. Activation of the Nrf2 Cell defense pathway by ancient foods: disease prevention by important molecules and microbes lost from the modern western diet. *PLoS One*. 2016;11:e0148042.

73 Uruno A, Yagishita Y, Yamamoto M. The Keap1-Nrf2 system and diabetes mellitus. *Arch Biochem Biophys*. 2015;566:76-84.

74 Vasileva LV, Savova MS, Amirova KM, Dinkova-Kostova AT, Georgiev MI. Obesity and NRF2-mediated cytoprotection: Where is the missing link? *Pharmacol Res*. 2020;156:104760.

75 Guo Z, Mo Z. Keap1-Nrf2 signaling pathway in angiogenesis and vascular diseases. *J Tissue Eng Regen Med*. 2020;14:869-883.

76 Zhang H, Davies KJA, Forman HJ. Oxidative stress response and Nrf2 signaling in aging. *Free Radic Biol Med*. 2015;88:314-336.

77 Rojo de la Vega M, Dodson M, Gross C, et al. Role of Nrf2 and autophagy in acute lung injury. *Curr Pharmacol Rep*. 2016;2:91-101.

78 Chen B, Lu Y, Chen Y, Cheng J. The role of Nrf2 in oxidative stress-induced endothelial injuries. *J Endocrinol*. 2015;225:R83-R99.

79 McCord JM, Hybertson BM, Cota-Gomez A, Gao B. Nrf2 Activator PB125(R) as a potential therapeutic agent against COVID-19. *bioRxiv* 2020.

80 Fang Y, Gao F, Liu Z. Angiotensin-converting enzyme 2 attenuates inflammatory response and oxidative stress in hyperoxic lung injury by regulating NF-kappaB and Nrf2 pathways. *QJM*. 2019;112:914-924.

81 Palliyaguru DL, Yuan JM, Kensler TW, Fahey JW. Isothiocyanates: Translating the Power of Plants to People. *Mol Nutr Food Res*. 2018;62:e1700965.

82 Oliviero T, Verkerk R, Dekker M. Isothiocyanates from Brassica vegetables-effects of processing, cooking, mastication, and digestion. *Mol Nutr Food Res*. 2018;62:e1701069.

83 Vanduchova A, Anzenbacher P, Anzenbacherova E. Isothiocyanate from Broccoli, Sulforaphane, and Its Properties. *J Med Food*. 2019;22:121-126.

84 Quirante-Moya S, Garcia-Ibanez P, Quirante-Moya F, Villano D, Moreno DA. The role of brassica bioactives on human health: are we studying it the right way? *Molecules* 2020;25(7):1591.

85 Luang-In V, Deeseenthum S, Udomwong P, Saengha W, Gregori M. Formation of sulforaphane and iberin products from thai cabbage fermented by myrosinase-positive bacteria. *Molecules*. 2018;23(4):955.

86 Yagishita Y, Fahey JW, Dinkova-Kostova AT, Kensler TW. Broccoli or sulforaphane: is it the source or dose that matters? *Molecules*. 2019;24(19):3593.

87 Hindson J. Brassica vegetable metabolism by gut microbiota. *Nat Rev Gastroenterol Hepatol*. 2020;17:195.

88 Houghton CA. Sulforaphane: Its "Coming of Age" as a clinically relevant nutraceutical in the prevention and treatment of chronic disease. *Oxid Med Cell Longev*. 2019;2019:2716870.

89 Horowitz RI, Freeman PR. Three novel prevention, diagnostic, and treatment options for COVID-19 urgently necessitating controlled randomized trials. *Med Hypotheses*. 2020;143:109851.

90 Yang L, Palliyaguru DL, Kensler TW. Frugal chemoprevention: targeting Nrf2 with foods rich in sulforaphane. *Semin Oncol*. 2016;43:146-153.

91 Bai Y, Wang X, Zhao S, Ma C, Cui J, Zheng Y. Sulforaphane protects against cardiovascular disease via Nrf2 Activation. *Oxid Med Cell Longev*. 2015;2015:407580.

92 Zhou S, Wang J, Yin X, et al. Nrf2 expression and function, but not MT expression, is indispensable for sulforaphane-mediated protection against intermittent hypoxia-induced cardiomyopathy in mice. *Redox Biol*. 2018;19:11-21.

93 Xu L, Nagata N, Ota T. Glucoraphanin: a broccoli sprout extract that ameliorates obesity-induced inflammation and insulin resistance. *Adipocyte*. 2018;7:218-225.

94 Teng W, Li Y, Du M, Lei X, Xie S, Ren F. Sulforaphane prevents hepatic insulin resistance by blocking serine palmitoyltransferase 3-mediated ceramide biosynthesis. *Nutrients*. 2019;11(5):1185.

95 Sun Y, Zhou S, Guo H, et al. Protective effects of sulforaphane on type 2 diabetes-induced cardiomyopathy via AMPK-mediated activation of lipid metabolic pathways and NRF2 function. *Metabolism*. 2020;102:154002.

96 Perez S, Talens-Visconti R, Rius-Perez S, Finamor I, Sastre J. Redox signaling in the gastrointestinal tract. *Free Radic Biol Med*. 2017;104:75-103.

97 An H, Zhai Z, Yin S, Luo Y, Han B, Hao Y. Coexpression of the superoxide dismutase and the catalase provides remarkable oxidative stress resistance in Lactobacillus rhamnosus. *J Agric Food Chem*. 2011;59:3851-3856.

98 Serata M, Iino T, Yasuda E, Sako T. Roles of thioredoxin and thioredoxin reductase in the resistance to oxidative stress in Lactobacillus casei. *Microbiology*. 2012;158:953-962.

99 Kong Y, Olejar KJ, On SLW, Chelikani V. The Potential of Lactobacillus spp. for Modulating Oxidative Stress in the Gastrointestinal Tract. *Antioxidants* 2020;9(7):610.

100 Lee E, Jung SR, Lee SY, Lee NK, Paik HD, Lim SI. Lactobacillus plantarum Strain Ln4 Attenuates diet-induced obesity, insulin resistance, and changes in hepatic mRNA levels associated with glucose and lipid metabolism. *Nutrients*. 2018;10(5):643.

101 Koutnikova H, Genser B, Monteiro-Sepulveda M, et al. Impact of bacterial probiotics on obesity, diabetes and non-alcoholic fatty liver disease related variables: a systematic review and meta-analysis of randomised controlled trials. *BMJ Open*. 2019;9:e017995.

102 Suzumura EA, Bersch-Ferreira AC, Torreglosa CR, et al. Effects of oral supplementation with probiotics or synbiotics in overweight and obese adults: a systematic review and meta-analyses of randomized trials. *Nutr Rev*. 2019;77:430-450.

103 Barengolts E, Smith ED, Reutrakul S, Tonucci L, Anothaisintawee T. The effect of probiotic yogurt on glycemic control in type 2 diabetes or obesity: a meta-analysis of nine randomized controlled trials. *Nutrients*. 2019;11(3):671.

104 Li B, Evivie SE, Lu J, et al. Lactobacillus helveticus KLDS1.8701 alleviates d-galactose-induced aging by regulating Nrf-2 and gut microbiota in mice. *Food Funct*. 2018;9:6586-6598.

105 Xu H, Wang J, Cai J, et al. Protective Effect of Lactobacillus rhamnosus GG and its Supernatant against Myocardial Dysfunction in Obese Mice Exposed to Intermittent Hypoxia is Associated with the Activation of Nrf2 Pathway. *Int J Biol Sci*. 2019;15:2471-2483.

106 Zhao Z, Wang C, Zhang L, et al. Lactobacillus plantarum NA136 improves the non-alcoholic fatty liver disease by modulating the AMPK/Nrf2 pathway. *Appl Microbiol Biotechnol*. 2019;103:5843-5850.

107 Qian Y, Zhang J, Zhou X, et al. Lactobacillus plantarum CQPC11 isolated from sichuan pickled cabbages antagonizes d-galactose-induced oxidation and aging in mice. *Molecules*. 2018;23(11):3026.

108 El-Baz AM, Khodir AE, Adel El-Sokkary MM, Shata A. The protective effect of Lactobacillus versus 5-aminosalicylic acid in ulcerative colitis model by modulation of gut microbiota and Nrf2/Ho-1 pathway. *Life Sci*. 2020;256:117927.

109 Chen YT, Lin YC, Lin JS, Yang NS, Chen MJ. Sugary Kefir Strain Lactobacillus mali APS1 ameliorated hepatic steatosis by regulation of SIRT-1/Nrf-2 and gut microbiota in rats. *Mol Nutr Food Res*. 2018;62:e1700903.

110 Xu C, Qiao L, Ma L, et al. Biogenic selenium nanoparticles synthesized by Lactobacillus casei ATCC 393 alleviate intestinal epithelial barrier dysfunction caused by oxidative stress via Nrf2 signaling-mediated mitochondrial pathway. *Int J Nanomedicine*. 2019;14:4491-4502.

111 Mu G, Li H, Tuo Y, Gao Y, Zhang Y. Antioxidative effect of Lactobacillus plantarum Y44 on 2,2'-azobis(2-methylpropionamidine) dihydrochloride (ABAP)-damaged Caco-2 cells. *J Dairy Sci*. 2019;102:6863-6875.

112 Kobatake E, Nakagawa H, Seki T, Miyazaki T. Protective effects and functional mechanisms of Lactobacillus gasseri SBT2055 against oxidative stress. *PLoS One*. 2017;12:e0177106.

113 Pistol GC, Marin DE, Dragomir C, Taranu I. Synbiotic combination of prebiotic grape pomace extract and probiotic Lactobacillus sp. reduced important intestinal inflammatory markers and in-depth signalling mediators in lipopolysaccharide-treated Caco-2 cells. *Br J Nutr*. 2018;1-15.

114 Xia L, Yang Y, Wang J, Jing Y, Yang Q. Impact of TGEV infection on the pig small intestine. *Virol J*. 2018;15:102.

115 Kumar R, Seo BJ, Mun MR, et al. Putative probiotic Lactobacillus spp. from porcine gastrointestinal tract inhibit transmissible gastroenteritis coronavirus and enteric bacterial pathogens. *Trop Anim Health Prod*. 2010;42:1855-1860.

116 Zhang X, Li P, Zheng Q, Hou J. Lactobacillus acidophilus S-layer protein-mediated inhibition of PEDV-induced apoptosis of Vero cells. *Vet Microbiol*. 2019;229:159-167.

117 Hassan SM, Jawad MJ, Ahjel SW, et al. The Nrf2 Activator (DMF) and Covid-19: is there a possible role? *Med Arch*. 2020;74:134-138.

118 Romero A, San Hipolito-Luengo A, Villalobos LA, et al. The angiotensin-(1–7)/Mas receptor axis protects from endothelial cell senescence via klotho and Nrf2 activation. *Aging Cell*. 2019;18:e12913.

119 Cai SM, Yang RQ, Li Y, et al. Angiotensin-(1–7) Improves Liver Fibrosis by Regulating the NLRP3 Inflammasome via Redox Balance Modulation. *Antioxid Redox Signal*. 2016;24:795-812.

120 Liu Q, Gao Y, Ci X. Role of Nrf2 and its activators in respiratory diseases. *Oxid Med Cell Longev*. 2019;2019:7090534.

121 Zhao H, Eguchi S, Alam A, Ma D. The role of nuclear factor-erythroid 2 related factor 2 (Nrf-2) in the protection against lung injury. *Am J Physiol Lung Cell Mol Physiol*. 2017;312:L155-L162.

122 Keleku-Lukwete N, Suzuki M, Yamamoto M. an overview of the advantages of KEAP1-NRF2 system activation during inflammatory disease treatment. *Antioxid Redox Signal*. 2018;29:1746-1755.

123 Mitchell F. Vitamin-D and COVID-19: do deficient risk a poorer outcome? *Lancet Diabetes Endocrinol*. 2020;8:570.

124 Hati S, Bhattacharyya S. Impact of thiol-disulfide balance on the binding of Covid-19 spike protein with angiotensin-converting enzyme 2 Receptor. *ACS Omega*. 2020;5:16292-16298.

125 Tarvainen M, Fabritius M, Yang B. Determination of vitamin K composition of fermented food. *Food Chem*. 2019;275:515-522.

126 An SY, Lee MS, Jeon JY, et al. Beneficial effects of fresh and fermented kimchi in prediabetic individuals. *Ann Nutr Metab*. 2013;63:111-119.

127 Kim EK, An SY, Lee MS, et al. Fermented kimchi reduces body weight and improves metabolic parameters in overweight and obese patients. *Nutr Res*. 2011;31:436-443.

128 Kim SA, Joung H, Shin S. Dietary pattern, dietary total antioxidant capacity, and dyslipidemia in Korean adults. *Nutr J*. 2019;18:37.

129 Das G, Paramithiotis S, Sundaram Sivamaruthi B, et al. Traditional fermented foods with anti-aging effect: A concentric review. *Food Res Int*. 2020;134:109269.

130 Hong E, Kim GH. GC-MS Analysis of the Extracts from Korean Cabbage (Brassica campestris L. ssp. pekinensis) and Its Seed. *Prev Nutr Food Sci*. 2013;18:218-221.

131 Park CH, Yeo HJ, Park SY, Kim JK, Park SU. Comparative Phytochemical Analyses and Metabolic Profiling of Different Phenotypes of Chinese Cabbage (Brassica Rapa ssp. Pekinensis). *Foods*. 2019;8(11):587.

132 Raghuvanshi R, Grayson AG, Schena I, Amanze O, Suwintono K, Quinn RA. Microbial transformations of organically fermented foods. *Metabolites*. 2019;9(8):165.

133 O'Dea K. Westernization and non-insulin-dependent diabetes in Australian Aborigines. *Ethn Dis*. 1991;1:171-187.

134 Kopp W. How western diet and lifestyle drive the pandemic of obesity and civilization diseases. *Diabetes Metab Syndr Obes*. 2019;12:2221-2236.

135 Mirabelli M, Chiefari E, Arcidiacono B, et al. Mediterranean diet nutrients to turn the tide against insulin resistance and related diseases. *Nutrients*. 12(4):1066.

136 Martucci M, Ostan R, Biondi F, et al. Mediterranean diet and inflammaging within the hormesis paradigm. *Nutr Rev*. 2017;75:442-455.

137 Darwiche G, Hoglund P, Roth B, et al. An Okinawan-based Nordic diet improves anthropometry, metabolic control, and health-related quality of life in Scandinavian patients with type 2 diabetes: a pilot trial. *Food Nutr Res*. 2016;60:32594.

138 Van Belle S, Affun-Adegbulu C, Soors W, et al. COVID-19 and informal settlements: an urgent call to rethink urban governance. *Int J Equity Health*. 2020;19:81.

139 Correa-Agudelo E, Mersha T, Hernandez A, Branscum AJ, MacKinnon NJ, Cuadros DF. Identification of Vulnerable Populations and Areas at Higher Risk of COVID-19 Related Mortality in the U.S. *medRxiv*. 2020.

AQ17 ✔ 140 Abedi V, Olulana O, Avula V, et al. Racial, Economic and Health Inequality and COVID-19 Infection in the United States. *medRxiv*. 2020.

✔ 141 Mode NA, Evans MK, Zonderman AB. Race, Neighborhood Economic Status, Income Inequality and Mortality. *PLoS One*. 2016;11:e0154535.

✔ 142 Abuelgasim E, Saw LJ, Shirke M, Zeinah M, Harky A. COVID-19: Unique public health issues facing Black, Asian and minority ethnic communities. *Curr Probl Cardiol*. 2020;45:100621.

✔ 143 Lassale C, Gaye B, Hamer M, Gale CR, Batty GD. Ethnic disparities in hospitalisation for COVID-19 in England: The role of socioeconomic factors, mental health, and inflammatory and pro-inflammatory factors in a community-based cohort study. *Brain Behav Immun*. 2020;88:44-49.

AQ18 ✔ 144 Raisi-Estabragh Z, McCracken C, Bethell MS, et al. Greater risk of severe COVID-19 in Black, Asian and Minority Ethnic populations is not explained by cardiometabolic, socioeconomic or behavioural factors, or by 25(OH)-vitamin D status: study of 1326 cases from the UK Biobank. *J Public Health (Oxf)*. 2020.

✔ 145 Rubin D, Huang J, Fisher BT, et al. Association of Social Distancing, Population Density, and Temperature With the Instantaneous Reproduction Number of SARS-CoV-2 in Counties Across the United States. *JAMA Netw Open*. 2020;3:e2016099.

AQ19 ✔ 146 SARS-CoV2 seroprevalence study in Mumbai: NTI Asayog-BMC-TIFR study-First round report. Municipal Corporation of greater Mumbai, Public Realtion Department, 28-07-2020 2020. https://www.livemint.com/news/india/mumbai-sero-prevalence-of-57-found-in-slums-and-16-in-residential-societies-11595952896909.html

✔ 147 Pereira RJ, Nascimento G, Gratao LHA, Pimenta RS. The risk of COVID-19 transmission in favelas and slums in Brazil. *Public Health*. 2020;183:42-43.

✔ 148 Smith RE. The effects of dietary supplements that overactivate the Nrf2/ARE System. *Curr Med Chem*. 2020;27:2077-2094.

✔ 149 Textor J, van der Zander B, Gilthorpe MS, Liskiewicz M, Ellison GT. Robust causal inference using directed acyclic graphs: the R package 'dagitty'. *Int J Epidemiol*. 2016;45:1887-1894.

✔ 150 Haahtela T, von Hertzen L, Anto JM, et al. Helsinki by nature: The Nature Step to Respiratory Health. *Clin Transl Allergy*. 2019;9:57.

✔ 151 O'Callaghan C, Anto J. COVID-19: The Disease of the Anthropocene. *Env Res*. 2020;187:109683.

✔ 152 Vandana UK, Barlaskar NH, Gulzar ABM, et al. Linking gut microbiota with the human diseases. *Bioinformation*. 2020;16:196-208.

✔ 153 McCall LI, Callewaert C, Zhu Q, et al. Home chemical and microbial transitions across urbanization. *Nat Microbiol*. 2020;5:108-115.

AQ20 ✔ 154 Haahtela T, Anto J, Bousquet J. Slow health catastrophe of Homo urbanicus - loss of resilience. *Porto Med J*. 2020.

✔ 155 Haahtela T, Valovirta E, Bousquet J, Makela M. The Finnish Allergy Programme 2008–2018 works. *Eur Resp J*. 2017;49(6):2008-2018.

1 | Appendix

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