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TAURINE AMINO ACIDS AND BRAIN DEVELOPMENT: A REVIEW

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ABSTRACT

This study reviews taurine amino acid research on brain development. Taurine, a brain-abundant non-protein amino acid, is essential for neuronal differentiation, migration, and survival. This research reviews the effects of taurine depletion and supplementation on brain development and their processes. The report also discusses current knowledge gaps and offers future research on taurine's role in brain development.

Keywords : GABA, Alzheimer, Parkinson, ROS, sulphur.

Introduction

Taurine is a non-essential amino acid which is widely distributed in animal tissues, especially in the brain, heart, liver, and muscles. It is a sulfur-containing amino acid, which is not incorporated into proteins, but plays an essential role in several physiological functions. This essay will discuss the biochemical and physiological roles of taurine, its dietary sources, metabolism, and its health benefits.

Taurine has several biochemical and physiological roles in the body. It is an osmoregulator and stabilizes cell membranes by increasing the fluidity of the lipid bilayer. Taurine also acts as an antioxidant, protecting cells from oxidative stress and inflammation (Schaffer *et al*., 2010). Taurine is also involved in the regulation of calcium homeostasis, neurotransmission, and the modulation of immune function (Ripps and Shen, 2012).

Taurine in Cardiovascular Health: Taurine has been found to have a beneficial effect on cardiovascular health. It has been shown to lower blood pressure and improve cardiac function (Zhang *et al*., 2017). Taurine supplementation has been found to decrease oxidative stress and inflammation in patients with heart failure (Xu *et al*., 2016). Taurine also plays a role in the prevention of atherosclerosis, by reducing the production of pro-inflammatory cytokines and inhibiting the proliferation of smooth muscle cells (Schaffer *et al*., 2010). Taurine has also been found to play an important role in vision. It is present in high concentrations in the retina and is essential for the development and maintenance of the visual system (Hayes *et al*., 2018). Taurine is involved in the regulation of photoreceptor cell function and the protection of photoreceptor cells from oxidative stress (Liu *et al*., 2019). Taurine is found in animal-based foods, such as meat, fish, and dairy products. Vegetarians and vegans may have lower taurine levels than those who consume animal-based products (Schaffer *et al*., 2010). However, the body can synthesize taurine from cysteine, methionine, and vitamin B6.

Taurine is synthesized in the liver from cysteine and methionine, and it is also obtained from the diet. The body can also convert taurine to taurocholic acid, which is an important component of bile acids (Ripps and Shen, 2012). Taurine is a sulfur-containing amino acid that plays an essential role in several physiological functions. It is involved in the regulation of calcium homeostasis, neurotransmission, and immune function. Taurine has been found to have a beneficial effect on cardiovascular health, vision, and the prevention of atherosclerosis. Taurine is found in animal-based foods, but the body can synthesize taurine from cysteine, methionine, and vitamin B6. Taurine supplementation may be beneficial in certain medical conditions, but further research is needed to fully understand the health benefits of taurine.

Children and Adult Brain Development and Taurine

Taurine, a sulphur-containing amino acid, is abundant in skeletal muscle, brain, and heart. Taurine, a non-essential amino acid, is critical to the body and assumed to be involved in many physiological functions. Taurine research focuses on brain development. This review summarises current knowledge of taurine's role in brain development. Researchers believe taurine has several important brain roles. GABA receptors, which regulate brain activity, interact with taurine. Brains have GABA receptors. Taurine increases GABAergic neurone function and potency, which may affect brain maturation (Wu *et al*., 2019). Taurine, an antioxidant, may help brain growth. Oxidative stress harms the brain due to its high oxygen consumption and low antioxidant capacity. Taurine protects the brain from oxidative damage as an antioxidant (Kang *et al*., 2020). Taurine regulates neurotransmitters, antioxidants, and brain calcium signalling. Taurine affects neuronal calcium signalling, which is crucial

since calcium ions are second messengers in many cellular signalling pathways (Schaffer *et al*., 2010). Calcium signalling is important in many developmental processes, which could affect brain development. Taurine may protect developing brains. Studies show that taurine protects against brain-damaging attacks. Hypoxia, neurotoxins, and oxidative stress (Li *et al*., 2017). Taurine protects and improves neuronal cell survival.Taurine may affect brain gene expression. Many studies have shown that taurine can affect the expression of brain-related genes. Taurine increases BDNF (brain-derived neurotrophic factor), which promotes neurone survival and adaptability (Kang *et al*., 2010). To conclude, taurine may aid brain development. Taurine's roles as a neurotransmitter regulator, antioxidant, calcium signalling modulator, neuroprotectant, and gene expression regulator support its role in brain development and function. Further research is needed to understand how taurine affects brain development and whether it might treat neurological diseases.

Taurine controls neurotransmitters

Neurotransmitter release controls taurine's brain effects. Neurotransmitters allow neurones to communicate. Gamma-aminobutyric acid is a major brain neurotransmitter (GABA). GABA, an inhibitory neurotransmitter, inhibits brain neurones. GABA performs this crucially. Taurine interacts with GABA receptors to alter GABA's brain effects. Taurine boosts GABA's brain actions, according to several research. Taurine increases GABA binding to its receptors, which increases GABA's inhibitory effects (Wu *et al*., 2019). Taurine can also boost GABAergic neurone function, which could affect brain function (El Idrissi *et al*., 2003). Taurine affects several brain neurotransmitter systems in addition to the GABA system. Taurine increases brain dopamine release (Wu *et al*., 2019). Dopamine, a neurotransmitter, affects movement, reward, and motivation. Taurine interacts with serotonin receptors; however, the exact mechanism is unknown (El Idrissi *et al*., 2003). We don't know how taurine regulates neurotransmitters. Taurine, however, may regulate neurotransmitter synthesis and breakdown enzymes. ц (Wu *et al*., 2019). Taurine increases brain GABA levels and its inhibitory power by inhibiting this enzyme. Neurotransmitter regulation requires brain taurine. Taurine may impact brain function due to its ability to enhance GABA and interact with other neurotransmitter systems. Further study is needed to understand how taurine affects neurotransmitters and whether it can treat neurological illnesses.

Taurine's Antioxidant Properties

Taurine, a naturally occurring amino acid, is abundant in the brain, heart, and liver. Taurine's antioxidant qualities are among its many benefits. Oxidative stress occurs when ROS generation exceeds antioxidant neutralisation. ROS are formed when oxygen generation exceeds body production. Reactive oxygen species (ROS)–molecules produced by biological metabolism–can damage cells and tissues if not neutralised. Antioxidants neutralise ROS and prevent damage. Taurine has antioxidant effects in the brain, heart, and liver. ц (Hansen *et al*., 2018). Taurine also boosts ROS-removing enzymes like catalase and SOD (Kim *et al*., 2014).

Taurine protects against oxidative damage in several disease models, according to studies. Taurine protects against brain oxidative damage in animal models of Alzheimer's and Parkinson's disease (Zhao *et al*., 2018). ц (Soltani *et al*., 2018). Taurine protects the heart against oxidative damage in animal models of heart failure and diabetes (Hansen *et al*., 2018). Hansen *et al*., 2018 published these findings. (El-Sayed, 2019). Taurine's antioxidant mechanisms are yet unclear. Taurine, on the other hand, modulates ROS-forming or ROS-neutralizing enzymes. Taurine reduces NADPH oxidase activity, which forms reactive oxygen species (ROS) (Kim *et al*., 2014). Taurine reduces ROS and oxidative damage by inhibiting this enzyme. Taurine is an important antioxidant that protects numerous biological tissues from oxidative stress. Due to its ability to scavenge reactive oxygen species (ROS), boost the effectiveness of other antioxidants, and control ROS-producing or neutralising enzymes, taurine may help prevent and treat oxidative stress-related illnesses. Further research is needed to fully understand taurine's antioxidant capabilities and its potential use in treating oxidative stress-related diseases.

Taurine Regulates Calcium Signaling

Cells use calcium signalling to contract muscles, release neurotransmitters, and express genes. Taurine affects calcium transport in several cell types. Taurine is abundant in the brain, heart, and skeletal muscles. Taurine regulates calcium signalling, which has therapeutic implications.

Taurine modulates calcium signalling via several methods. Taurine increases L-type calcium channel activity in cardiac myocytes, which raises intracellular calcium ($[Ca^{2+}]i$) (Schaffer *et al*., 1996). Taurine also affects muscle cell sarcoplasmic reticulum ryanodine receptors (RyR), the main calcium release channels. Taurine increases cardiac myocyteRyR activity and $[Ca^{2+}]i$ (Schaffer *et al*., 1996). Taurine controls calcium buffering.

increases brain calbindin-D28k production. Calcium-binding proteins regulate $[Ca^{2+}]i$ via sequestering calcium (Kontro *et al*., 1994). Taurine may regulate calcium-ATPases, which regulate calcium equilibrium in the body. Taurine boosts rat skeletal muscle calcium-ATPase activity (Kontro *et al*., 1994).

Taurine may treat cardiovascular, neurological, and metabolic diseases. ц (Schaffer *et al*., 2009). Taurine may also prevent neurodegeneration and cognitive impairment (El-Idrissi and Trenkner, 1999). Taurine improves glucose homoeostasis and insulin sensitivity, lowering diabetes risk (Hansen *et al*., 2013). Taurine regulates calcium signalling in many cells and organs. It regulates calcium channels, intracellular calcium release, and calcium buffering mechanisms. All modulate calcium signalling. Taurine may treat cardiovascular, neurological, and metabolic diseases. Further research is needed to understand taurine's effects on calcium signalling and its medicinal potential.

Taurine neuroprotection

Taurine, a sulphur-containing amino acid, is distributed throughout the body, especially in the central nervous system (CNS). Taurine is neuroprotective in several animal models of neurodegenerative diseases and traumas. This paper discusses taurine's neuroprotective and therapeutic properties.

Taurine's Anti-Inflammatory, Anti-Oxidative, and Anti-Apoptotic Actions Are Neuroprotective. Anti-inflammatory, anti-oxidative, and anti-apoptotic qualities make taurine neuroprotective. Taurine inhibits pro-inflammatory cytokines

and chemokines in activated microglia and astrocytes, reducing neuroinflammation (Chang *et al*., 2015).

Taurine also neutralises free radicals and reduces central nervous system oxidative stress (Wu *et al*., 2016). Taurine increases brain SOD and catalase levels (Wu *et al*., 2016).

Taurine suppressed apoptosis in various animal models of neurodegenerative diseases and traumas. Taurine prevents caspase-3 activation and DNA breakage in neurones under oxidative stress or excitotoxicity (Wu *et al*., 2016). Taurine reduces neuronal death in animal models of traumatic brain injury and ischemia/reperfusion injuries (Kontro *et al*., 1994).

Patient Treatment Implications

Taurine may cure neurological diseases and traumas. Taurine protects neurones in animal models of Alzheimer's, Parkinson's, Huntington's, and multiple sclerosis (Wu *et al*., 2016). Taurine reduces amyloid-beta deposition and neuroinflammatory reactions in animal models of Alzheimer's disease, improving cognition (Chang *et al*., 2015). Taurine improves motor deficits and dopaminergic neurone loss in animal models of Parkinson's disease (Wu *et al*., 2016).

Taurine has neuroprotective qualities in several animal types of injury. Taurine prevents neuronal death and improves neurological outcomes in animal models of ischemia/reperfusion, traumatic brain, and spinal cord injury (Kontro *et al*., 1994). Taurine reduces inflammation, oxidative stress, and neuronal apoptosis in these animals.

Taurine has neuroprotective properties like anti-inflammatory, anti-oxidative, and anti-apoptotic. Further research is needed to understand taurine's neuroprotective and therapeutic effects

Taurine, a naturally occurring amino acid-like molecule, is abundant in many bodily tissues. Several studies have demonstrated that taurine regulates many genes involved in physiological and pathological processes.

Taurine regulates gene expression via multiple molecular mechanisms

Taurine, a cell osmolyte, regulates gene expression. Taurine can act as an osmolyte to maintain cellular homoeostasis under environmental challenges such high temperature or osmolarity. Taurine regulates cell survival and stress response genes in response to osmotic stress. Taurine influences gene expression via these genes. Brocker (2012).

Taurine also affects lipid metabolism genes. Taurine modulates lipid synthesis and fatty acid oxidation genes, suggesting it may regulate lipid metabolism Hoffman *et al.* (2009). Taurine supplements also improve lipid profiles and lessen cardiovascular disease risk in animal models and humans (Ripps and Shen, 2012).

Taurine also alters immune response genes. Many studies have demonstrated that taurine can control the expression of cytokines and chemokines, which regulate immunological responses Chen *et al.* (2019). Taurine also boosts the innate immune response's natural killer cells and macrophages. Bailu *et al.* (2020).

Finally, taurine can alter oxidative stress-controlling gene expression. Taurine alters antioxidant enzyme synthesis, including superoxide dismutase, catalase, and glutathione peroxidase. Oxidative stress protection requires these enzymes. Chen *et al.* (2019). Taurine regulates gene expression and is very flexible. Taurine influences gene expression via multiple molecular mechanisms. These pathways affect osmotic stress, lipid metabolism, immunological response, and oxidative stress. Research is needed to understand how taurine impacts gene expression. Taurine's therapeutic potential in various degenerative illnesses must be researched.

Brain Development Without Taurine

Brain development requires taurine. Taurine produces and differentiates neurones, astrocytes, and oligodendrocytes in foetal and neonatal development. It also regulates GABA and glutamate neurotransmitter networks. Taurine deficiency during brain development can affect cognitive and behavioural functioning for life.

Taurine deficiency in early postnatal animals causes neuronal atrophy and cognitive impairment. Huxtable and colleagues found in 1981 that early postnatal rats fed a taurine-free diet had lower brain weight, neuronal degeneration, and behavioural deficits. El Idrissi *et al*. found that early postnatal taurine deficiency in mice affected spatial learning and memory and hippocampal GABA and glutamate levels (2003).

Clinical Relevances

Taurine deficiency can cause epilepsy, Alzheimer's, and autism. Taurine has anticonvulsant properties and may impact the epilepsy-related GABAergic system. Zhang *et al*. found that taurine reduced epileptic seizures in rats (2004). Taurine is also neuroprotective in Parkinson's disease. Han *et al*. studied an Alzheimer's mice model (2013). Taurine reduced cognitive impairments and amyloid-beta buildup.

Taurine deficiency may cause autism spectrum disorder (ASD). El-Ansary *et al*. discovered lower plasma taurine levels in autistic children than controls (2011). Geier *et al*. (2013) found that children with autism have lower urine taurine levels than controls.

Taurine deficiency during brain development can affect cognitive and behavioural functioning for life. Epilepsy, Alzheimer's, and autism have been related to choline deficiency, which is essential for brain development. Further research is needed to fully understand taurine's involvement in brain development and its potential neurological disease treatments. Taurine May Cure Neurological Diseases.

Taurine, a non-essential amino acid, is abundant in many tissues, including the brain. Taurine may treat several neurological disorders, according to research. Despite its unknown role in the body. This article will address contemporary taurine studies for neurological diseases.

Azuma and colleagues found in 1992 that taurine injections protected rats' brains against ischemia. In another study, Huxtable and colleagues (1992) demonstrated that taurine can protect neurones from excitotoxicity. Overstimulated neurones die from excitotoxicity.

Epilepsy causes frequent seizures. Taurine prevents seizures. Taurine reduced seizures in rats with epilepsy, according to El Idrissi and colleagues (2003). In another study, Yang *et al*. (2014) found that taurine supplementation improved cognition and reduced seizure activity in epileptic rats.

Parkinson's illness affects motor function. Taurine protects Parkinson's disease-damaged dopaminergic neurones. Taurine injections protected dopaminergic neurones in Parkinson's disease mice. Yamada and colleagues conducted 2014 research. Alzheimer's disease, a neurodegenerative disease, impairs memory and cognition. Taurine protects the brain and may treat Alzheimer's disease. Wu *et al*. found that taurine supplementation in mice with Alzheimer's disease improved cognition and reduced amyloid-beta plaques (2018).

Taurine may treat neurological disorders. It may treat neurological illnesses like Alzheimer's, Parkinson's, and epilepsy due to its neuroprotective properties. Although more research is needed to understand taurine's brain effects,

Table 1 : Taurine-containing foods

Food/Dairy Product	Taurine Content (mg/100g)
Beef (cooked)	47
Chicken (cooked)	41
Pork (cooked)	39
Lamb (cooked)	37
Fish (raw)	136
Shrimp (cooked)	183
Scallops (cooked)	125
Clams (cooked)	244
Oysters (cooked)	195
Cheese (Parmesan)	2
Cheese (Cheddar)	3
Cheese (Swiss)	3
Milk (whole)	3
Yogurt (plain, whole)	8
Eggs (cooked)	12

USFDA (2022), NCBI (2022)

Taurine content varies by source and processing.

Conclusions and Recommendations

Mammalian tissues, especially the heart, brain, and skeletal muscles, contain taurine, a sulfonic amino acid. Some bacteria have modest quantities. Taurine regulates osmoregulation, antioxidation, neurotransmitter release, and ion channels without being integrated into proteins. . This page discusses taurine's physiological roles, the health benefits of taking taurine supplements, and the future of taurine research. Taurine is involved in many physiological processes and deficiency has been associated to cardiovascular disease, diabetes, and neurological disorders. Taurine regulates calcium, potassium, and sodium channels, as is well known. Normal cellular activities require this regulation. Taurine's anti-inflammatory properties lessen the risk of chronic illnesses. Antioxidant taurine protects cells against oxidative stress.

Taurine supplements may improve health, especially for persons with several health issues. Taurine lowers blood pressure, improves lipid profiles, and reduces atherosclerosis risk. Taurine improves diabetes by increasing insulin sensitivity and glucose tolerance. Increasing glucose tolerance did this. Taurine supplements have also been demonstrated to benefit neurological diseases like Parkinson's, Alzheimer's, and epilepsy.

Taurine has been studied extensively, yet its physiological activities and health benefits remain unclear. Research is needed to determine how taurine modifies ion channels and which channels it affects. Taurine supplementation's health benefits must be examined in larger human trials, particularly randomised controlled trials. Taurine supplementation, especially at higher doses, needs more safety and toxicity studies. Higher doses especially. Conclusion: Taurine is an important sulfonic amino acid involved in many physiological processes. Osmoregulation, antioxidation, neurotransmitter release, and ion channel regulation are examples. Taurine deficiency has been connected to many diseases, and taurine supplementation can enhance one's health, especially for those with specific health issues. .

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