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Ancient Indian Diet – A Balanced Diet For the Healthy Diversity of Gut Microbiota and Management of Asthma

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Abstract

Modernization, a stressful lifestyle, attachment to a Western diet, and the use of preserved and processed foods lead to a loss of homeostasis of intestinal microbial diversity. The use of refined flour and refined sugar, which lack of micro biota-accessible carbohydrates (MAC), means dietary fiber high salt consumption, and saturated fats in fried and packaged foods cause gut microbiota dysbiosis. Microbial dysbiosis caused by high fat, salt, and lack of fiber causes several metabolic diseases, including asthma. The objective of the study is to develop a hypothetic model that “Ancient Indian diet” which is inspired by thousands of years of Indian science, including Yoga, Ayurveda, and Naturopathy may maintain the diversity of the gut microbiota and may inhibits the asthmatic symptoms by enhancing the growth of antiasthmatic bacteria. A keyword search utilizing the phrases "western diet, beneficial microbiota, asthma, gut microbial dysbiosis, Ancient Indian diet" was conducted electronically search through the SCOPUS ,Science Direct , PubMed, Web of Science, and PsycINFO databases. Search criteria are divided into two arms the first one includes different full-text research papers including how Indian diet altered gut microbial composition. The second one, we included the full text including how presence of certain gut microbiota can prevents the asthmatic attack. To find publications that met the eligibility requirements, the first and third authors separately reviewed each publication's title and abstract using the previously described inclusion criteria. We have included 124 research articles, which is published between 1989 to 2024. A plant-based ancient Indian diet increases the diversity of *Bacteroidetes, Actinobacteria, Prevotella, Bifidobacterium, Lactobacillus, Ruminococcus, Roseburia, Lactobacillus, Lachnospira, Akkermansia* and shows inhibitory effects against *Clostridium, E. coli, Staphylococcus, Haemophilus, Moraxella* and *Neisseria*.The ancient Indian diet a low-fat lacto-vegetarian diet maintains gut microbiota homeostasis,

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and suppresses the growth of pathogenic asthmatic bacteria and promotes the growth of beneficial asthmatic bacteria.

Introduction

In developed countries, allergies, and asthma have become more common in recent years.[1] Th2 cell activation by an allergen or an antigen is the first step in the development of asthma or allergy. Cytokines including IL-4, IL-5, and IL-13 are released by activated Th2 cells and are crucial mediators of asthmatic or allergic inflammation. Eosinophil infiltration, mast cell degranulation, and elevated IgE concentrations are the hallmarks of asthma.[2] Even while genetics have a major role in the development of asthma, western lifestyle modifications in food contribute to an increase in asthma symptoms. Symbiotic human gut microbiota is responsible for preserving homeostasis between various tissues.[3] The wide spectrum of the gut microbiota is influenced by several factors, and nutrition is crucial in preserving this diversity. Low microbiota-available carbohydrates (MACS) in the Western diet, which also reduces the fiber content, excessive sugar, fat, and cholesterol, lowers microbial diversity and may result in the extinction of bacterial species.[4] Dysbiosis is caused by the decline of microbial species. Inflammatory diseases like allergies and asthma can be brought on by the dysbiosis of the gut microbiota.[5]

Ayurveda, Naturopathy, and Yoga were the three primary components of the ancient Indian diet.[6] According to geography and season, Ayurveda outlined what to eat. It is linked to Indian culture through traditional food (*Sadya* is a typical dish in Kerala), festival food (*Mohan bhog Thali* in North India), food served in temples, and seasonal dishes (Badam ka halwa in North India during the winter season). To maintain the nutritious integrity of the food, Indian temples have kept an antiquated cooking technique (cooking in clay pots with ancient grains and lentils). The fundamental tenet of this tradition and ritual is the consumption of wholesome foods that are rich in all the nutrients and shield the body from illness. Naturopathy is a different type of therapy, though, and it places a strong emphasis on eating foods that are fresh, preservative-free, in season, and green. A healthy person should eat a variety of cooked and raw foods, according to naturopathy.[7] Indian cuisine places a strong emphasis on eating foods raw or uncooked, such as Kusumbari, a dish from Karnataka made of raw vegetables and raw lentils. Naturopathic ideas hold that "food is medicine" and recommend leaving one-fourth of the stomach empty, as advised by yoga. A rigorous yogic diet (no-spice, vegetarian, low-fat diet) for the Satvic guna promotes clarity and tranquillity while being beneficial to the body. Water, some spices, grains, vegetables, legumes, fruits, nuts, fresh milk, and its derivatives (ghee, butter, cream, cheese, and yogurt), as well as unpasteurized and homogenized fresh milk, are examples of such meals8. In this review, we propose that the traditional vegetarian, high-fiber diet of ancient India may enhance gut microbial diversity and lessen asthma symptoms. The aim of this review is to explore the potential of the ancient Indian diet in enhancing gut microbial diversity and increasing the population of beneficial probiotic bacteria, with the potential to alleviate symptoms of asthma.

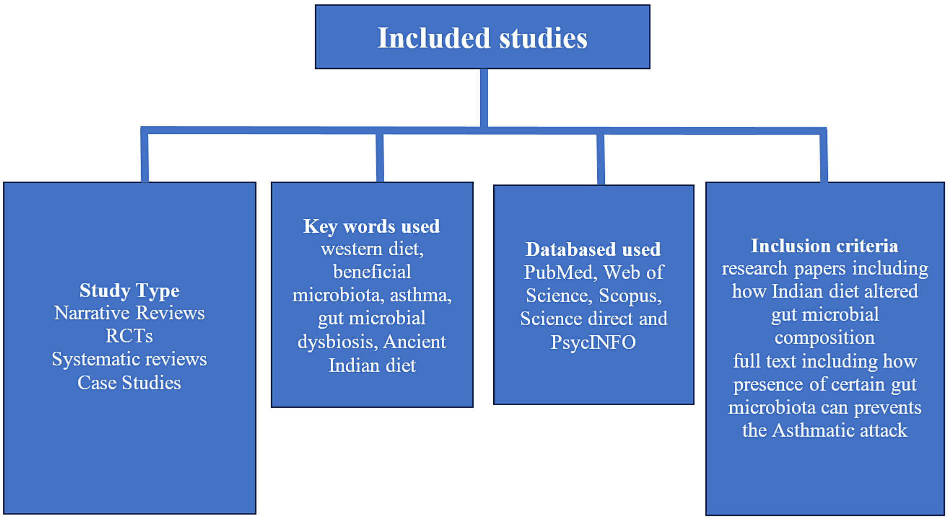
Materials and Methods

Search Process

A keyword search utilizing the phrases "western diet, beneficial microbiota, asthma, gut microbial dysbiosis, Ancient Indian diet" was conducted electronically through the SCOPUS ,Science Direct PubMed, Web of Science, and PsycINFO databases. Books are also included in the PsycINFO database, which was We included in this narrative review are the RCTS, Systematic reviews, case studies and review article that look at how ancient Indian diet consumption maintain the gut microbial diversity, which may prevent gut microbial dysbiosis. preemptively removed from the search.

Inclusion Criteria

Search criteria are divided into two arms the first one includes different full-text research papers including how Indian di*et al*tered gut microbial composition. The second one, we included the full text including how presence of certain gut microbiota can prevents the Asthmatic attack. No limitation was set with regard to study participants as to the effect of Ancient Indian on gut microbiota.



Study Selection

To find publications that met the eligibility requirements, the first and second authors separately reviewed each publication's title and abstract using the previously described inclusion criteria. We have included 124 research articles, which is published between 1989 to 2024.

Western Diet and Asthma

Soft drinks, fried foods, and fast food are all heavy in trans fats, sugar, and salt, and Western diets tend to be low in antioxidants and high in pro-inflammatory foods (omega-6 fatty acids).[9] Omega-6 fatty acids obtained through fast food and junk food are converted to arachidonic acid, arachidonic acid acts as a precursor molecule for leukotrienes and prostaglandins (inflammatory mediators).[10] Antioxidants are lacking when fruits and vegetables aren't consumed frequently. Antioxidants typically neutralize reactive oxygen species (ROS), and antioxidant deprivation causes NF-kB factors to become activated. The Western diet is dominated by highly processed foods, highly refined carbohydrates, high fats, especially high saturated fat, highly processed food and preservatives. According to one study a large increase in the consumption of animal fats ,vegetable oils ,sugar and sweeteners is associated with the development of asthma.[11] In patients with asthma, eating a high-fat mixed meal has been demonstrated to raise sputum and neutrophil levels four hours after the meal.[12] Higher fat and lower fiber intake have been linked to increased eosinophilic airway inflammation in persons with severe asthma.[13] A high fat diet activates several genes involved in immune system functions in sputum, including TLR 4, which suggests increased inflammation of the airways.[14] Many studies have shown that high salt intake causes all types of asthma. Moreover, a study suggested that low salt intake improves lung function in allergic and exercise-induced asthma.[15] According to one study, eating a lot of ultra processed food was positively correlated with wheezing and asthma among teenage Brazilians.[16] Another study discovered that eating more than four servings of processed meat per week, as opposed to fewer than one, is linked to worsening symptoms of asthma.[17]

Western Diet and the Diversity of Gut Microbiota

The development of allergic disease depends on homeostasis between epithelial cells, regulatory T cells, and the gut microbiome.[18] The Western diet is a rich source of simple sugars and fats, increases intracellular prooxidants, and causes changes in the diversity and function of the intestinal microbiota.[9] 19 Changes in the diversity and composition of the microbiota are known as dysbiosis. Lack of fiber in the Western diet reduces the intestinal microbiota population, leads to impaired short-chain fatty acids (SCFA) synthesis, and increases the inflammatory state, leading to chronic metabolic disease. Decreased absorption of SCFA increases the concentration of bicarbonate ions in the large intestine. A higher concentration of bicarbonate ion promotes the increase of pH. A high pH Favors the growth of pathogenic bacteria, while a low pH

(5.5) in the ileum and cecum inhibits the growth of pathogenic bacteria (Firmicutes phylum). In mice given a high-fat diet for 12 weeks, there are increases in Rikenellaceae and decreases in Ruminococcacea.[20] There were significantly fewer rats in the high-fat diet group than in the normal diet group that had virrucomicrobia, a form of bacteria that is common in the mucosa and which will decrease in high-fat diets, obesity, and other disorders.[21] Significant microbial changes, increased susceptibility to microbial stimulation in blood and bone marrow-derived monocytes, and a lack of ileal defense were all brought on by a high-sucrose meal that was ingested for a short time. These findings suggest that even in the presence of a high-sugar diet, there is potential for rapid and significant changes in gut microbial composition and systemic immune response.[22]

Clostridium is a pathogenic bacterium belonging to the genus Firmicutes that causes excessive inflammation and increases the number of pathogenic immune cells leading to asthma.[23] The abundance of the genera Lachnospira, Veillonella and Faecalibacterium (phylum Firmicutes) increases the risk of asthma during the first 100 days of life.[24] If the pH value of the large intestine is increased, butyrate-producing bacteria (Faecalibacterium, Roseburia, and Eubacterium phylum) decrease and the population of acetate- and propionate-producing bacteria (Bacteroidetes phylum) increases. High pH also Favors the growth of harmful microorganisms (inflammatory endotoxin from lipopolysaccharide producers) and oxygen-resistant microorganisms that damage the intestinal epithelial lining.[25] Higher populations of Haemophilus and Moraxella are associated with severe airway obstruction and airway neutrophilia.[26] *Staphylococcus* contains various endotoxin-like proteases, such as SPLS, which binds to protease-activated receptors on epithelial cells and stimulate secretion of the cytokine-like IL-33 and TSLP, which induces Th2 cell activation leading to asthma.[27] People on a long-term western diet (rich in animal protein, the nutrient choline and saturated fat) have a high diversity of Bacteroides bacteria and a low concentration of Prevotella.[28] However, refined carbohydrates (bran and non-fibrous grains) are consumed in the Western world, including bread, white pasta, starch, sucrose and fructose syrup. High sugar intake increases the population of Enterobacteriaceae and reduces Lactobacilli associated with both intestinal and brain inflammation in rodents.[29]

Concept of Ancient Indian Balanced Diet

The Indian diet shows its uniqueness due to its diversity, history, geography, immigrants, and complexity. The country's diversity has not only shaped its social and political status in today's world, but it has also influenced food culture across the continent. The beauty of traditional Indian food is not only that it is versatile, but also has great nutritional value.[30] From North India to South India, the tradition of combining grains and legumes provides all the essential amino acids and other macro and micronutrients. Typically, an Indian would eat Khichidi (rice, lentils, vegetables, and ghee), Dalia (crushed wheat, vegetables, and ghee), Dosa (rice, lentils, and butter or ghee), Idly (rice and lentils), and Samber (lentils, vegetables, oil, tamarind with spices), as well as chutney (typically peanut chutney, pudina (peppermint leaf) , Upma (crushed whole grains with vegetables and Hindi), Khij (finger millet khichdi), Roti with ghee (Bajara roti, Makka ki roti), North Indian thali (Dal, Roti, vegetable curries, ghee or curd), South Indian thali (Rice, Samber, Rasam, vegetable curry, ghee), Rajama chawal (broad grain rice), Kadi chawal (curd, gramme flour, and spices), chole bature (wheat flour and horse gram). According to Indian custom, a meal made out of grains, lentils, vegetables, fruits, spices, nuts, oil, milk, and buttermilk with ghee or butter makes the food more compact. Indian cuisine is a type of balanced diet that includes every essential nutrient, and this diet is currently acknowledged as a lacto-vegetarian diet.[31] It includes all of the macronutrients (carbohydrates, proteins, and fats), fiber, MUFA, PUFA, antioxidants (vitamins C, E, A, and K), and prevents inflammation.[32] Green leaves of the plant are a rich source of phytochemicals, fibres, and minerals with great anti-inflammatory and antibacterial effects, coupled with edible flowers.[33]

Every meal should balance the six primary tastes (sweet, salty, sour, bitter, pungent, and astringent), according to Ayurveda.[34] Starting with the meal from Kerala, Sadya, it has each of the six flavors.[35] Every traditional Indian dish, not just those from Kerala, is rich in all flavours and provides a balanced combination of carbs, proteins, fats, vitamins, minerals, and phytochemicals.

Table 1 : ncient Indian diet in the form of balanced diet enhances microbial diversity and has a great antimicrobial effects

Sl. No.	Food materials		Traditional Indian cuisine	Soluble carb	Dietary fibres	Pro tein	Fat	Vitamins	Minerals hemicals	Phytoc	Effect on gut microbial diversity and Pathogenic bacteria increases	Reference
1.	Cereal	Whole Wheat	Roti, Upama (Broken Wheat, Vegetable, Ghee), Dalia, Paratha	72%	10.70%	13.2%	2%	Vitamin B1	Ca, Fe	Erulic acid, Phen -olics, Flavonoids, Zeaxanthin, Lutein, Cryptoxanthin	Dietary fibre increases of *Bifido bacterium* spp and *Lactobacillus* spp	36
2.		Rice (white), Brown (wild variety), Black (northeast states of India)	Plain rice, Khichidi (rice, dal, Vegetables, spices andghee), Dosa, Idly, Coconut rice, Pongal (rice, dal, coconut, Ghee spices),Edipum, Apam (rice and Coconut), Ada (with coconut)	77.20%	3.50%	8%	4%	Vitamin B1	Ca, Fe	Flanes and gama-Oryzanols' in white and brown rice. Black rice has diverse phytoc -hemicals	Rice bran increase the *Lachnospiraceae* and *Ruminococcaceae* and decrease the *Salmonella* typhi	37,38
3.		Bajara (Pearl millets)	Bajara ki Roti , Khej (Bajara ki kichidi), Rabidi (bajara flour along with buttermilk)	73%	3.30%	10.8%	5% hav -ing PUFA	A, B1	Ca, Fe	Phenolic acids, Flavonoids and carotenoids	Fermented millet with a mixture of *Lactobacilli* , L. *pentosus*	39
4.		Ragi (Finger millets)	Ragi muda , Ragi dosa , Ragi milk shake	72%	3.60%	7.3%	1.5%	B1B2, Niacin	Ca, Fe, Zn	Tannin, Flavonoids, Alkaloids, Saponin, terpenoid and steroids	Increase of *Lactobacillus, Bifidobacterium, Roseburia*	40
5.		Sorghum (Jwar)	Jwar khichidi, Jwar roti, Rabdi (jwar flour along with butter milk), Jowar kanji	77.50%	6.6%	7.9%	2%	A, B1	Ca, Fe	Tannins, phenolic acids anthocyanins, phytosterols	Increase of*Akkermansia, Bifidobacterium,*Decr-ease of *Paraba-cteroides*	41
6.		Amaran -thus (Rajgira)	Amaranth dal, Rajgira ladoo, Rajigira Theplas	65.33%	6.7%	13.6%	2%	Vitamin C	Zn, Ca, Fe	Phenolics, Flavon -oids, Alkaloids, Saponins	Amaranthus protein decreases the *Helicobacter* and improved Microbial profile of the	42

											Prevotellaceae	
7.	Pulses	Chick pea (Chana)	Chole(Chick pea curry), Dhokla (Rice and Chick Flour along with spices), Paisum (chana dal, Jagry along with Coconut)	61.2%	10%	17%	5%	A, B1, E, C, B9	Ca, Fe, Mg, K	Saponins, Phytic acid, Lectins, Bioactive peptides sterols	Resistant starch of Chick pea increases Bifidobacte rium, *Lactobacillus,* Eubacterium and decreases Clostridium and Bacteroides	43
8.		Green gram (Mung Dal)	Dal, Dhokla, Mung dal Halwa, Mung dal Barfi, Khichidi, Mung dal paisum (Mung dal, jagry and coconut)	54%	16%	24%	1.3%	A, B1, B1nia cin	Ca, Fe, Zn, Mg	Phenol, Flavonoids, Alkaloid, Saponin	Protein of Mung dal increases *Bacteroidetes* and decreases Firmicutes	44
9.		Green pea	Green pea curry	56%	11%	20%	1.1%	B1, C	Ca, Fe, Zn	Carotenoids, Phenolic compound, Flavonoids	*Bifidobacterium* and *Lactobacillus* species were increased and decreased C. perfingens and Bacteroides fragilis	45
10.	Oil seeds	Coconut	Virgin form of Coco -nut oil Mostly used as cooking oil in Southern part of India. Costal belt of India both eastern as well western part of India used coconut to make some sweat dishes like, Nariel ki ladoo, Madak, Manda pitha, Puli pitha, Coconut milk is taditionallly used in many south Indian recepies	15%	9%	3%	34% 86% of satu rated fatty acid (medium chain) 12% unsatu rated fatty ac -id and 2%PU -FA	A,E	Co, Se, Mg, P, Fe, K	Phenol, Tanin, Flavonoids, Triterpenes, Steroids and Alkaloids	Coconut oil is increases abundance of Lactoba -cillus, Allobaculum and *Bifidobacterium* species	46
11.		Ground -nut seed	Northern and Middle part of India used ground nut as a	20.3%	2%	26%	49% 18% satur	E	Fe, Zn, K, Mg	Phenolic acids, Flavonoids, Tan -nins, Phytates	Resveratrol increases *Bacteroides,* Parabacte roides and decreases	47

		cooking oil for making curries, and for Frying. Apart from that from ground nut Ckiki can be made.				-ated fatty acid, 46%un satura ted fatty acids, 36% of PUFA				Lachnospiraceae and *Akkermansia*	
12.	Sesame seed	Sesame oil mainly extracted from Ses -ame seeds used in Southern and Westen part of India. From sesame some of the seasonal sweats like Til ki ladoo, Gajak, Tilkut, Til papdi can be made by Indians.	9%	4%	17%	48% 13% of satu -rated fatty acids, 50% of MUFA and 37% PUFA	A,C	Ca, Fe, K	Lignan, Glycosides	The sesame peptides enhance the intestinal diversity of Lactobacilli and decrease the *E. coli*	48
13.	Sunflower	Sunflower oil mainly traditionally Not used by the Indians But In early eighteen century it is introduced as a cooking oil in India	11%	9%	21%	51% 12% of saturate, 24 % of MU -FA and 64% of PUFA rich in omega -3-fatty acids	C,B6	Fe,Mg	Flavonoids, Phe -nolic acids	Omega -3-fatty acid s increases *Bifidobacterium* and *Akkermansia* . Omega 3 fatty acid decrease the *Firmicutes* and *Bacteroidetes* ratio	49,50
14.	Butter	Butter can be used for making Dosa, Paratha some tradi- tional Indian dishes like Panner butter masala	-	-	-	75% of Satur ated (small chain	A, D, E, K, B12	Se	-	High butter influences the increase of Desulfovibrionaceae	51

							fatty acid), 20% of MUFA and 5% PUFA					
15.		Ghee	In sated of oil most of the Indian used Ghee as cooking item to make khichidi, Upama, Ponga l, Laddo, Halwa, Paratha		--		80% of sat urated fatty acid (medi um cha in fatty acid s), 15% monou -nsatu- rated fatty acids and 5% of PU FA.	A, D, K	-	-	Ghee prompted the growth of *Lactobacillus, Bacteroidetes*, Ruminococcaceae, *Bifidobacterium* suppressed Firmicutes and *proteobacteria*	52,53
16.	Preb iotics	Curd	Raita, Dahi bangan (curd with Egg plant)	1%	-	22%	6%	C, D, B6,	Calcium, Magnesiu, Iron,	-	Increases *Lactobacillus* bacteria and suppress the normal growth of *E.coli*, *Bacillus* and Staphylococ -cus aureus	54
17.		Milk	Haldi dudh, Kesar badam Dudh, Badam Milk	2%	-	3,4%	3.3%	A and B12	Na, K, Ca, Zn	-	Casein increases the communities of Lactobacilli and Bifido -bacterium and dec- ease the count of Staphylococci, and streptococci	55,56
18.	Nuts	Almonds	Badam ki halwa, Badam milk, Polao	22%	11%	21%	50%	A, D, E, K	Copper	Flavonoids, Plant srerols, Phenolic	Almond increases Clostridium,	57

										acids	Roseburia, Dialister, Lachnospira and decreases the Oscillospira, Parabacte-roides, Allistipes, Butyrici-monas, *Bifidobacterium*	
19.		Walnuts	Walnuts ki ladoo, Kheer, Dry fruit gajak	8%	1.90%	9%	83%	A, D, E, K, B6	Mg, P, Cu	Anthocyanins	Walnuts increases the diversity of Faecalibacte-rium, Clostridium, Rose -buria, Dialister, Coprococcus, *Bifidobacterium* and decreases Oscillospira, *Ruminococcus*	58
20.	Spices	Garlic (Lehes un)	Garlic mostly used in Indian curry as a spices and some time as Lehesun chatney or Lehsun Achar	-	0.19%	0.50%	-	B6, C	Mn, Se	Gamma-glutamy l-s-alk(en)yl-L-Cysteines, S-alk (en)yl-L-cysteine sulfoxides	Garlic fructan (GF) increases Lachnospirace -ae, *Bifidobacterium* and decrease the *E.coli* coli, Salmonela typhiand Neisseria gonorrhoeae	53
21.		Ginger (Adrak)	Ginger also used a Spicing agent for indian curry. apart from that can be used a adrak achar, Adrak chai (Tea along with ginger)	6%	8%	--	-	C, B1,B2, Niacin	Ca, Mg, Na, P, Mn, Fe, Z	Gingerols, Shoga -ols and Paradols	Ginger supplement can increase SCFA producing species like Allobaculum and *Bifidobacterium* and decrease the Clostridia	59
22.		Black papper	Spicing agent	1%	1%	-	-	A, B1, B2, B5, B6	Manga -nese	Tannins, Flavonoids and Carotenoids	Black papper shows anti-microbial activity against *B.Megaterium, B. Sphaer-icum*, *B.polymyxa, S.aureus* and *E.coli*	60
23.		Curcumin	Curcumin as spicing colour agent for Indian curry. In some part of India, they consume haldi bala Dud (Milk along with Curcumin) and Haldi ki sabji.	6.50%	2.10%	1%	0.30%	Vitamin C, B6		Manganes, Fe, K	Curcuminoids is a polyp -henol Iincreases Prevotel -laceae, Bacteroidaceae and Rickenellaceae	61–63

24.		Cinnamon	Cinnamon is a Spi cing agent and can be used for making masala chai.	2.10%	-	-	-	Vitamin A	Ca, Fe, Mg, PP, K	Cinnamaldehyde and trance – cinnamaldehyde	Cinnamon has inhibitory effect on opportunistic pathogenic bacteria includ -ing Streptococcus, Staphyl -ococcus, Enterococus and Pseudomonas	64,65
25.		Cumin	Spicing agent	-	-	-	-	Vitamin C	Calcium, Iron, Mag -nesium	Monoterpenes bet –pinene, P-cymene -ene and gamma-terpin and terpeno -ids aldehydes	Reduction of *Clostridium*	66
26.	Ancient Indian Fruit	Jamun	Whole	-	-	-	-	Vitamin C, B6	Ca, Fe, P, K, Mn	Raffinose, citric acids, Gallic acid, Malic acid, Antho-cyanin, Delphinidin	Jamun fruit restors the ratio of Firmicutes to *Bacteroidetes*	67,68
27.		Guava	Whole, Guava juice	4%	20%		-	A, C, Folic acid	K, Cu, Mn, P	Carotinoids and polyphenol	Guava polysaccharide treatment restored the *Firmicutes/Bacteroidetes* ratio and decrease the bacterium Mucispirillum	69
28.		Bael (stone apple) (Aegle Marmelos)	Bel muraba, Bael shabat, Bela pana (banana, coconut , cottage chese)	31.80%	2.90%	1.80%	0.70%	Vitamin C	K	Mararmelosin, Marmesin, Marmin, Xanthotoxol, Scopoletin, Umbelliferon	Inhibits the growth of *Listeria monocytogenes, S.typhi, S.aureus, Candida albicans, Aspergillus* and *Aspergillus niger*	70
29.		Grape fruit	Whole	3%	6%	1%	-	C, K, Folic acid	Fe, Ca, Zn, Cu	Beta carotein, Lycopene, Phen -olic acid D-glucaric acid flavonoids	Increase of *Bacteroides, Parabacteroides, Olsenella, Firmicutes, Proteobacteria* & *Bifidobacteria* and decrease of *Bacteroidetes*	71
30.		Jack fruit	Raw jackfruit consu-med by the Indian throughout the country some recipies like kathal ki sabji, panasa katha bara, Chakka puzhukku, Chakka	9.4-11.5%	2.6-3.6%	2-2.6%	0.1-0.6%	Vitamin A, Thia -mine, Vitamin C, Rib of lavin	Ca, Mg, P, K, Fe	Carotenoids, Flavonoids, Volatile acids, Tannins,	Resveratrol is a type of polyphenol increase the *Bacteroidetes*, Blautia, *Ruminococcus* and *Parabacteroides*.	72,73

			paysam Rice jackfruit can be consumed as a whole									
31.		Mango	Raw mango can be used as a keri chutney, Raw mango dal,Green mango kadi, Minty raw chutney, Raw mango coconut chutney Ripe Mango can be used as a mango juice, Manbazha pulissery(mango along with Curd)	15%	2%	1%	0.5%	Vitamin C, E, Niacin, Panthot -henic acid, Pyri -doxine,	Mg, Na, Co, Fe, Mn, Beta carotene	Gallic acid and gallonyl –derived polyphenols, gallotannins	Increase growth of *Bifidobacterium, Lactob -acillus, Faecalibacterium, Roseburia, Prevotela* Decrease *Clostridium leptum*	74,75
32.	Tub ers	Tapioca	Kappa Puzhukku (boiled spiced Tapioca)	22%	-	2%	3.9%	Vitamin C, B6	Fe, Mg	Alkaloids, Flavon-oids, Tannins, Anthraquinone	Tapioca enriched the family *Porphyromanadaceae*, *Faecalibacterium* and *Eiserbargiella*	76
33.		Colocasia (Arbi)	Arbi sabji, Colocasia stem sauté, Colocasia stem kayirasa	-	9%	11%	-	C,B1, Niacin, B6	Fe, Ca, Na, Mg, P, Z, Cu, K,	Beta carotene, Mucilage, Oxalic acid	Shifts of *Bacteriodes*	77
34.	Indian vege-tables	Indian Cabbage	Pata kobi ki sabji	6.3%	2.5%	2%	.1%	Vitamin A, B1, C,	Ca, Fe, Mg, K	Phenolics, Carotenoids, Glucosinolates	*Roseburia intestinalis, Faecalibacterium, Eubacterium rectale*	78
35.		Carrot	Mixed vegetable curry, Gajar ki halwa	10.7%	2.8%	.9%	.2%	Vitamin A, B1, K, B6,	Ca, Fe, Biotin, K	Phenolics, Carot-enoids, Polyacet -ylenes and Ascor -bic acid	Increase the growth of *Bifidobacterium bifidum*	79
36.		Egg plant	Bangan Barta (meshed steamed Egg pant), Egg plant curry, Bagun baja (Egg plant fry)	6.4%	3.5%	1.3%	0.3%	A, B1, C, K, B6, Folic acid	Ca, Fe, Mn, P, Cu, K	Anthocyanin, Phenols, Glycoa-kaloids and Amide protein	Phenols of egg plant can Increases the abundance of *Bifidobacteria*ceae and *Lactobacillales*	80
37.		Pumpkins	Dalma (Dal with vege -tables), Kadu ki sabji, Aviyal (mixture of veg -etable along with	10.3%	7%	1.4%	.1%	Vitamin A, B1, B2, C, E	Ca, Fe, Mn, K	Carotenoids, Delta-7-sterols	Increases *Bacteroidetes*, Prevotella, Delta *proteo -bacteria*, Oscillospira and *Bilophila*	81

		curd), Olan (pumpkins, nuts and curd), Kadu ka Halwa (with ghee)									
38.	Radish	Muli ki sabji, Muli ka paratha,Ghanta, Supata (Mix vegetable curry)	6.2%	1.6%	0.6%	0.3%	Vitamin A, B1, C, Niacin, B6	Ca, Fe, K	Flavonoids, Terpenes	Increase the growth of *Bifidobacterium longum*	79
39.	Bottle guard	Loki ki sabji, Loki ki Halwa, Lau pitha (Bottle guard along with Rice and coco-nuts)	-	2%	-	1%	C, Ribof -lavin, Thiamine	Fe, Zn Mn, Mg	Terpenoids, Flavonoids	Flavonoids improves the diversity of gut microbiota	82
40.	Ash guard	Petha, Olan (Ash -guard along with nuts and curd), Kakharu Rai (Asgguard along with mustard paste)	-	3.3%	0.4%	0.1%	B1	Ca,Fe	Flavonoids, Polyphenolics	Increase the growth of *Bifidobacteriumlongum, B.adolescentis, B.bifidum*	79
41.	Raw banana	Banana fry, Banana sabji, Kaalan (curd and raw banana),Vaz -akai poriyal (Coconut and Raw banana), Raw banana Bharta	22%	2.6%	1%	0.3%	C, B1, B2, B3, B5, B6, A folic acid	Ca, K, Fe, Na, Mg, P, Zn, Se, Cu	Flavonoids, Sapo -nins,Glycosides	Flavonoids improves the diversity of gut microbiota	82
42.	Banana stem	Manja rai (Banana stem with Mustard paste) Vazhappindi parippu curry (dal, banana stem)	-	27%	5%	11%	Niacin, Ribofl-avin, Tha -imin	K, Ca, P, Mg, Na, Fe	Tannin, Carotene	Antimicrobial effect	83
43.	Bamboo shoot	Bamboo shoot usually consume in North eas-tern part of India, Eastern India and Karnataka state. Bamboo shoot curry, Coorg style Bamboo curry, Bamboo pickle, Bausa gaja bhaja		2.20%			Folic acid and Niacin	-	-	High fiber content increase the diversity of gut microbiota. A significant increase of *Bacteroidetes*.	84

44.	Lea-ves /Saag	Sahjan ka Saag (Drum-stick leaf)	Sahjan ka saag, Sambar, Sajana saga boiutalu Bhaja (drumstick leaf along with Pumpkins)	-	13%	6.7%	1.7%	Vitamin A, B, C	Ca, Fe	Alkaloids, Pro-tein, Quinine, Saponins, Flavonoids, Tannin	Increase the level of *Bifidobacterium* and reduces leakiness in the gut	85
45.		Spinach (palak)	Dal palak (along with pulses), Palak panner (along with cottage cheese)	1%	8%	2.9%	0.4%	C, B6, Folic acid,D	Ca, Fec-obalamin, Mg	Carotenoids, B-carotene, Lutein, Zeaxanthin	Increase of *Akkermansia* and decrease of *Lacto-bacillus*	86,87
46.		Amranth leaf (cha-ulai saag)	Sambar, Saag	5.7%	-	4.9%	.5%	A, E, C and folic acid	Iron	B cyanins, Phenol-ics, Betalains, Flavonoids	Shows antibacterial effects against *E. coli*, S.*typhi,* K. pneumoniae and P. aeruginosa	88
47.		Kalmi saag (Water spinach)	Saag (leafs and spices)	1%	2.1%	2.6%	0	A, B1, B2, B6, B12, C, E, K	Ca, Fe	-	Vitamin B12 of spinach promotes the growth of *Proteobacteria* and reduces *Escherichia, Shigella* and *Klebsiella*	86,89
48.		Bathua ka Saag	Saag, besara (Along with Mustard Paste)	7%	4%	4.2%	0.8%	Vitamin A, C, B6	Potassi-um, Zinc, Phospho-ru,Calcium	Alkaloids, Sapo-nins, Nananoic acid	Antibacterial activity against *Staphylococcus aurus, Bacillus, E coli*	90
49.		(colocasia leaf) Arbi saag	Arbi pate ki sabji (along with Black grams)	-	5.1%	1%	-	Vitamin C, Thia-min, Ribo-flavin, Niacin	Ca,P,	Oxalic acid, Sapotoxin, Flavones	Flavones and Flavonoids can inhibit the pathogenic bacteria and increasing beneficial genera such as *Bifidobacterium* and *Lactobacilus.*	91
50.		Gongura leaf	Pickle and Chutney	9.2%	1.6%	3%	3%	A, B1, B2, B9, C	Ca, Mg	Polyphenol, Flavonoids, Tannins	Shows antibacterial activity of *S. aureus, Bacillus stearothermophilus, Micrococcus luteus, Serratia mariescens. Clostridium sporogenes, E.Coli, K Pneumo-niae, Bacillus cereus and P. fluorescence*	92
51.		Meethi	Alu methi (along with	-	Rich in	-	-	Niacin,	Mg	Alaloids,	Dietary fibres increase	93,94

		saag (Fenug -reek leaf)	potato), Methi ki paratha		fiber			A, B1, B2, C		Saponins, Polyphenols, Flavonoids	the diversity of *Bifido -bacterium* and *Ruminococcus*	
52.	Edible flower	Saffron	Kesar dudha, Indian curries, Kesar pista peda	-	-	-	-	-	-	Safranal, Crocin, Crocetin and Picrocin	Phytochemicals of saffron increases *Akkermansia -ceae*, *Christensenellcea*	95
53.		Agasti flower (Sesbania Grandi-flora)	Agasti phula bhaja (Fried with Rice flour /Gram Flour along with spices)	-	-	-	-	Folic acid, Thaimin, Niacin, Vitamin C, A	-	Alkaloids, Flavo -noids, Glycosides, Tannin, Antraqui -none,Steroid	Shows antimicrobial activities against *S. aureus* and promote the probiotic bacteria *Lactobacillus*	96
54.		Pumpkin flower (Cucurbita maxima)	Kakharu phula Bhaja (Fried with Rice flour/ Gram Flour along with spices)	-	-	-	Oleic acid, Myristic acids, Fatty acids and steric acid	-	Na, K,. Ca	Phenol, Flavo -noids, Anthoc -yanin	Antimicrobial activity against S. *typhi, E.coli*, *E. faecalis, B.cereus*, *C.lunata* and *C.albicans*	97
55.		Banana flower	Bhanda patua (banana flower with mustard paste), Banana flower Sabji	-	50%	2%	0.4%	E	K, Ca, Mg, P	Alkaloid, Saponin, Favomoids	Shows antibacterial activity against *S. aureus* and *E. coli*	98
56.		White Kanchan flower (Bauhinia)	Kanchan Phula bhaja (Fried with Rice flour/ Gram Flour along with spices)	-	-	-	-	-	-	Citric acid, Tannins, Flavonoids	Show antibacterial activities against *B.Subtitus, S. aureaus, S. epidermis, E.coli, S. flexineria, P. auriginosa*	99
57.		Neem flower	Nimba phula bhaja, Nimba phula bara	-	-		3%	-	Ca, Mg, Fe	-	Antioxidant effect	100

Result

Discussion

The body receives all the macro and micronutrients from the traditional Indian practise of eating dishes with all the flavours (sweet, sour, bitter, salty, and spicy) in one meal. It is not a part of Indian cuisine culture to eat canned food, processed food, or fried food. Fresh, thoroughly cooked, and balanced food is required. The Indian diet is full of anti-inflammatory and antioxidant foods that protect the body's symbiotic microbial variety and prevent the growth of harmful microbes.[101]

Dietary fibres and prebiotics: Grains, fruits, vegetables, legumes, leaves, edible flowers and nuts are all sources of fibre. Consuming greater amounts of fibre promotes the growth of *Bifidobacterium* and *Lactobacillus* species. Resistant starch and whole grain barley can also increase the number of lactic acid bacteria, including *Ruminococcus, Eubacterium rectste* and *Roseburia*. *Bifidobacterium* and Lactobacilli play a protective role against pathogenic bacteria and maintain intestinal permeability.[36,102] Dietary fiber acts as a substrate for intestinal bacterial metabolism and SCFAs as an end product of metabolism.[103] The main SCFAs are acetate and propionate (used as substrates for metabolism of lipids, glucose and cholesterol) and butyrate (which plays a key role in immunoregulation and maintenance of tissue barrier function), which act as energy substrates for intestinal epithelial cells.[104] Curd is rich in *Lactobacillus* bacteria. Bioactive compounds such as hydrogen peroxide and reuterin produced by *Lactobacillus bacteria* inhibit the growth of pathogenic bacteria, especially *E. coli, Bacillus* and *Staphylococcus aureus*.[54]

Phytochemicals: In contrary, Phytochemicals are noncaloric plant compounds found in grains, legumes, fruits, vegetables, nuts, and spices.[105] Phytochemicals include polyphenols and derivatives, carotenoids and thiol sulfides, mainly anti-inflammatory, antibiotic and antioxidant. Polyphenols are the most versatile phytochemicals, which are mainly divided into four different types. Flavonoids, phenolic acids, stibenoids (resveratrol), lignans.[106,107] Fruits such as grapes, blueberries, sweet soap, mango and citrus fruits, vegetables, herbs, microalgae, herbs, seeds, grains are good sources of polyphenols.[104] Polyphenols have been shown to increase the number of *Bifidobacterium* and *Lactobacillus* species. The reduction of pathogenic Clostridium perfringi and Clostridium histolyticum is probably due to the consumption of polyphenols.[45] Ingestion of mango peel and pulp increases *Lactobacillus*, *Bifidobacterium*, *Akkermansia, Faecalibacterium* and decreases Clostridium leptum.[74] Curcumin is a good source of polyphenols, which significantly increases the number of *Prevotellaceae, Bacteroidaceae* and *Rickenellaceae bacteria* (Shen *et al*., 2017). The addition of garlic to the diet increases the number of Lachnospiraceae and Allobaculum and has a bactericidal effect on some bacterial species, including *Escherichia coli, Salmonella typhimurium* and *Neisseria gonorrhoeae*.[52,53,73]

Essential oil of cinnamon inhibits opportunistic pathogenic bacteria including *Streptococcus, Staphylococcus, Enterococcus* and *Pseudomonas aeruginosa*.[64] The polyphenol in the ginger supplement was able to increase SCFA production by increasing the abundance of SCFA-producing species such as *Allobaculum* and *Bifidobacterium* and reducing Clostridia.[59] Almond phytochemicals increase *Clostridium, Roseburia, Lachnospira decrease Oscillospira, Parabacteroides, Allistipes, Butyricimonas, Bifidobacterium*.[57] Phytochemicals in walnuts increase the diversity of *Faecalibacterium, Clostridium, Roseburia, Dialister, Coprococcus, Bifidobacterium* and *decrease Oscillospira, Ruminococcus* and *Ruminococcus*.[58]

Plant based fat and milk-based fat: Indians consume vegetable fat and milk-based fat (ghee), which comes mainly obtained from grains, oilseeds, nuts, vegetables and milk. Plant fats are low-fat diets that contain mono- and polyunsaturated fats and alter gut microbial composition by increasing the Bacteroidetes: Firmicutes ratio. Coconut oil is characterized by the presence of both medium and long chain fatty acids and an increased abundance of beneficial bacteria such as *Lactobacillus*, *Allobaculum* and *Bifidobacterium* species.[46] Ghee is rich in medium-chain fatty acids and MUFA, the MUFA-enriched diet induced *Bifidobacteriaceae, Lactobacillus, Bacteroidetes, Ruminococcaceae* and reduced the growth of Firmicutes and Proteobacteria.[52,53,108]

Plant-based protein and milk-based protein: - The protein in peas increased *Bifidobacterium* and

Lactobacillus populations and increases intestinal SCFA levels. Pea protein has an inhibitory effect on pathogenic C. perfingens and Bacteroides fragilis species.[45] Casein is a milk protein that can increase the communities of Lactobacilli and *Bifidobacterium* and reduce the abundance of *Staphylococci* and *Streptococci*.[55,56]

Vitamins: - Vitamins, including vitamin K and vitamin B complexes (biotin, cobalamin, folate, nicotinic acid, pantothenic acid, pyridoxine, riboflavin, thiamine) participate in bacterial metabolism, few of them are synthesized in the intestine microbiota.[109] However, a study reported that carotenoids such as black fluo-lutein increased *Bifidobacterium* and *Lactobacillus* spp and decreased Bacteroides spp and Clostridium spp populations[39.110] An abundance of vitamin A in the diet may cause Clostridium to grow while *Enterococcus* and *Bacteroides* decrease. Kids who don't get enough vitamin A in their diets have less diverse gut microbiomes and more *Enterococcus* in their excrement.[111] *Lactobacillus* species could become much more prevalent in a mouse model if vitamin A was given.[112] The delivery of retinoic acid, a physiologically active metabolite of vitamin A, was shown in this study to significantly boost the number of *Lactobacillus* spp. during a norovirus infection.

The authors postulated that the presence of *Lactobacillus* in the gut was partially responsible for naro virus suppression after *Lactobacillus* demonstrated antiviral activity against the norovirus in an *in vitro* model. Additionally, it was demonstrated that the treatment of retinoic acid raised the number of *Allobaculum, Aggregatibacter, Bifidobacterium, Dialister,* and *Enhydrobacter*.[113,114] The colonization of *Bacteroides thetaiotaomicrons* in the gut of an experimental gnotobiotic mouse model was reported to be enhanced by vitamin B12 administration.[115] A small group of free-living people with stable cystic fibrosis were assessed, and the results showed that vitamin C intake was negatively correlated with Bacteroidetes and negatively co-related with Firmicutes and its lower taxa.[116] An investigation on early-weaned pigs revealed the antioxidant potential of vitamin C in scavenging free radicals, repairing the gut microbiota microenvironment, and raising the numbers of *Lactobacillus* and *Bifidobacterium* in the gut.[117]

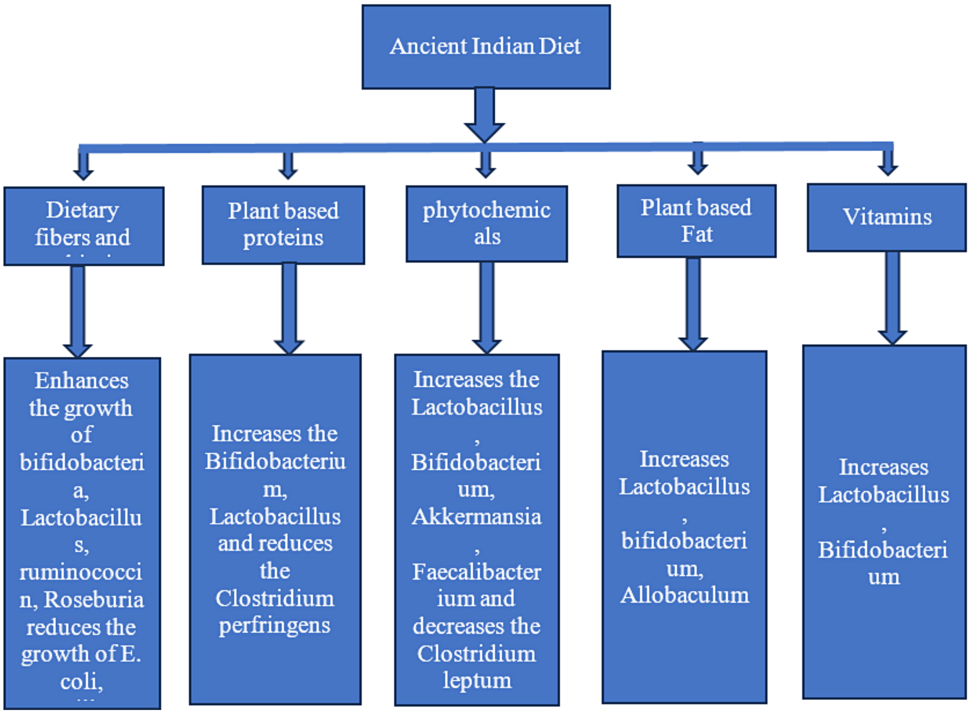


Fig. 1: Role of ancient Indian diet for the growth of beneficial probiotic bacteria and inhibits the growth of pathogenic bacteria

Ancient Indian Diet on Asthmatic Bacteria

The Indian diet is a low-fat, plant-based diet that is rich in all micro- and macronutrients and has a significant impact on gut microbial diversity. The density of the food ensures antioxidant, antimicrobial and anti-inflammatory effects on pathogenic asthmatic bacteria and increases the diversity of antiasthmatic bacteria. A plant-based diet increases the diversity of *Bacteroidetes, Actinobacteria, Prevotella, Bifidobacterium, Lactobacillus, Ruminococcus, Roseburia, Lactobacillus, Lachnospira, Akkermansia* and reduces the risk of asthma by stimulating the production of SCFAs. SCFAs bind to a G protein-coupled receptor on the surface of naïve CD4+ T cells. In turn, the SCFA-GPR 43 complex promotes acetylation of the T reg transcription factor. Increase T reg differentiation and suppress pathogenic immune cells. *Bifidobacterium infantis* can increase the number of $CD4^+$, $CD25^+$, $FoxP3^+$ cells in the spleen .$CD4^+$, $CD25^+$ T cells can suppress the activation and proliferation of other $CD4^+$ and $CD8^+$ cells in an antigen-nonspecific manner and reduce the incidence of asthma.[118] *Lactobacillus* species have also been shown to increase FoxP3 expression by CD25 cells. *in vitro*. Supplementation with *Lactobacillus reuteri* increases Treg in splenocytes and developed key features of asthmatic reactions and methacholine hyperreactivity. Consumption of probiotic bacteria such as *Lactobacilli/Casei/ Lactis/acidophilus* and *Bifidobacteria bifidium/lactis* reduced allergic diseases.[42] Prebiotic consumption at a very early age increases the abundance of *Firmicutes* and *Actinobacteria*, as well as the proliferation of CD Treg cells and cecal butyrate concentration. Oral administration of *Bifidobacterium lactis* or *Lactobacillus rhamnosus* to newborn mice suppressed all aspects of the asthma phenotype.[119]

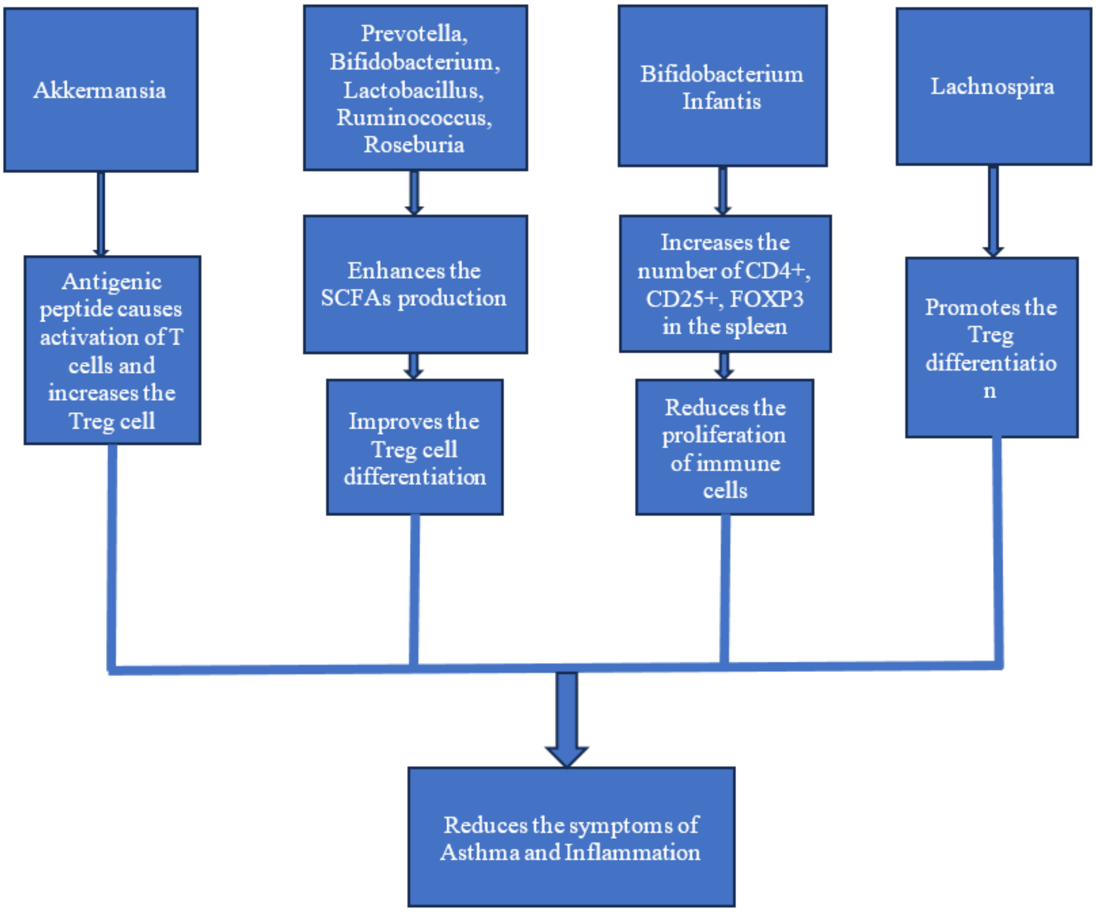


Fig.2: How probiotic bacteria inhibits the development of Asthma

Bacteroides fragilis is sufficient to induce the expression of a specific subset of IL-10-producing $CD4^+$, $CD25^+$, Fox $P3^+$, Treg cells. Bacteria such as *Lactobacillus* and Helicobacter pylori have been reported to be protective against asthma.[120] Antigenic peptide of Akkermansia causes the activation of T cell and increases the peripheral T reg population.[121] *Lachnospira* promotes the T reg cell differention 24Traditional Indian food shows antimicrobial activity against *Clostridium, E. coli, Staphylococcus, Haemophilus, Moraxella and Neisseria*. The above-mentioned facts are supported by the studies which demonstrated that *Haemophilus influenza, Streptococcus Pneumoniae,* and *Moraxella* cause respiratory diseases and asthma risk in children.[55] Higher concentration of Clostridium increases the concentration of fecal IgE level in asthmatic children ,promotes inflammation and increases the incidence of asthma.[23] *Staphylococcus aureus* produces exotoxin serine protease like (SPLS),which promotes the development of eosinophilic asthma.[112] Higher population of *Haemophilus* and *Moraxella* increases the incidence of childhood asthma.[123] *Pseudomonas aeruginosa* having a protein flagellin increases secretion of IL-6 and IL-8 ,which act as a neutrophil chemoattractant.[124]

Conclusion

People are demonstrating their preference for fast food and canned goods as the world becomes more westernised. Inflammation and other chronic disorders like asthma are brought on by a fast-paced lifestyle, stress, and modern cuisine. A balanced, nutrient-rich diet (heavy in fibre, antioxidants, anti-inflammatory, and probiotic foods) and ancient Indian cooking techniques are being used today. Bacteria in the human digestive tract are significantly influenced by the ancient Indian diet. It promotes the growth of symbiotic helpful bacteria while inhibiting the growth of harmful bacteria that take advantage of opportunities. Consuming a traditional Indian cuisine may conserve gut microbial variety, populations, and avoid the extinction of helpful microbial species (dysbiosis), according to our hypothesis. The ancient Indian cuisine is high in fibre, which boosts the population of bacteria that produce SCFAs. A high SCFA content lowers the absorption of bicarbonate ions and raises the pH of the GI tract. Pathogenic bacteria cannot infect a person when the pH is acidic. In several animal models, dietary change decreases airway hyperresponsiveness, lung inflammation, and enhances gut microbial diversity.

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Conflict of Interest

We hereby declare that there is no conflict of interest among the authors for both conceptualization and preparation of the manuscript

Authors contribution

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Data Availability Statement

Not applicable

Ethics Approval statement

As it is a review article there is no need of ethical statement.

Future direction

Till date, no direct research has been done to investigate the impact of the ancient Indian diet on the gut flora of humans.Future research in this field may shed light for a deeper comprehension.

Reference

1. Strachan DP. Hay fever, hygiene, and household size. *Br Med J.* 1989;299(6710). doi:10.1136/bmj.299.6710.1259
2. Rangasamy T,++ Guo J, Mitzner WA, *et al*.

Disruption of Nrf2 enhances susceptibility to severe airway inflammation and asthma in mice. *Journal of Experimental Medicine.* 2005;202(1). doi:10.1084/jem.20050538

3. Schroeder BO, Fredrik Backhed. Signals from the gut microbiota to distant organs in physiology and disease. *Nat Med.* 2016;22(10):1079-1089.
4. Sonnenburg ED, Smits SA, Tikhonov M, Higginbottom SK, Wingreen NS, Sonnenburg JL. Diet-induced extinctions in the gut microbiota compound over generations. *Nature*. 2016;529(7585). doi:10.1038/nature16504
5. Chung KF. Airway microbial dysbiosis in asthmatic patients: A target for prevention and treatment? *Journal of Allergy and Clinical Immunology.* 2017;139(4). doi:10.1016/j.jaci.2017.02.004
6. Samanta AK, Kolte AP, Senani S, Sridhar M, Jayapal N. Prebiotics in ancient Indian diets. *Curr Sci.* 2011;101(1).
7. Oberg EB, Bradley RD, Allen J, McCrory MA. CAM: Naturopathic dietary interventions for patients with Type 2 diabetes. *Complement Ther Clin Pract.* 2011;17(3). doi:10.1016/j.ctcp.2011.02.007
8. Das M, Pundir M, Nayak P, Patra S, Thajuddin N. Yogic diet on gut microbial diversity in asthma. *Yoga Mimamsa.* 2023;55(01):58-66.
9. Monteiro CA, Moubarac JC, Cannon G, Ng SW, Popkin B. Ultra-processed products are becoming dominant in the global food system. *Obesity Reviews.* 2013;14(S2). doi:10.1111/obr.12107
10. Agus A, Planchais J, Sokol H. Gut Microbiota Regulation of Tryptophan Metabolism in Health and Disease. *Cell Host Microbe.* 2018;23(6):716-724. doi:10.1016/J.CHOM.2018.05.003
11. Ahmed A, Elbushra A, Salih O. Food consumption patterns and trends in the Gulf Cooperation Council. *Pak J Nutr.* 2019;18:623-636.
12. Wood LG, Garg ML, Gibson PG. A high-fat challenge increases airway inflammation and impairs bronchodilator recovery in asthma. *Journal of Allergy and Clinical Immunology.* 2011;127(5). doi:10.1016/j.jaci.2011.01.036
13. Berthon BS, MacDonald-Wicks LK, Gibson PG, Wood LG. Investigation of the association between dietary intake, disease severity and airway inflammation in asthma. *Respirology.* 2013;18(3). doi:10.1111/resp.12015
14. Li Q, Baines KJ, Gibson PG, Wood LG. Changes in expression of genes regulating airway inflammation following a high-fat mixed meal in asthmatics. *Nutrients*. 2016;8(1). doi:10.3390/nu8010030
15. López-Otín C, Blasco MA, Partridge L, Serrano M, Kroemer G. The hallmarks of aging. *Cell.* 2013;153(6). doi:10.1016/j.cell.2013.05.039
16. Melo B, Rezende L, Machado P, Gouveia N, Levy R. Associations of ultra-processed food and drink products with asthma and wheezing among Brazilian adolescents. *Pediatric Allergy and Immunology.* 2018;29(5). doi:10.1111/pai.12911
17. Li Z, Rava M, Bédard A, *et al*. Cured meat intake is associated with worsening asthma symptoms. *Thorax*. 2017;72(3). doi:10.1136/thoraxjnl-2016-208375
18. O'Toole PW, Jeffery IB. Gut microbiota and aging. *Science* (1979). 2015;350(6265). doi:10.1126/science.aac8469
19. Martínez Leo EE, Acevedo Fernández JJ, Segura Campos MR. Biopeptides with antioxidant and anti-inflammatory potential in the prevention and treatment of diabesity disease. *Biomedicine and Pharmacotherapy.* 2016;83. doi:10.1016/j.biopha.2016.07.051
20. Daniel H, Moghaddas Gholami A, Berry D, *et al*. High-fat di*et al*ters gut microbiota physiology in mice Microbe-microbe and microbe-host interactions. *ISME J*. 2014;8.
21. Sharaf LK, Sharma M, Chandel D, Shukla G. Prophylactic intervention of probiotics (L. acidophilus, L. rhamnosus GG) and celecoxib modulate Bax-mediated apoptosis in 1, 2-dimethylhydrazine-induced experimental colon carcinogenesis. *BMC Cancer.* 2018;18(1):1-13.
22. Rajaruban S, Fedorak R, Zalasky A, *et al*. A77 Consumption of Refined Sugar Rapidly Decreases Microbial Diversity And Enhances Systemic Response To Microbial Stimuli. *J Can Assoc Gastroenterol.* 2019;2(Supplement_2). doi:10.1093/jcag/gwz006.076
23. Chiu CY, Chan YL, Tsai MH, Wang CJ, Chiang MH, Chiu CC. Gut microbial dysbiosis

is associated with allergen-specific IgE responses in young children with airway allergies. *World Allergy Organization Journal*. 2019;12(3). doi:10.1016/j.waojou.2019.100021

24. Arrieta MC, Stiemsma LT, Dimitriu PA, *et al*. Early infancy microbial and metabolic alterations affect risk of childhood asthma. *American Association for the Advancement of Science.* 2015;7(307):307-152.
25. Chakraborti CK. New-found link between microbiota and obesity. *World J Gastrointest Pathophysiol.* 2015;6(4). doi:10.4291/wjgp.v6.i4.110
26. Taylor SL, Leong LE, Choo JM, *et al*. Inflammatory phenotypes in patients with severe asthma are associated with distinct airway microbiology. *Journal of Allergy and Clinical Immunology.* 2018;141(1):94-103.
27. Krysko O, Teufelberger A, Van Nevel S, Krysko D V., Bachert C. Protease/antiprotease network in allergy: The role of *Staphylococcus aureus* protease-like proteins. Allergy: *European Journal of Allergy and Clinical Immunology.* 2019;74(11). doi:10.1111/all.13783
28. Hamr SC, Wang B, Swartz TD, Duca FA. Does nutrient sensing determine how we “see” food? *Curr Diab Rep.* 2015;15:1-10.
29. Statovci D, Aguilera M, MacSharry J, Melgar S. The impact of western diet and nutrients on the microbiota and immune response at mucosal interfaces. *Front Immunol.* 2017;8(JUL). doi:10.3389/fimmu.2017.00838
30. Srinivas T. Exploring Indian culture through food. *Education about Asia*. 2011;16(03):38-41.
31. Agrawal S, Millett CJ, Dhillon PK, Subramanian S, Ebrahim S. Type of vegetarian diet, obesity and diabetes in adult Indian population. *Nutr J.* 2014;13(1). doi:10.1186/1475-2891-13-89
32. Shridhar K, Dhillon PK, Bowen L, *et al*. Nutritional profile of Indian vegetarian diets - The Indian Migration Study (IMS). *Nutr J.* 2014;13(1). doi:10.1186/1475-2891-13-55
33. Bhat RS, Al-Daihan S. Phytochemical constituents and antibacterial activity of some green leafy vegetables. *Asian Pac J Trop Biomed.* 2014;4(3). doi:10.1016/S2221-1691(14)60230-6
34. Chopra A, Doiphode V V. Ayurvedic medicine: Core concept, therapeutic principles, and current relevance. *Medical Clinics of North America*. 2002;86(1). doi:10.1016/S0025-7125(03)00073-7
35. Unnithan AK. Gastronomy Of Kerala Community: Ethnic Nutritional Value Of Onam Sadya. *Think India Journal.* 2019;22(14):5447-5459.
36. Tomova A, Bukovsky I, Rembert E, *et al*. The effects of vegetarian and vegan diets on gut microbiota. *Front Nutr*. 2019;6. doi:10.3389/fnut.2019.00047
37. Zhang X, Dong L, Jia X, *et al*. Bound phenolics ensure the antihyperglycemic effect of rice bran dietary fiber in db/db mice via activating the insulin signaling pathway in skeletal muscle and altering gut. *J Agric Food Chem.* 2020;68(15):4387-4398.
38. Nealon NJ, Worcester CR, Ryan EP. *Lactobacillus* paracasei metabolism of rice bran reveals metabolome associated with Salmonella Typhimurium growth reduction. *J Appl Microbiol.* 2017;122(6). doi:10.1111/jam.13459
39. Rizzello CG, Lorusso A, Montemurro M, Gobbetti M. Use of sourdough made with quinoa (Chenopodium quinoa) flour and autochthonous selected lactic acid bacteria for enhancing the nutritional, textural and sensory features of white bread. *Food Microbiol.* 2016;56. doi:10.1016/j.fm.2015.11.018
40. Murtaza N, Baboota RK, Jagtap S, *et al*. Finger millet bran supplementation alleviates obesity-induced oxidative stress, inflammation and gut microbial derangements in high-fat diet-fed mice. *British Journal of Nutrition.* 2014;112(9). doi:10.1017/S0007114514002396
41. Wu T, Gao Y, Hao J, *et al*. Lycopene, amaranth, and sorghum red pigments counteract obesity and modulate the gut microbiota in high-fat diet fed C57BL/6 mice. *J Funct Foods.* 2019;60. doi:10.1016/j.jff.2019.103437
42. Olguin-Calderon D., JL González-Escobar, J. L. RV, R. DAE, Leon-Rodriguez D, de la Rosa APB. Modulation of caecal microbiome in obese mice associated with administration of amaranth or soybean protein isolates. *Pol J Food Nutr Sci.* 2019;69(1).

43. Han J, Zhang R, Muheyati D, Lv MX, Aikebaier W, Peng BX. The Effect of Chickpea Dietary Fiber on Lipid Metabolism and Gut Microbiota in High-Fat Diet-Induced Hyperlipidemia in Rats. *J Med Food*. 2021;24(2). doi:10.1089/jmf.2020.4800
44. Nakatani A, Li X, Miyamoto J, *et al*. Dietary mung bean protein reduces high-fat diet-induced weight gain by modulating host bile acid metabolism in a gut microbiota-dependent manner. *Biochem Biophys Res Commun.* 2018;501(4):955-961.
45. Singh RK, Chang HW, Yan D, *et al*. Influence of diet on the gut microbiome and implications for human health. *J Transl Med*. 2017;15(1):1-17.
46. Djurasevic S, Bojic S, Nikolic B, *et al*. Beneficial effect of virgin coconut oil on alloxan-induced diabetes and microbiota composition in rats. *Plant Foods for Human Nutrition.* 2018;73:295-301.
47. Sung MM, Kim TT, Denou E, *et al*. Improved glucose homeostasis in obese mice treated with resveratrol is associated with alterations in the gut microbiome. *Diabetes.* 2017;66(2). doi:10.2337/db16-0680
48. Liu BL, Chiang PS. Production of hydrolysate with antioxidative activity and functional properties by enzymatic hydrolysis of defatted sesame (Sesamum indicum L.). *International Journal of Applied Science and Engineering.* 2008;6(2):73-83.
49. Kaliannan K, Wang B, Li XY, Kim KJ, Kang JX. A host-microbiome interaction mediates the opposing effects of omega-6 and omega-3 fatty acids on metabolic endotoxemia. *Sci Rep*. 2015;5. doi:10.1038/srep11276
50. Onishi JC, Campbell S, Moreau M, *et al*. Bacterial communities in the small intestine respond differently to those in the caecum and colon in mice fed low- and high-fat diets. *Microbiology* (United Kingdom). 2017;163(8). doi:10.1099/mic.0.000496
51. Prieto I, Hidalgo M, Segarra AB, *et al*. Influence of a diet enriched with virgin olive oil or butter on mouse gut microbiota and its correlation to physiological and biochemical parameters related to metabolic syndrome. *PLoS One.* 2018;13(1). doi:10.1371/journal.pone.0190368
52. Zhou S, Wang Y, Jacoby JJ, Jiang Y, Zhang Y, Yu LL. Effects of medium-and long-chain triacylglycerols on lipid metabolism and gut microbiota composition in C57BL/6J mice. *J Agric Food Chem.* 2017;65(31):6599-6607.
53. Bindels LB, Delzenne NM, Cani PD, Walter J. Opinion: Towards a more comprehensive concept for prebiotics. Nat Rev Gastroenterol *Hepatol.* 2015;12(5). doi:10.1038/nrgastro.2015.47
54. Sarkar S, Misra A. Bio-preservation of milk and milk products. *Indian Food Industry.* 2001;20(4):74-77.
55. Hooper L V., Littman DR, Macpherson AJ. Interactions between the microbiota and the immune system. *Science* (1979). 2012;336(6086). doi:10.1126/science.1223490
56. Hancock REW, Haney EF, Gill EE. The immunology of host defence peptides: Beyond antimicrobial activity. *Nat Rev Immunol.* 2016;16(5). doi:10.1038/nri.2016.29
57. Holscher HD, Taylor AM, Swanson KS, Novotny JA, Baer DJ. Almond consumption and processing affects the composition of the gastrointestinal microbiota of healthy adult men and women: a randomized controlled trial. *Nutrients.* 2018;10(2):126.
58. Holscher HD, Guetterman HM, Swanson KS, *et al*. Walnut consumption alters the gastrointestinal microbiota, microbially derived secondary bile acids, and health markers in healthy adults: a randomized controlled trial. *J Nutr.* 2018;148(06):861-867.
59. Wang J, Wang P, Li D, Hu X, Chen F. Beneficial effects of ginger on prevention of obesity through modulation of gut microbiota in mice. *Eur J Nutr.* 2020;59:699-718.
60. Author C, Abu Sayeed M, Abbas Ali M, Mahbub Alam N, Sarmina Yeasmin M, Mohal Khan A. Antimicrobial Screening of Different Extracts of Piper longum Linn. *Res J Agric Biol Sci.* 2007;3(6).
61. Di Meo F, Margarucci S, Galderisi U, Crispi S, Peluso G. Curcumin, gut microbiota, and neuroprotection. *Nutrients.* 2019;11(10). doi:10.3390/nu11102426
62. Jagetia GC,, Aggarwal BB. “Spicing up” of the immune system by curcumin. *J Clin Immunol. Published online* 2007:19-35.
63. Shen L, Liu L, Ji HF. Regulative effects of curcumin spice administration on

gut microbiota and its pharmacological implications. *Food Nutr Res*. 2017;61. doi:10.1080/16546628.2017.1361780

64. Unlu M, Ergene E, Unlu GV, Zeytinoglu HS, Vural N. Composition, antimicrobial activity and *in vitro* cytotoxicity of essential oil from Cinnamomum zeylanicum Blume (Lauraceae). *Food and Chemical Toxicology.* 2010;48(11). doi:10.1016/j.fct.2010.09.001
65. Kandhare AD, Bodhankar SL, Singh V, Mohan V, Thakurdesai PA. Anti-asthmatic effects of type-A procyanidine polyphenols from cinnamon bark in ovalbumin-induced airway hyperresponsiveness in laboratory animals. *Biomedicine and Aging Pathology.* 2013;3(1). doi:10.1016/j.biomag.2013.01.003
66. Kumar P, Patra AK, Mandal GP, Samanta I, Pradhan S. Effect of black cumin seeds on growth performance, nutrient utilization, immunity, gut health and nitrogen excretion in broiler chickens. *J Sci Food Agric.* 2017;97(11):3742-3751.
67. Xu J, Liu T, Li Y, *et al*. Jamun (Eugenia jambolana Lam.) Fruit Extract Prevents Obesity by Modulating the Gut Microbiome in High-Fat-Diet-Fed Mice. *Mol Nutr Food Res.* 2019;63(9). doi:10.1002/MNFR.201801307
68. Xu J, Liu T, Li Y, *et al*. Jamun (Eugenia jambolana Lam.) fruit extract prevents obesity by modulating the gut microbiome in high-fat-diet-fed mice. *Mol Nutr Food Res.* 2017;97(11):3742-3751.
69. Li Y, Bai D, Lu Y, *et al*. The crude guava polysaccharides ameliorate high-fat diet-induced obesity in mice via reshaping gut microbiota. *Int J Biol Macromol.* 2022;213:234-246.
70. Gheisari HR, Amiri F, Zolghadri Y. Antioxidant and antimicrobial activity of Iranian Bael (Aegle marmelos) fruit against some food pathogens. *Int J Curr Pharm Res.* 2011;3(3):85-88.
71. Gong Y, Dong R, Gao X, *et al*. Neohesperidin prevents colorectal tumorigenesis by altering the gut microbiota. *Pharmacol Res.* 2019;148:104460.
72. Zhang J, Yang G, Wen Y, *et al*. Intestinal microbiota are involved in the immunomodulatory activities of longan polysaccharide. *Mol Nutr Food Res.* 2017;61(11). doi:10.1002/mnfr.201700466
73. Zhang X, Zhao Y, Xu J, *et al*. Modulation of gut microbiota by berberine and metformin during the treatment of high-fat diet-induced obesity in rats. *Sci Rep*. 2015;5(1):14405.
74. Barnes RC, Kim H, Fang C, *et al*. Body Mass Index as a Determinant of Systemic Exposure to Gallotannin Metabolites during 6-Week Consumption of Mango (Mangifera indica L.) and Modulation of Intestinal Microbiota in Lean and Obese Individuals. *Mol Nutr Food Res*. 2019;63(2). doi:10.1002/mnfr.201800512
75. Gutiérrez-Sarmiento W, Sáyago-Ayerdi SG, Goñi I, *et al*. Changes in intestinal microbiota and predicted metabolic pathways during colonic fermentation of mango (Mangifera indica L.)—based bar indigestible fraction. *Nutrients.* 2020;12(3). doi:10.3390/nu12030683
76. Deehan EC, Yang C, Perez-Muñoz ME, *et al*. Precision Microbiome Modulation with Discrete Dietary Fiber Structures Directs Short-Chain Fatty Acid Production. *Cell Host Microbe*. 2020;27(3). doi:10.1016/j.chom.2020.01.006
77. Saxby S, Tipton L, Lee C, *et al*. Prebiotic Potential of Taro (Colocasia esculenta) to Modulate Gut Bacteria Composition and Short Chain Fatty Acid Production. *Curr Dev Nutr.* 2020;4. doi:10.1093/cdn/nzaa062_039
78. Louis P, Flint HJ. Formation of propionate and butyrate by the human colonic microbiota}. *Environ Microbiol*. 2017;19(01):29-41.
79. Prabha R, Ramachandra B, Shankar P. Effect of vegetable extract as bifidogenic agents on the growth of wild strains of bifidobacteria. *J Pharmacogn Phytochem.* 2021;10(06):279-282.
80. Nissen L, Cattivelli A, Casciano F, Gianotti A, Tagliazucchi D. Roasting and frying modulate the phenolic profile of dark purple eggplant and differently change the colon microbiota and phenolic metabolites after *in vitro* digestion and fermentation in a gut model. *Food Research International.* 2022;160. doi:10.1016/j.foodres.2022.111702
81. Liu G, Liang L, Yu G, Li Q. Pumpkin polysaccharide modifies the gut microbiota during alleviation of type 2 diabetes in rats. *Int J Biol Macromol.* 2018;115:711-717.
82. Päivärinta E, Niku M, Maukonen J, *et al*. Changes in intestinal immunity, gut microbiota,

and expression of energy metabolism–related genes explain adenoma growth in bilberry and cloudberry-fed ApcMin mice. *Nutrition Research.* 2016;36(11). doi:10.1016/j.nutres.2016.10.003

83. Hemanta MR, Mane VK, Bhagwat A. Analysis of traditional food additive kolakhar for its physico-chemical parameters and antimicrobial activity. *J Food Process Technol.* 2014;387:5-11.

84. Valcheva R, Hotte N, Gillevet P, Sikaroodi M, Thiessen A, Madsen KL. Soluble dextrin fibers alter the intestinal microbiota and reduce proinflammatory cytokine secretion in male IL-10-deficient mice. *Journal of Nutrition.* 2015;145(9). doi:10.3945/jn.114.207738

85. Elabd EMY, Morsy SM, Elmalt HA. Investigating of Moringa oleifera role on gut microbiota composition and inflammation associated with obesity following high fat diet feeding. *Open Access Maced J Med Sci.* 2018;6(8):1359.

86. Elvira-Torales LI, Periago MJ, González-Barrio R, *et al*. Spinach consumption ameliorates the gut microbiota and dislipaemia in rats with diet-induced non-alcoholic fatty liver disease (NAFLD). *Food Funct.* 2019;10(4). doi:10.1039/c8fo01630e

87. Li Y, Cui Y, Lu F, *et al*. Beneficial effects of a chlorophyll-rich spinach extract supplementation on prevention of obesity and modulation of gut microbiota in high-fat diet-fed mice. *J Funct Foods.* 2019;60:103436.

88. Maiyo Z, Ngure R, Matasyoh J, Chepkorir R. Phytochemical constituents and antimicrobial activity of leaf extracts of three Amaranthus plant species. *Afr J Biotechnol.* 2010;9(21):3178-3182.

89. Cordonnier C, Le Bihan G, Emond-Rheault JG, Garrivier A, Harel J, Jubelin G. Vitamin B12 uptake by the gut commensal bacteria Bacteroides thetaiotaomicron limits the production of shiga toxin by enterohemorrhagic *Escherichia coli. Toxins* (Basel). 2016;8(1):14.

90. Pandey S, Gupta RK. Screening of nutritional, phytochemical, antioxidant and antibacterial activity of Chenopodium album (Bathua). *Journal of Pharmacognosy and Phytochemistry JPP.* 2014;1(33).

91. Oteiza P, Fraga CG, Mills D, Taft D. Flavonoids and the gastrointestinal tract: Local and systemic effects. *Mol Aspects Med.* 2018;61:41-49.

92. Olalye MT, Rocha JBT. Commonly used tropical medicinal plants exhibt distinct *in vitro* antioxidant activities against hepatotoxins in rat liver. *Experimental and Toxicologic Pathology}.* 2007;58(06):433-438.

93. Holscher HD, Bauer LL, Gourineni V, Pelkman CL, Fahey GC, Swanson KS. Agave inulin supplementation affects the fecal microbiota of healthy adults participating in a randomized, double-blind, placebo-controlled, crossover trial. *Journal of Nutrition.* 2015;145(9). doi:10.3945/jn.115.217331

94. Walker AW, Ince J, Duncan SH, *et al*. Dominant and diet-responsive groups of bacteria within the human colonic microbiota. *ISME Journal.* 2011;5(2). doi:10.1038/ismej.2010.118

95. Pontifex MG, Connell E, Le Gall G, *et al*. Saffron extract (Safr'InsideTM) improves anxiety related behaviour in a mouse model of low-grade inflammation through the modulation of the microbiota and gut derived metabolites. *Food Funct.* 2022;13(23). doi:10.1039/d2fo02739a

96. China R, Mukherjee S, Sen S, *et al*. Antimicrobial activity of Sesbania grandiflora flower polyphenol extracts on some pathogenic bacteria and growth stimulatory effect on the probiotic organism *Lactobacillus acidophilus. Microbiol Res.* 2012;167(8). doi:10.1016/j.micres.2012.04.003

97. Muruganantham N, Solomon S, Senthamilselvi M. Antimicrobial activity of Cucurbita maxima flowers (Pumpkin). *Journal of Pharmacognosy and Phytochemistry* . 2016;5(1).

98. Sitthiya K, Devkota L, Sadiq MB, Anal AK. Extraction and characterization of proteins from banana (Musa Sapientum L) flower and evaluation of antimicrobial activities. *J Food Sci Technol.* 2018;55(2). doi:10.1007/s13197-017-2975-z

99. Kulshrestha PK, Mishra AK, Pal VK, Pandey S, Tripathi D, Yadav P. The antimicrobial activity of bahunia variegata linn. Flower extract (Methanolic). *Asian Journal of Pharmaceutical and Clinical Research.* 2011;4(SUPPL. 1).

100. Singh P, Junnarkar A, Reddi G,

Singh K. Azadirachta indica neuro psychopharmacological and anti-microbial studies. *Fitoterapia.* 1987;58(4):233-248.

101. Shondelmyer K, Knight R, Sanivarapu A, Ogino S, Vanamala JKP. Focus: Nutrition and Food Science: Ancient Thali Diet: Gut Microbiota, Immunity, and Health. *Yale J Biol Med*. 2018;91(2).
102. Slavin J. Fiber and prebiotics: Mechanisms and health benefits. *Nutrients.* 2013;5(4). doi:10.3390/nu5041417
103. Graf D, Di Cagno R, Fåk F, *et al*. Contribution of diet to the composition of the human gut microbiota. *Microb Ecol Health Dis.* 2015;26(0). doi:10.3402/mehd.v26.26164
104. Rinninella E, Cintoni M, Raoul P, *et al*. Food components and dietary habits: Keys for a healthy gut microbiota composition. *Nutrients.* 2019;11(10). doi:10.3390/nu11102393
105. Gallagher EJ, LeRoith D, Karnieli E. The Metabolic Syndrome-from Insulin Resistance to Obesity and Diabetes. *Medical Clinics of North America.* 2011;95(5). doi:10.1016/j.mcna.2011.06.001
106. Medina-Remón A, Casas R, Tressserra-Rimbau A, *et al*. Polyphenol intake from a Mediterranean diet decreases inflammatory biomarkers related to atherosclerosis: a substudy of the PREDIMED trial. *Br J Clin Pharmacol.* 2017;83(1). doi:10.1111/bcp.12986
107. Xu J, Liu T, Li Y, *et al*. Jamun (Eugenia jambolana Lam.) fruit extract prevents obesity by modulating the gut microbiome in high-fat-diet-fed mice}. *Mol Nutr Food Res.* 2019;63(9):1801307.
108. An J, Lee H, Lee S, *et al*. Modulation of pro-inflammatory and anti-inflammatory cytokines in the fat by an aloe gel-based formula, qdmc, is correlated with altered gut microbiota. *Immune Netw.* 2021;21(2). doi:10.4110/in.2021.21.e15
109. Rowland I, Gibson G, Heinken A, *et al*. Gut microbiota functions: metabolism of nutrients and other food components. *Eur J Nutr.* 2018;57(1). doi:10.1007/S00394-017-1445-8
110. Molan AL, Liu Z, Plimmer G. Evaluation of the effect of blackcurrant products on gut microbiota and on markers of risk for colon cancer in humans. *Phytotherapy Research.* 2014;28(3). doi:10.1002/ptr.5009
111. Lv Z, Wang Y, Yang T, *et al*. Vitamin A deficiency impacts the structural segregation of gut microbiota in children with persistent diarrhea. *J Clin Biochem Nutr.* 2016;59(2). doi:10.3164/jcbn.15-148
112. Hibberd MC, Wu M, Rodionov DA, *et al*. The effects of micronutrient deficiencies on bacterial species from the human gut microbiota. *Sci Transl Med*. 2017;9(390). doi:10.1126/scitranslmed.aal4069
113. Lee H, Ko GP. Antiviral effect of Vitamin A on norovirus infection via modulation of the gut microbiome. *Sci Rep.* 2016;6. doi:10.1038/srep25835
114. Lee H, Ko G. New perspectives regarding the antiviral effect of vitamin A on norovirus using modulation of gut microbiota. *Gut Microbes.* 2017;8(6). doi:10.1080/19490976.2017.1353842
115. Degnan PH, Barry NA, Mok KC, Taga ME, Goodman AL. Human gut microbes use multiple transporters to distinguish vitamin B 12 analogs and compete in the gut. *Cell Host Microbe*. 2014;15(1). doi:10.1016/j.chom.2013.12.007
116. Li L, Krause L, Somerset S. Associations between micronutrient intakes and gut microbiota in a group of adults with cystic fibrosis. *Clinical Nutrition.* 2017;36(4). doi:10.1016/j.clnu.2016.06.029
117. Xu J, Xu C, Chen X, *et al*. Regulation of an antioxidant blend on intestinal redox status and major microbiota in early weaned piglets. *Nutrition.* 2014;30(5). doi:10.1016/j.nut.2013.10.018
118. Kursar M, Bonhagen K, Fensterle J, *et al*. Regulatory CD4+CD25+ T cells restrict memory CD8+ T cell responses. *Journal of Experimental Medicine*. 2002;196(12). doi:10.1084/jem.20011347
119. Forsythe P, Inman MD, Bienenstock J. Oral treatment with live *Lactobacillus reuteri* inhibits the allergic airway response in mice. *Am J Respir Crit Care Med.* 2007;175(06):561-569.
120. Hansel TT, Johnston SL, Openshaw PJ. Microbes and mucosal immune responses in asthma. *The Lancet.* 2013;381(9869). doi:10.1016/S0140-6736(12)62202-8
121. Kuczma MP, Szurek EA, Cebula A, *et al*. Self and microbiota-derived epitopes induce CD4+ T cell anergy and conversion into

CD4+Foxp3+ regulatory cells. *Mucosal Immunol.* 2021;14(2). doi:10.1038/s41385-020-00349-4

122. Stentzel S, Teufelberger A, Nordengrün M, *et al*. Staphylococcal serine protease–like proteins are pacemakers of allergic airway reactions to *Staphylococcus aureus*. *Journal of Allergy and Clinical Immunology.* 2017;139(2):492-500.e8. doi:10.1016/J.JACI.2016.03.045

123. Teo SM, Mok D, Pham K, *et al*. The infant nasopharyngeal microbiome impacts severity of lower respiratory infection and risk of asthma development. *Cell Host Microbe.* 2015;17(05):704-715.

124. Nakamoto K, Watanabe M, Sada M, *et al*. Pseudomonas aeruginosa-derived flagellin stimulates IL-6 and IL-8 production in human bronchial epithelial cells: A potential mechanism for progression and exacerbation of COPD. *Exp Lung Res.* 2019;45(8). doi:10.1080/01902148.2019.1665147