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Review Article

Traditional Indian Food for Improving Brain Cognition

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Abstract

Foods not only supply energy but also help in growth, development and maintenance of health including cognitive functions. It has also been observed that specific nutrients can affect cognitive abilities at different ages. Diverse nutrients present in the food play a crucial role in the maintenance of cognitive functions and deficiencies of such nutrients might lead to neurodegenerative diseases such as Alzheimer disease, Parkinson's disease and other neuronal dysfunction including dementia. The purpose of the present study is to determine the existing data available in different science literature regarding food items available in India that have potent action on brain function. Searched in PubMed, Google Search, Google Scholar, Research Gate. Using the keywords "Foods for Brain", Diet influence on cognition'', "Micronutrients on cognition ", "Diets in Cognition". The direct connection between nutrition, brain function and behaviour exist in several research. Traditional Indian diet consists of many phytochemicals/phytonutrients which have shown one pivotal role in reducing inflammation. There are hundreds of different spices that are specifically used in traditional Indian food which are rich in many phytonutrients that proves to play an important role in better nerve health like turmeric prevents brain damage due to oxidative stress even saffron has neuroprotective properties that protects the hippocampus against age related damage. Many studies proved that specific nutrients can affect our brain development. Phytonutrients present in the Indian food does improves alertness, concentration and performance of brain by reducing oxidative stress, high inflammation, stress induced neurotoxicity and it also impacted on the nerve functionality, however how much portion of such specific food we need to include in diet for best cognitive performance is yet to get disclosed, further research is still needed in this field. Furthermore, traditional Indian foods are having bright future in improving neurological health of an individual.

Keywords: Cognitive Abilities; Brain; Food; Micronutrients; Traditional Indian Food; Diet

Introduction

Cognitive impairments are increasing every 5 years and affecting 20% of those aged 65 years and 45% of those aged ≥ 90 years [1] Cognitive and emotional dysfunctions are an increasing burden in our society. The exact components and underlying mechanisms cause these disorders to have not yet been clarified [2] Next to our genetic makeup, the interplay between specific environmental challenges occurred during well-defined developmental periods seems to play an important role. Interestingly, such brain debliation most often co-occurs with metabolic disorders and/or poor dietary habits. Furthermore, obesity and poor diet can lead to negative health implications including cognitive and mood dysfunctions, suggesting a strong interaction between these elements [3,4]. Obesity is a global phenomenon, with around 38% of adults and 18% of children and adolescents worldwide classified as either overweight or obese [3,5]. Even in the absence of obesity, poor diet is commonplace for an instance, many eating foods that are highly processed and lacking in important polyphenols and antioxidants, consisting below the recommended levels of omega-3 polyunsaturated fatty acids as well (PUFA). Previously it was believed that food only sup-

plies energy for maintaining well-being, but it has also shown an important role in preventing several diseases [6]. In a study it has been demonstrated that dietary influences are crucial on brain functions. There is a close relationship between cognition and nutritional status of an individuals. Several factors are responsible for the effective functionality of the brain [7]. Dietary habits, exercises, environmental exposures, medications, stress and family history are all integrative parts of our mental health [8]. Neurological diseases are increasing gradually, again psychopathologies increase health risk and malnutrition, which are also becoming one of the dominant factors in this case. Currently nutrition plays an important role in the treatment of mental health disorders as well [7,8]. Over the last many years' studies have been going to bridge the gap between mental health and nutrition and it has also been observed that even learning abilities and mood are also influenced by foods [8]. The hippocampus is one of the structures of the brain that is responsible for mood, memory and even learning. There has been evidence that modulation of adult hippocampal neurogenesis by diet appears to be attainable by which nutrition impacts mental wellbeing [9]. Several dietary factors have been seen to improve cognitive abilities. Dietary components can affect brain processes by regulating pathways and they even subdue neuroinflammation and promote learning as well as cognitive abilities [10]. India is the epitome of culture, language and cuisine. The states and union territory have their own cuisines with different spices that carry their own heritage. Many foods do have phytochemicals that have potential effects on our mental health and even on cognition. The current review aims to determine the significant role of Indian traditional food in terms of gaining better neurocognition among individual. Additionally, brief discussion will be included regarding the existing data available in different science literature regarding traditional Indian food items and their potent action on brain functioning.

Data synthesis

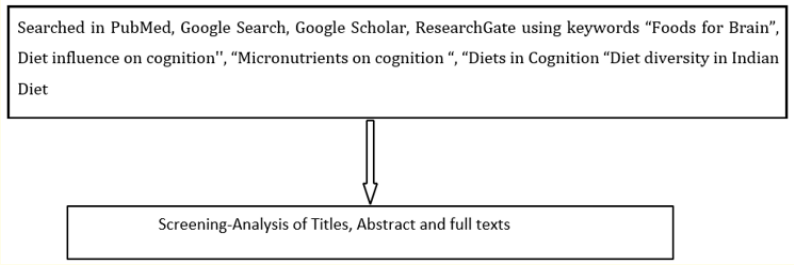

Figure 1: Details Data Synthesis Process

Overview of existing relations between food and brain function

According to the ancient eastern concept, mindfulness includes one being fully aware of what is happening around the circumstances and" mindful eating" is paying attention to the food without any judgement [11]. Therefore, it is important to chew food slowly, preventing any distractions from any gadgets, and having food without any anxiety and guilt which is very important for our wellbeing [12].

Living organisms need food for survival. After consumption of food in the body it breaks down to the simplest forms such as glucose, amino acids and fatty acids which are taken to the cells by blood for further utilisation. Therefore, when we are hungry lots of mechanisms go on so that the brain can give signals to the body that we need food. [13,14]' which is also responsible for influencing our immune system as well [15]. The hypothalamus is an important area in the centre of the brain that connects the nervous system to the endocrine system via the pituitary gland and helps to transmit signals via neurotransmitters. It measures the body's energy, glucose level and even the hormones responsible for satiety. A specialised area in the hypothalamus called the arcuate nucleus, where signals are there that control metabolic rate, hunger and satiety [16]. In Arcuate nucleus two types of cells are present one is POMC (Pro-opiomelanocortin) this is one satiety cell if stimulated we feel fullness and another one is NPY/AGRP (Neuropeptide Y/ Agouti related protein), which are hunger cells when stimulated we feel hungry [17].

Figure 2: Relation between food intake and satiety [16].

Mitochondrial functions in cognition

Mitochondria is the powerhouse of the cells. In all multicellular eukaryotes, the mitochondria are the fundamental for metabolic homeostasis [18] Mitochondria play an important role in neurodevelopment and neurogenesis [15]. Especially in nervous system, the adenosine triphosphate (ATP) generated by mitochondria is required to establish reliable synaptic transmission and appropriate electrochemical gradients [19,20]. Therefore, upset of normal mitochondrial function is detrimental to cellular activity. Nerve cells are specifically dependent on mitochondria for calcium buffering and ATP production and, thus are highly susceptible to mitochondrial defects [21]. Cognitive decline does occur due to synaptic damage caused by mitochondria and amyloid β. Recent studies have revealed changes caused by Aβ due to increased mitochondrial fragmentation, decreased mitochondrial fusion and mitochondrial dysfunction. Mitochondrial therapeutics play an important role in the treatment of Alzheimer's Diseases [18]. Mitochondrial dysfunction also leads to Parkinson's Disease associated dementia due to imbalanced redox mechanisms and dysregulated mitochondrial dysfunction [19]. Impairment in mitochondria depletes the neural stem cell pool (NSC) and impacts embryogenic neurogenesis. Studies have revealed that a low protein to carbohydrate ratio can improve the motor ability of mitochondrial functions. The results have also shown that hepatic mitochondrial function is impaired due to obesity and high fat, high fructose feeding [20,21].

The role of different macro and micro-nutrients is inescapable in-context to proper functioning of mitochondria. Certain micronutrients like vitamins and trace minerals are crucial for mitochondrial functioning, either by acting as cofactors in energy metabolism or by acting as antioxidants [22]. Both of these functions are interlinked as the antioxidants can avert the damage of the enzymes that are taking part in energy metabolism, owing to this there is enhancement in energy production. The B vitamins (Thiamine, Riboflavin, Niacin, Pantothenic acid and Biotin) have an important role in regulation of the mitochondrial enzymes [23]. It has also been reported that a deficiency in B vitamins present in diet leads to a compromised integrity and functions of the Mitochondria [23]. Also, Vitamin C and Vitamin E being potential antioxidants have been found to reduce the oxidative stress thereby enhancing the mitochondrial functions [24]. In certain in-vitro

Figure 3: Role of Mitochondrial DNA in pathogenesis of Cognitive dysfunction [28].

studies on the neurons cells of the hippocampus it has been found that Selenium protects the mitochondrial complexes from effects of hypoxia by normalising the levels of complexes I and IV and also significantly improves activity of complex II and III [25]. The coenzyme Q10 (CoQ10) has been linked with the activity of complexes I and II or III [26]. It has also been associated with reduction of oxidative stress and maintenance of membrane potential of mitochondria [26]. Alpha lipoic acid has shown to be beneficial in treatment of disorders associated with the mitochondrial function. The results of a randomised controlled trial have shown that LA, CoQ10, and creatine when given in combination to patients with mitochondrial disorders reduced oxidative stress, resting lactate levels and also resulted in positive changes in body composition [25,26]. Now, considering the macronutrients broadly the Carbohydrates, proteins and fats, the ratio in which three of these can be taken is still a wide area of research. Some studies suggest that a Ketogenic diet (high in fats, moderate protein and low carbohydrate) has shown beneficial roles in treating mitochondrial dysfunction as in converse to the balanced diets where the brain depends on glucose metabolism for energy, here in KD it relies on ketone bodies produced as a result of fat metabolism in the liver [27].

Role of micronutrients in cognitive functions

Many micronutrients are required for ideal physical growth and neuromotor development [29]. Study indicated that folate and metabolically related B vitamins have specific roles in C1 metabolism and in production of S-adenosylmethionine, a methyl donor essential in the production of neurotransmitters. Optimal Vitamin B status maintains cognitive health in ageing [30]. In an evaluation, accelerated brain atrophy with mild cognitive inabilities was found and plasma homocysteine can be lowered by dietary administration of folic acid, vitamin B 12 (some rich sources of vitamin B 12c is meat, poultry, (shell) fish, eggs like animal food products and milk and other dairy products) [31] and vitamin B6 which is available in Indian traditional food (like wheat and rice) [32]. Pregnant mothers who have severe vitamin B deficiency it has been observed that the infants show abnormalities in behaviour involving the basal ganglia and pyramidal tract. Folic acid deficiency delays in the electroencephalographic patterns as well [33,34]. Several studies have suggested that Vitamin D is a neuroactive steroid that helps in the development of the brain and deficiencies can cause neuropsychiatric disorder such as schizophrenia, Parkinson's disease, Alzheimer's disease, depression and cognitive decline [35]. There are some limited dietary sources of vitamin D in Indian foods like fish, mushroom fortified food, but grains and vegetables are poor sources [36,37]. Vitamin D deficiency affects cerebellar development, It leads to reduction in nerve growth factor and glial cell line derived neurotrophic factor and reduce the expression of p75, the low affinity neurotrophin receptor [38,39].

Experiments have shown that Vitamin E which is mostly seen in edible vegetable oils like sunflower oil, almonds, hazelnut, peanut butter, broccoli and kiwi [40] reduces oxidative stress. High oxidative stress is one common concern in Alzheimer's disease, as induced oxidative stress promotes reactive oxygen species (ROS) production which is destructive to synapses and neurons [41]. Vitamin E may normalise serotonin levels in the brain as it can reduce thiobarbuturic reactive substances, which can be indicators of lipid peroxidation caused by lindane toxicity [42]. Apart from the role of blood coagulation vitamin K, which is derived mainly from meat; egg yolks, liver; butter; fermented foods (eg, cheese, yoghurt and curd) (5). These are also important for a better nervous system. As they help in the formation of sphingolipids; an important class of lipids present in brain cell membranes [44]. Furthermore, evidence shows that K vitamin, menaquinone -4 have anti-inflammatory properties that prevent oxidative stress [44]. A cross -sectional study was published in 2013 which demonstrated that higher vitamin K status is strongly associated with improved cognitive impairment, including improved verbal and memory performance [44].

Zinc Has an important role in the regulation of neurotransmitter systems, antioxidant mechanisms, neurotrophic factors and neuronal precursor cells [45]. Zinc is crucial for foetal and neonatal brain growth and development deficiency leads to brain atrophy and dysfunction [45]. Some fish, egg, milk, nuts and legumes are dietary sources of zinc that are available in traditional Indian dishes [45].

Magnesium which can be derived from pumpkin seeds, flax seeds, spinach [46]. take part in over 600 enzymatic reactions including energy and protein metabolism [46]. In study demonstrated that using magnesium sulphate, acted as a neuroprotectant and prevented cerebral palsy within 2 years [46]. However how magnesium affects neuronal functions has not yet been established but it has been shown that lowered magnesium can cause epileptiform activity and even seizures [46]. Iron plays an important role in many neurodevelopmental processes. It helps in myelination and oligodendrocyte processes; deficiency of iron can cause a lower rate of myelin basic protein 21(MBP21) and even proteolipid protein (PLP) and it affects the hippocampus the brain region responsible for learning and memory [47].

Iodine is required for the synthesis of thyroid hormones which are required for brain development, and deficiency in pregnancy can lead to delayed intellectual development in infants and children. Cretinism has severe consequences that can lead to neurological damages in infants. Iodine deficiency causes an outcome in global loss of 10-15 intellectual quotient points at the population level. Which is one of the reasons for preventable brain damage and mental retardation [48,49]. One of the major causes of iodine deficiency is lack of natural resources of iodine present in diet, hence only fortified salt is the source that every person has access to [49]. Omega 3 fatty acids play an important role to reduce the risk of cognitive decline which can occur due to age related issues. Some traditional western food that are rich sources of omega-3 fatty acid are Mackerel, cod-liver oil, oysters, flax seed, walnut, salmon [50]. Unfortunately, traditional Indian diet is deficient in omega 3 Fatty acid. Although proper modification in diet can make it sufficient to produce enough omega 3 Fatty acid for proper brain functioning. It has been observed in a study higher levels of omega 3 fatty acids were associated with low dementia risk and very less atrophy in medial temporal lobe [51]. It is also known as docosahexaenoic acid (DHA) which are needed for nervous functions. Inadequate DHA affects neurotransmitter metabolism which also influences learning abilities. Previous studies concluded that maternal fatty acid nutrition is important to transfer DHA to infants before and after birth for neural functions [51]. Mfsd2a (major facilitator superfamily domain containing 2a) is a major transporter of DHA into the brain. Lipidomic results showed that in mice those who are deficient in Mfsd2a also showed reduced DHA concentrations in the brain which affected the hippocampus and resulted in anxiety and even microcephaly [52]. But, the fat composition of a diet is both ethnic/region specific as well as income dependent. Indian diets are mostly vegetarian and low in fat. Moreover, the chief sources of fat are of plant origin rather than animal origin. This results in a diet that is relatively low in omega 3 fatty acids [53]. Coenzyme Q 10 is also an antioxidant. An experiment was conducted on symptomatic cerebral vasospasm rabbits and it has been found to prevent neurological defects and brain damage after being treated with it [54]. Coenzyme Q 10 has more scavenging properties, reduces oxidative damage and has anti-inflammatory properties [55].

Other than that traditional Indian diet consists of many phytochemicals/nutrients which have shown a pivotal role in reducing inflammation. There are hundreds of different spices that are specifically used in traditional Indian food which are rich in many phytonutrients that proves to play an important role in better nerve

health (brief information were summarised in table 1) by regulating neurotransmitter pathways, synaptic transmission and other transduction pathways.

Nutrient dense foods are very important for better health and to improve concentration and performance, so it will be beneficial

Food Sources	Nutrients	Effects on Cognition
Lettuce leaves, egg yolk, chicken veal	Choline	Supplementation of choline prevents effects of several neurotoxic agents in offspring [56]
Turmeric	Curcumin	Prevents brain damage due to oxidative stress [57]
Cocoa, Green tea, Red wine, Apples, Onions, Soya beans	Flavonoids	Decline the cognitive damage in senior citizens [58]. Flavonoids improves neuronal functions, helps in neuronal regeneration and responsible for many neuronal signalling pathways [119]
Butter, ghee, coconut oil, meat	Cholesterol	Abnormal cholesterol metabolism links many neurodegenerative disorders such as Alzheimer's disease, Parkinson's disease, Huntington's disease and amyotrophic lateral sclerosis [59]
Black pepper, cocoa, lamb liver	Copper	Disturbed copper level leads to mild to moderate Alzheimer's disease [60]
Fish, poultry, lentils, flattened rice	Iron	Iron deficiency leads to disruption in metabolic process which impairs cognitive function [61]
Cabbage, Cauliflower, Radish, Broccoli	Sulforaphane	In mice model it activates Nrf2-ARE response pathway to reduce brain damage in traumatic brain injury [62]
Fruits, rice and vegetables like tomato, sweet corn	Ferulic acid	It plays an important role in protection of neuronal cells against Amyloid βpeptide toxicity in Alzheimer's disease [63]
Almonds, Cow's Milk Sunflower seeds	Tryptophan, Acetylcholine	Adequate tryptophan improves 5HT metabolism which improves mood, sleep and even cognition [108,109]. Acetylcholine plays an important role in attention and cognition. Even cholinergic signalling in sept hippocampal system improve the memory process [110]
Drumstick	Phytochemicals	It is also known as "Miracle tree" as almost all part of the tree is useful including bark, flowers, leaves, roots and seeds [111]. In a study it has seen drumstick leaves extract maintains the monoamines levels of brain in mice so it can have a protecting effect against Alzheimer's diseases by altering the electrical activities [112]
Flaxseeds	Alpha linolenic acid, dietary fibers, lignans and digestible proteins	. It reduces oxidative stress, high inflammation, lead induced neurotoxicity and it also improves the nerve functions [113, 114].
Saffron	Crocin, Safranal and Crocetin	It has antioxidant properties. and has neuroprotective properties that protects the hippocampus against age related damage [115]. It had modulatory actions onacetylcholinesterase activity, dopaminergic signalling, and free radical scavenging activity. Studies have shown it improves motor functions and seizures in brain diseases [115]
Bitter gourd, Aloe Vera	Vitamin-c, Antioxidants	As per the name it is bitter but it is packed with Vitamin C. It has anti-inflammatory properties, anti-oxidant properties and enhances the 5HT neurotransmitter in the brain thus preventing cognitive decline [116] Aloe vera has immune boosting, anti-viral properties and helps in digestion as well. It is good for detoxification and important tonic for nervous system [121]
Pomegranate	Polyphenols	Loaded with antioxidants and vital nutrients it is a sweet pungent in taste with red outer skin. It improves neurophysiological functional improvement after stroke [118]. Polyphenols are present which at the time of metabolism prevent neuronal damage from free radicals [119]. Oxidative stress is one the primary causes of amyloid β toxicity which gives rise to Alzheimer disease. In the Transgenic mice model, 4% pomegranate was provided with a diet and it showed significant improvement in memory, learning as well as reduction in anxiety [119]
Cranberry, red grapes, blueberry, peanuts, mulberry,	Resveratrol	It is a potent anti-oxidant and possesses anti carcinogenic properties. It has exhibited protective effects in Parkinson, Alzheimer's disease. It improves glutathione levels in the hippocampus and cerebral cortex in case of vascular dementia and helps to delay it [120].

Table 1: Different traditional Indian food content and its importance considering neuro cognition.

if they are incorporated into our daily diet to obtain maximised results. Thus, on the basis of the functional ability of the food on cognition we need to accustomed to the diet to increase neuron resistance to injury which will be helpful in cognitive function.

Different Indian traditional diet on brain health

Balanced diet is very important not only for brain health but also to reduce the risk of metabolic disorder. Though these diets have shown positive results what are the combination need to be included additional research is needed as well [64,65].

Plant based diet includes vegetarian diet and vegan diet and research is still going on about their possible benefits for the health and cognitive functions. Many plant foods are rich in polyphenols like citrus fruits, grapes, berries, cocoa and many more can promote brain health [66] but it is still ambiguous how the cognitive functions are getting improved, it is still unknown further research is needed [67].

Indian diets are very diverse. There are approximately 30 cuisines which are most popular throughout India. Indian traditional foods are also called functional foods because of the presence of many functional components, dietary fibres, prebiotics, probiotics and many more [68].

Traditional South Indian foods are a perfect combination of legumes, coconut, rice, sprouted grams, drumstick and vegetables rich in antioxidants. Dishes in this culture developed from Ayurveda. Various spices are used such as black pepper, curry leaves, turmeric, tamarind, coriander, garlic, mustards and chilies which have many antioxidant properties [69]. Tamarind has many therapeutic properties as well, it has natural phytochemicals, phytohormones and is rich in fatty acids, flavonoid and saponins [70]. There are possible neuroprotective effects of saponins and few studies have shown memory improvement in dementia by improving beta amyloid signalling pathways [71]. Recent studies have suggested that antioxidants present in curry leaves (*M. Koenigii*) reduces cognitive decline [72]. Positive results have been observed in dementia mice. Curry leaf extract improved the memory score and also have indirect felicitation of acetylcholine activity in the brain [73].

North India foods belong to many states of India, packed with different styles of cooking, spices and techniques and vibrancy of cuisine. Variations in chicken and lamb dishes are seen from Rajasthan, Punjab, Delhi. Chicken had potential benefits on cognitive performance. In a study 794 subjects were chosen and positive cognitive changes were observed by calculating the standardized mean difference [74]. Kidney beans (Rajma) one of the popular dishes in northern part of India, are a good source of thiamine, which is important for brain cell functioning as thiamine is used for the synthesis of acetylcholine and acts as an important neurotransmitter for memory. Rajma (kidney beans) contains manganese which is a co-factor for many enzymes that prevents oxidative damage [75]. Spinach is a winter staple food used in many dishes such as daal sag, sarso saag, palak paneer and many. Flavonoids and nitrate have a protective function against cognitive decline through the effects of nitric oxide (NO)status [76]. Saffron is commonly used in Kashmir and it has antioxidant properties as well.

Western Indian Foods- Most of the Western part of India's food patterns are influenced by merchants or trading communities. Parsi delicacies such as Dhansaak are quite popular and are made with lentils, meat and seasonal vegetables and altee paletee is made with eggs for breakfast. As eggs are the primary source of choline and xanthophyll carotenoids, they have positive attributes in memory [77]. In Gujrat predominantly more, vegetarian dishes are seen and one of the popular dishes is kadhi made with chickpea flour. Buttermilk is widely used and has interesting biological properties, in a rat model positive changes in cognitive functions were observed with Krill oil [78].

Eastern Indian foods - Foods in Eastern India are one of the oldest cuisines in the country. Aloo chokha or Aloo bhatay, one of the delicious cuisines, can be paired with any delicacies. In seasonal vegetables such as chorchori and sukto which are widely made in households, sweet potatoes are used in curries have anthocyanin, including antioxidant which have neuroprotective properties [79]. Panta bhaat or pokhalo (fermented rice), litti (sattu filled donuts), pithas (rice pancakes) and chena (ricotta cheese) are common foods consumed in this region. Fermented rice is highly nutritious and beneficial for the gut and has neuroprotection effects against the neurotoxicity [80]. Mustard oils one of the chief cooking oils, rich in Polyunsaturated Fatty acid (PUFA), Medium chain Fatty acids (MCFA) regular intake of these compounds improves cholinergic transmission in the brain possibly improving cognitive functioning [80,81]. Fish intakes are high as many places are near coastal areas. Fresh fish provide eicosatetraenoic acid, which improves cognitive functions and improves the neural framework [82].

North -East Indian foods- part of India are known for its flavourful tribal cuisine. The region is famous for meat delicacies. Fermented foods are widely consumed.as in other parts of India. Fermented mixes such as akhuni (dish made with fermented soya beans). Fermented soya beans prevent memory impairment by modulating brain insulin sensitivity, neuroinflammation and the gut microbiome brain axis [83]. Pig meat is also one of the chief ingredients in cuisine and it also possesses antioxidant properties [84].

Food item	Ingredients	Amount (gm)	Thiamine B1 (mg)	Riboflavin B2 (mg)	Folate B9 (µg)	Vit-K	Calcium	Potassium	Threonine	Dietary Fiber
Curd rice	Rice	30	0.051	0.018	2.925	0.45	2.433	42.6	0.972	1.122
	Curd	70	0.035	0.091	5.99	-	84.7	76.3	3.094	-
Utthapam	Rice	40	0.068	0.024	3.9	0.6	3.244	56.8	1.296	1.496
	Urad dal	40	0.084	0.036	35.5	3.32	22.26	462.8	1.196	4.772
	Onion	10	0.007	0.002	2.968	0.53	1.992	16	0.362	0.116
	Tomato	10	0.003	0.003	1.946	4.98	1.017	20.4	0.271	0.158
Dosa	Rice	50	0.085	0.03	4.875	0.75	4.005	71	1.62	1.87
	Urad dal	50	0.105	0.045	44.37	4.15	27.835	578.5	1.49	5.96
	Potato	30	0.018	0.003	4.65	0.54	2.85	162.3	1.05	0.51
	Mustard seed	5	0.02	0.016	4.74	0.41	20.1	34.7	0.201	0.70
	Curry leaves	5	0.002	0.003	3.51	13.75	19.77	17.52	0.116	0.50
Idli Sambar	Rice	50	0.085	0.03	4.875	0.75	4.055	71	1.62	1.87
	Urad dal	50	0.105	0.045	44.37	4.15	27.835	578.5	1.49	5.96
	Arhar dal	30	0.105	0.04	14.99	2.18	13.89	287.1	0.972	4.545
	Dramstick	20	0.008	0.014	54.6	-	6.66	83.8	0.766	1.368
	Pumpkin	20	0.006	0.004	12.55	16.74	4.82	37.5	0.694	0.506
	Carrot	10	0.004	0.003	6.32	1.83	4.106	26.7	0.3	0.449
	Tamarind	5	0.017	0.003	2.367	0.08	7.45	41.8	0.163	0.265
Alu paratha	Refined flour	45	0.067	0.027	7.31	0.45	1.08	66.6	1.16	1.124
	Potato	45	0.022	0.004	6.232	0.81	3.852	213.3	1.836	0.760
	Onion	10	0.007	0.002	2.968	0.53	1.992	16	0.362	0.116
Dhokla	Besan	40	0.14	0.06	72.8	0.6	18.52	382.8	1.296	6.06
Palak paneer	Paneer	50	0.01	0.05	46.65	-	238	31.76	2.185	-
	Spinach	100	0.16	0.10	142	325	82.29	625	4.70	2.38
Rajma chawal	Rajma	70	0.21	0.133	221.2	3.43	88.2	926.8	2.92	11.599
	Onion	30	0.012	0.003	8.664	1.59	6.309	51.3	0.63	0.735
	Rice	30	0.051	0.018	2.92	0.45	2.433	42.6	0.972	1.122
Sukto	Bitter gourd	20	0.012	0.003	10.29	0.91	3.254	56.4	0.944	0.698
	Papaya	20	0.004	0.006	5.95	0.49	4.544	4.6	0.57	0.456
	Drumstick	20	0.008	0.014	12.55	-	6.66	83.8	0.766	1.368
	Brinjal	20	0.014	0.022	6.442	2.70	3.406	45.4	0.646	0.826
	Mustard seed	10	0.055	0.033	9.488	0.41	40.2	69.4	1.402	1.41

Labra	Potato	30	0.018	0.003	4.653	0.54	2.85	162.3	1.05	0.513
	Brinjal	30	0.021	0.033	9.663	4.05	5.109	68.1	0.969	1.239
	Tomato	30	0.009	0.009	5.838	5.15	3.051	61.2	0.813	0.531
	Onion	10	0.004	0.001	2.888	0.53	2.10	17.1	0.21	0.245
Hilsa vapa	Hilsa	100	0.01	0.04	2875	0.94	19.82	341	5.8	-
	Mustad seed	10	0.055	0.033	9.488	0.41	40.2	69.4	1.402	1.41
Litti	Wheat flour	40	0.168	0.06	11.68	0.4	12.37	124.4	4.108	4.544
	Sattu	60	0.22	0.14	139.8	0.9	90	561	2.13	15.13
Momo	Refined flour	20	0.03	0.012	3.25	0.2	0.48	29.6	0.516	0.552
	Chicken	50	0.05	0.03	5.22	13.5	6.455	147	2.83	-
	Onion	30	0.021	0.006	8.904	1.59	1.992	16	0.362	0.348
Thukpa	Noodles	20	0.03	0.012	3.25	0.2	0.48	29.6	0.516	0.552
	Chicken	20	0.02	0.012	2.088	5.4	2.582	59	1.132	-
	Carrot	10	0.004	0.003	2.404	1.83	3.509	27.3	0.398	0.418
	Onion	10	0.007	0.002	2.968	0.53	1.992	16	0.362	0.116
	Cabbage	10	0.003	0.005	4.636	11.7	5.176	23.3	0.376	0.276
Chicken curry	Chicken	100	0.1	0.06	10.44	27	12.9	294	5.66	-
	Onion	10	0.007	0.002	2.968	0.53	1.992	16	0.362	0.116
Fish Curry	Fish	100		0.04	1263	1.03	39.37	282	2.90	-
	Onion	10	0.007	0.002	2.968	0.53	1.992	16	0.362	0.116
	Potato	30	0.018	0.003	4.653	0.54	2.85	162.3	1.05	0.513

Table 2: Different traditional Indian recipes and its contribution towards neuro cognition.

*Derived from Indian Food Composition table book, 2017 [122].

Gut microbiota functions with the brain and benefit of traditional foods

Probiotics have beneficial effects on human health, they help to build immunity, reduce pathogenic microorganisms and protect DNA, protein and lipids from oxidative stress [86]. World Health Organisation (WHO) defined probiotics are live organisms that if taken in adequate amounts are beneficial to human health. Many microbes are present in our gastrointestinal tract which is collectively known as the gut microbiome and is mostly present in colon [87]. In reports it has observed that gut microbes may play an important role in brain diseases including anxiety, depression and even chronic pain [88].

In the human intestine many microorganisms are present and underlying causes of psychiatric disorders can also occur due to intestinal dysbiosis [88,89]. It has been found in previous studies that there is communication between microbes of G.I tract and brain. Data indicates that gut microbes communicate with the brain through neural networks. endocrine and immune pathways [90]. Microbial actions can be altered due to sleep patterns, food patterns [90] and exposure to antibiotics [91]. In Indian diet pulses are widely used like chana, rajma, moong, tur, urad, masoor, soybean, horse gram and many more, in a study it has been observed pulses are rich in fermentable fibre and has phenolic compounds that have the potential to modify baseline function within the gut microenvironment (microbiota and epithelial barrier), thereby mitigating gut-associated diseases [92]. Even Prebiotics like raw banana, garlic, onions which are widely used in Indian curries has beneficially affect the host by stimulating growth, activity or both of specific intestinal bacteria [93].

Tea and coffee are widely popular in Indian households containing phytochemicals which can alter gut microbiota diversity and function and could manipulate health. It can modify the composition of gut microflora through selective stimulation of proliferation or inhibition of certain microbial communities in the intestine [95].

Diet plays an important role in microbiome development and a high fat diet (HFD) affects the brain functioning and impairs synaptic plasticity [97]. A high sucrose diet can alter gut microbes which impairs brain functionality and its effects on long term memory, short term memory and reversal training as compared to a normal diet [96] whereas 15% low calorie diet(LCD) increases hippocampus functions and brain derived neurotrophic factors and positively increases spatial memory in adulthood [98,99].The termination of smoking increases microbial diversity in the gut [100] and even alcohol consumption can cause oxidative stress, intestinal Hypermeability to luminal bacterial products which can lead to gastric intestinal inflammation [101].

Other than Gut microbiota functions with the brain many hormones have shown a pivotal role in cognitive functions. Recent findings have shown that many gut hormones are associated with the brain to influence cognition and emotions of an individual's [90] (It is briefly summarised in Table 3) by regulating synaptic transmission, by advancing hippocampal neurogenesis and other transduction pathways.

These hormones act on different tissues for food intake but also have effects on the brain. Gut hormones influence our memories, emotions and even overall mental outcome.

Hormones	Sources	Role in Cognition
Leptin	Adipocytes	Receptors which are activated by leptin are involved in cognitive processes, even though they have shown antidepressant properties [97]. Leptin improves facilitating NMDA receptors which enhance Ca^{2++}levels and activates phosphoinositide 3 kinase which improves synaptic plasticity of the hippocampus [98]
Insulin	Pancreas	It increases the metabolism of the local hippocampal and regulates synaptic plasticity [99]. It has been shown to improve cognition and modulate beta amyloid in early Alzheimer's disease [100].
Ghrelin	Stomach	It controls appetite and acyl ghrelin is used to delay the early signs of Alzheimer's disease [102] Studies on depressed mice have shown that lower Ghrelin affects Brain derived nerve growth factor (BDNF) and reduces BDNF through the cAMP CREB signalling pathway [103]. Ghrelin triggers adaptive responses by advancing hippocampal neurogenesis from neural stem cells which prevents cognitive decline [104]
Cholecystokinin (CCK)	Nervous system (CNS)	CCK with opioid peptides in the limbic system proposed that there might be an opioid CCK link that might affect the modulation of stress and anxiety [105]. CCK receptors are divided into 2 types according to amino acid composition CCK -A (present in a few parts of the nuclei of the brain) and CCK -B (predominant receptor subtype of brain). Studies also indicate that subgroups play an important role in satiety, anxiety, learning and memory [105].
Glucagon- like peptide-1(GLP-1)	Small intestine	GLP-1 is also present in the central nervous system (CNS). Currently it has gained attention as there is a possible link between metabolism and brain impairment. GLP-1 protects beta cells from apoptosis, which prevents dementia [106]. It has also seen GLP-1 influences the dopamine levels in Parkinson's diseases. In animal models it inhibits oxidative stress and inflammation and reduces hippocampal neurodegeneration [107,108]

Table 3: Different gut hormones and its role in cognition.

Conclusion

Diet plays an important role in brain health and mental abilities. Many studies have suggested that food plays an important role in enhancing cognitive abilities. Balanced diets are important, popular commercial diets are there for drastic loss in weight, but they might hamper our normal brain functionality. Many pathways are involved in a bidirectional communication between the gut microbiota and brain, numerous factors are responsible for it such as genetic, health status and most importantly dietary patterns. The role of mitochondria had been proven to have a pivotal role in brain and neurodevelopment. Impaired mitochondrial ATP production is associated with cognitive dysfunction. Several dietary foods and micronutrients play crucial role on cognitive abilities. Many polyphenols have neuroprotective functions that protect neurons from neurotoxicity. Traditional Indian diet consists of many phytochemicals/nutrients which have shown a pivotal role in reducing inflammation. There are hundreds of different spices that are specifically used in traditional Indian food which are rich in many phytonutrients that proves to play an important role in better nerve health as well as better mitochondrial functions like turmeric prevents brain damage due to oxidative stress even saffron has neuroprotective properties that protects the hippocampus against age related damage. Many studies have proved that specific nutrients can affect our brain development. The local diet does have several Alpha Lipoic acids, Coenzyme Q 10 that affect our brain function ability as well but how much quantity needs to be taken is still not answered, even though how local foods can influence brain function and its portion need to be included in the diet still unanswered further detail research required.

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Conflict of Interest

The authors declare no conflicts of interest.

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