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## **Role of Vitamin B-3 and Ionized Calcium-binding Adapter Molecule 1 (IBA-I) on the Brain**

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### **Abstract**

Vitamin B3 also known as Niacin, is a critical nutrient with roles in cellular energy production, neuroprotection, and anti-inflammatory processes. Research indicates that niacin positively influences brain health through its conversion into nicotinamide adenine dinucleotide (NAD<sup>+</sup>), a coenzyme essential for cellular metabolism and repair. NAD<sup>+</sup> levels are particularly important for brain cells, as they influence mitochondrial function and reduce oxidative stress, both key for neuroprotection. Ionized calcium-binding adapter molecule 1 (IBA1), on the other hand, is a protein expressed in microglia, the brain's resident immune cells, and is involved in the regulation of inflammatory responses in the central nervous system (CNS). IBA1's role in modulating neuroinflammation makes it a valuable marker for microglial

activation in various neurological conditions, including neurodegenerative diseases. The interplay between niacin and IBA1 may hold significant implications for brain health, particularly in the context of neuroinflammation and neurodegeneration. Niacin's ability to modulate inflammation may influence IBA1 expression and microglial activation, suggesting a potential therapeutic pathway. Understanding how niacin supplementation affects IBA1 levels could offer insights into treatments for neurodegenerative diseases such as Alzheimer's and Parkinson's, where chronic inflammation plays a critical role. This review explores the potential therapeutic benefits of niacin through its effects on IBA1 expression, aiming to highlight its role in neuroprotective strategies for brain health.

**Keywords:** Niacin, IBA1, Brain, Neurodegenerative Diseases, Alzheimer's Diseases, Parkinson's Diseases

### **Introduction**

Vitamin B3, also known as Niacin, is a water-soluble vitamin that plays a crucial role in various physiological functions within the human body. It is an essential nutrient, meaning the body cannot produce it independently and must obtain it through dietary sources or supplements<sup>[1]</sup>.

Iba1 (Ionized calcium-binding adapter molecule 1), also known as Aif1, is a protein predominantly expressed in microglia, the resident immune cells of the central nervous system. It plays a crucial role in various neurological conditions and has been extensively studied due to its potential as a biomarker for neuroinflammation and neurodegeneration. This review synthesizes recent findings on Iba1's structure, function, and implications in neurological diseases, drawing from reputable sources [2].

### Chemical Structure and Forms of Vitamin B3

Chemically, Vitamin B3 exists in two primary forms: Nicotinic acid and nicotinamide (also known as niacinamide). Both forms are converted into coenzymes nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP) in the body, which are essential for energy metabolism, DNA repair, and cell signaling [2].

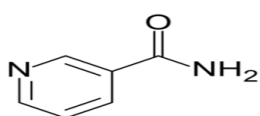


Fig 1: Chemical structure of Vitamin B3

### Biological Functions of Niacin

Niacin participates in various biological processes, including:

- Energy Production:** Niacin is a vital component of NAD and NADP, which act as coenzymes in numerous enzymatic reactions involved in cellular energy production. These reactions are crucial for the metabolism of carbohydrates, fats, and proteins.
- DNA Repair:** Niacin plays a role in DNA repair mechanisms, helping to maintain the integrity of genetic material and prevent mutations.
- Cell Signaling:** Niacin influences cell signaling pathways involved in cell growth, differentiation, and apoptosis (programmed cell death).
- Cholesterol Management:** Niacin has been shown to increase levels of high-density lipoprotein (HDL) cholesterol, commonly referred to as "good" cholesterol, while decreasing levels of low-density lipoprotein (LDL) cholesterol and triglycerides, thereby reducing the risk of cardiovascular disease.
- Skin Health:** Topical niacinamide has been used in skincare products for its anti-inflammatory properties and ability to improve skin barrier function, reduce hyperpigmentation, and alleviate symptoms of conditions such as acne and rosacea.

### Food Sources



Fig 2: Food supplements for niacin

Niacin is found in a variety of foods, including:

**Meat:** Particularly in poultry, beef, and fish; **Whole Grains:** Such as wheat, barley, and rice; **Legumes:** Like lentils, beans, and peanuts; **Nuts and Seeds:** Including almonds, sunflower seeds, and peanuts; **Vegetables:** Such as mushrooms, avocados, and potatoes.

### Deficiency and Toxicity

Niacin deficiency can lead to a condition known as pellagra, characterized by symptoms such as dermatitis, diarrhea, dementia, and death if left untreated. Pellagra was prevalent in populations relying heavily on corn-based diets lacking in niacin and tryptophan, an amino acid that can be converted into niacin in the body [3,4].

On the other hand, excessive intake of niacin supplements can lead to niacin toxicity, resulting in symptoms such as flushing, itching, liver damage, and impaired glucose tolerance. However, these adverse effects are rare when niacin is consumed from food sources.

Niacin is a vital nutrient with diverse physiological functions, including energy metabolism, DNA repair, cell signaling, and cholesterol management. Adequate intake of niacin through a balanced diet is essential for maintaining overall health and preventing the development of deficiency-related conditions such as pellagra. However, supplementation should be approached with caution to avoid the risk of toxicity [4].

### Niacin: Its Uses and Pharmacological Effects of Vitamin B3

Vitamin B3 known as nicotinic acid, is a water-soluble B-complex vitamin essential for various physiological functions in the human body. Its diverse roles range from energy metabolism to cardiovascular health, making it a crucial component of a balanced diet. This article delves into the multifaceted uses and pharmacological effects of niacin, shedding light on its significance in healthcare [1].

### Metabolic Functions of Vitamin B3

One of the primary roles of vitamin B3 is its involvement in energy metabolism. It serves as a precursor for the coenzymes nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP), which play key roles in cellular respiration and energy production. Vitamin B3 facilitates the conversion of carbohydrates, fats, and proteins into usable energy, thus contributing to overall metabolic health [5].

### Cardiovascular Health benefits of Vitamin B3

Niacin has garnered attention for its beneficial effects on cardiovascular health. It is known to increase high-density lipoprotein (HDL) cholesterol levels while decreasing low-density lipoprotein (LDL) cholesterol, triglycerides, and lipoprotein (a) concentrations. These lipid-modifying effects make niacin a valuable tool in the management of dyslipidemia and prevention of cardiovascular diseases [6].

### Dermatological Applications associated with Vitamin B3 consumption

In dermatology, niacin has been utilized for its vasodilatory properties. When applied topically, niacin causes vasodilation, leading to increased blood flow to the skin. This effect is harnessed in skincare products to improve skin

texture, enhance moisture retention, and promote a healthy complexion [7].

**Psychiatric Disorders associated with Vitamin B3 consumption**

Vitamin B3's involvement in neurotransmitter synthesis and regulation has sparked interest in its potential role in the management of psychiatric disorders. Research suggests that niacin may have therapeutic benefits in conditions such as schizophrenia, depression, and anxiety disorders, although further studies are needed to elucidate its mechanisms of action and clinical efficacy [8].

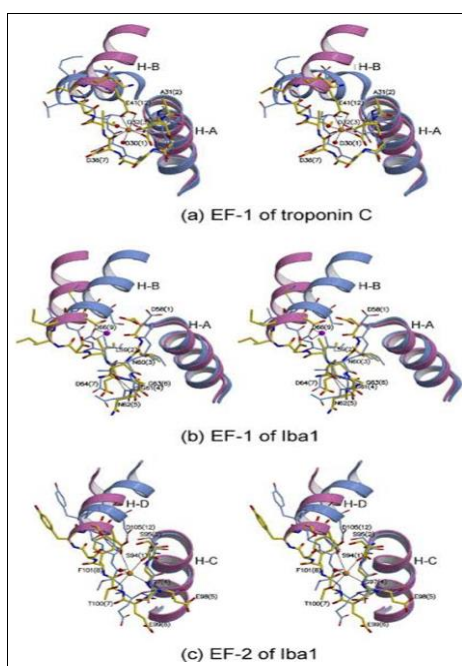
**Pharmacological Effects of Niacin**

Niacin exerts its pharmacological effects through various mechanisms. As a precursor to NAD and NADP, it participates in redox reactions and energy metabolism pathways. Additionally, niacin activates G-protein-coupled receptors, namely GPR109A and GPR109B, which mediate its lipid-modifying effects. Furthermore, niacin-induced vasodilation is mediated by the release of prostaglandins, particularly prostaglandin D2 and prostaglandin E2, leading to relaxation of vascular smooth muscle cells [9].

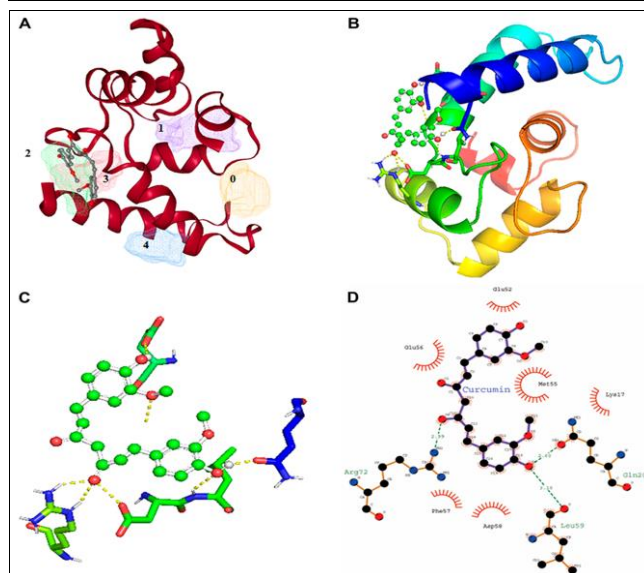
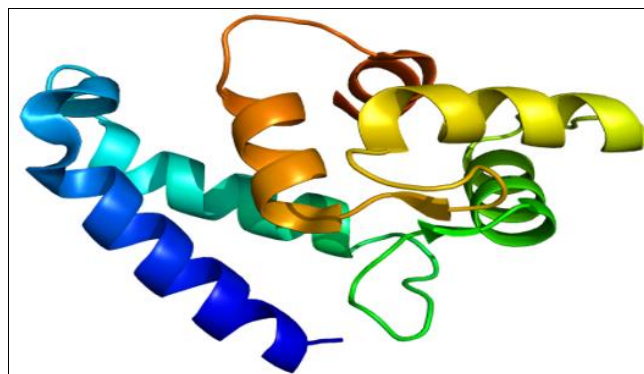
In conclusion, niacin plays a pivotal role in metabolic processes, cardiovascular health, dermatological applications, and potentially psychiatric disorders. Its pharmacological effects are mediated through multiple pathways, highlighting its versatility as a therapeutic agent. Further research is warranted to explore its full therapeutic potential and optimize its clinical use.

**Structure and Function of Iba1 Protein**

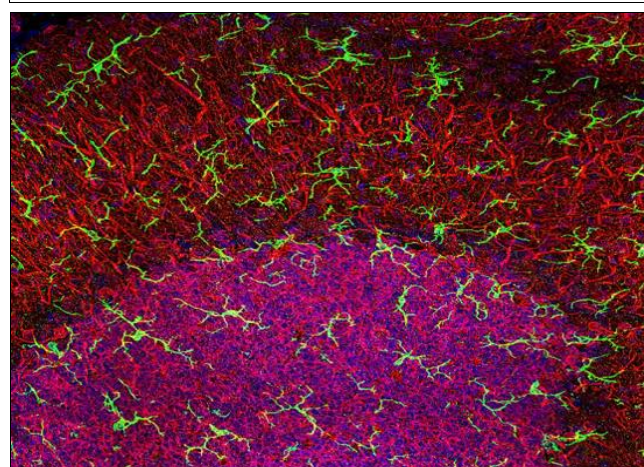
Iba1 is a 17 kDa protein that binds calcium and interacts with actin filaments, contributing to the regulation of cell morphology and movement [10]. It is characterized by its EF-hand motifs, which are essential for its calcium-binding properties [11]. These structural features enable Iba1 to modulate microglial responses, including phagocytosis and cytokine production, which are vital for maintaining neural homeostasis [11].



**Fig 3: EF-hand motifs**



**Fig 4: Iba1 Proteins**



**Expression and Regulation**

Iba1 is highly specific to microglia and is used as a marker for these cells in immunohistochemical studies. Its expression is upregulated in response to various stimuli, such as injury, infection, or neurodegeneration [12]. This upregulation is indicative of microglial activation, a hallmark of neuroinflammatory processes [13]. For instance, studies have shown that Iba1 levels are significantly increased in conditions like Alzheimer's disease (AD), Parkinson's disease (PD), and multiple sclerosis (MS), reflecting the role of microglia in these pathologies [14, 15].

**Iba1 and Neurodegenerative Diseases**

In Alzheimer's disease, Iba1 is upregulated in response to amyloid-beta plaques and neurofibrillary tangles, suggesting

its involvement in the inflammatory response associated with AD pathology<sup>[16]</sup>. Similarly, in Parkinson's disease, Iba1 expression correlates with the progression of neurodegeneration and is considered a marker of disease severity<sup>[17]</sup>. Multiple sclerosis research also highlights the role of Iba1 in demyelination and subsequent axonal damage, further establishing its significance in central nervous system disorders<sup>[18]</sup>.

### Research and Clinical Implications

The use of Iba1 as a biomarker extends beyond diagnostic applications. Its quantification can aid in assessing disease progression and the efficacy of therapeutic interventions. For example, the use of Iba1 in preclinical models has provided insights into the effectiveness of anti-inflammatory drugs in neurodegenerative diseases<sup>[19]</sup>. Furthermore, targeting Iba1 or its pathways may offer novel therapeutic strategies for managing neuroinflammation and neurodegeneration<sup>[20]</sup>. (Liao *et al.*, 2020).

### Conclusion

Iba1 serves as a critical marker and mediator of microglial activation and neuroinflammation. Its role in various neurological disorders underscores its potential as a diagnostic and therapeutic target. Continued research into Iba1 will enhance our understanding of its mechanisms and improve strategies for managing neurodegenerative diseases.

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