Fact Sheet FOOD/PHARMA/COSMETIC

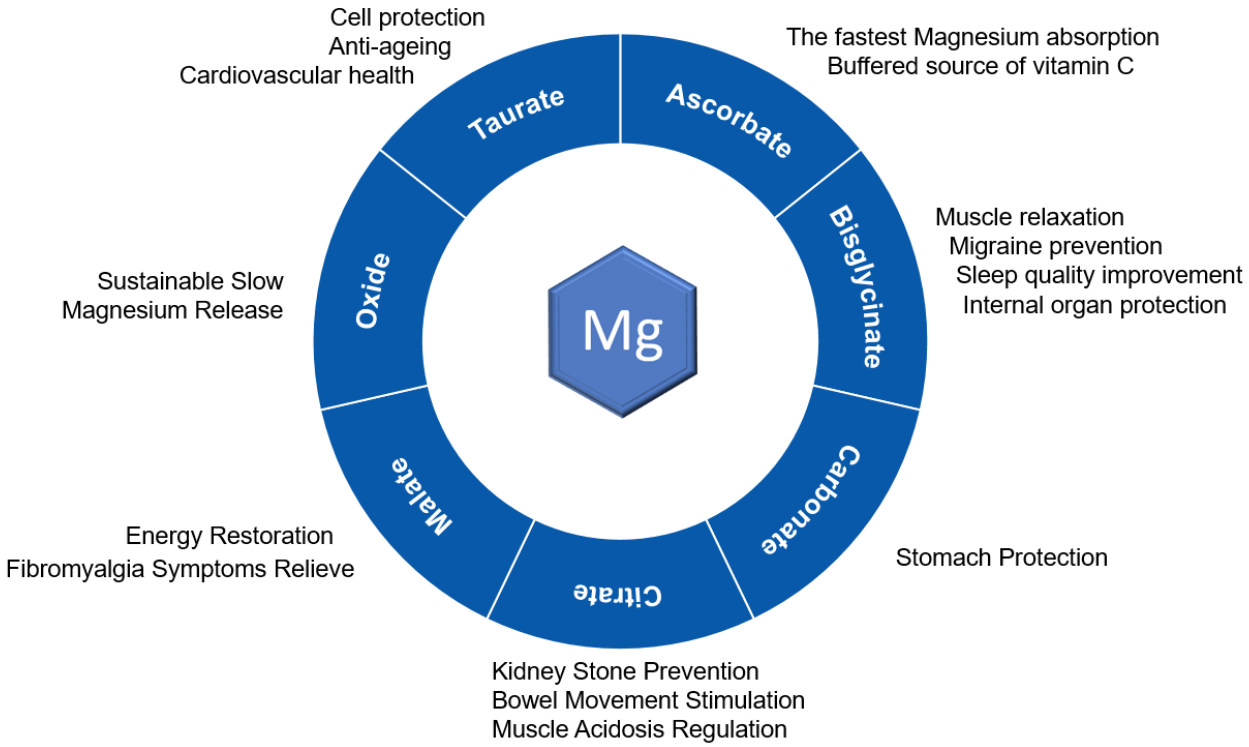
# Diversity of Magnesium Salts

## Introduction

Magnesium, the fourth most abundant cation in the human body and second most abundant intracellular cation after Potassium, plays a crucial role in various physiological and biochemical functions. This essential mineral is involved in over 300 enzymatic reactions, acting as a cofactor in many of them, particularly those dependent on ATP. Magnesium is vital for several important biochemical pathways, including macronutrient degradation, oxidative phosphorylation, DNA and protein synthesis, neuromuscular excitability, and the regulation of parathyroid hormone secretion.[1]

In order to maintain a balanced intake and achieve optimal levels of Magnesium in the body, Magnesium supplements are sometimes recommended. These supplements come in different forms and concentrations, containing various compounds of Magnesium. Research has indicated that the composition of these supplements plays a crucial role in effectively restoring the optimal Magnesium levels in the body.[2] Magnesium used to make food supplements is found in various forms that contain different anionic parts: Oxide, Malate, Citrate, Carbonate, Glycinate etc.

## Is the anionic part of the molecule important?



# Diversity of Magnesium Salts

## Magnesium Ascorbate

### Fastest Magnesium plasma elevation

Magnesium Ascorbate is a highly soluble Salt of Magnesium and ascorbic acid. It is the fastest source of Magnesium because $Mg^{2+}$ from Magnesium Ascorbate is absorbed after the first 15 minutes to the highest extent of all studied Salts (Magnesium Chloride, Magnesium Sulfate, Magnesium Acetate, Magnesium Lactate, and Magnesium Hydrocitrate).[3]

### Source of vitamin C

Magnesium Ascorbate is a buffered (non-acidic) form of vitamin C, which is generally more tolerable to the stomach than ascorbic acid. EFSA has established a list of the permitted health claims including the conditions, which has to be followed when using the claim. In general, vitamin C contributes to fatigue and tiredness reduction in situations of inadequate micronutrient status. A rich source of vitamin C has immune-stimulating activities – it helps to maintain the normal function of the immune system especially during and after intense physical exercise. It contributes to normal energy-yielding metabolism and normal release of energy for use in the body. Vitamin C is inevitable for healthy physical development; it contributes to normal collagen formation, which is necessary for the normal function of blood vessels, bones, cartilage, skin and teeth. Nevertheless, it plays a significant role in normal functioning of the nervous system and normal psychological/mental performance by influencing those aspects of brain and nerve functions, which determine concentration, learning, memory and reasoning. Well-known antioxidant properties of vitamin C helps to protect the cells from oxidative stress – to protect DNA, proteins and lipids from oxidative damage. Vitamin C as a water-soluble antioxidant can also regenerate reduced alpha-tocopherol (vitamin E).[4]

## Magnesium Bisglycinate

### Internal organs protection

Glycine is an amino acid that has been shown to have a protective effect against oxidative stress induced by a variety of chemical agents, pharmaceuticals, and toxic substances at the cellular and organ levels in the liver, kidneys, intestines, and vascular system.[5] It also acts as a neurotransmitter in the central nervous system. In addition to its role as a neurotransmitter, glycine has been shown to have a variety of other functions in peripheral and nervous tissues, including antioxidant, anti-inflammatory, cryoprotective, and immunomodulatory effects.[6]

### Migraine prophylaxis

Migraine is a neurological disease characterized by headaches, hypersensitivity to light and sound, nausea and vomiting. In people with migraines, it has been found that they have lower levels of serotonin and Magnesium in their saliva. When there is a deficiency of Magnesium in the brain, it triggers a chain reaction that starts with platelet aggregation and the release of glutamate, leading to the formation of 5-hydroxytryptamine (5-HT). This acts as a vasoconstrictor at the end of the process. A lack of Magnesium can also cause spasms in the cerebral artery and increase the release of pain intermediaries.[7] A positive ischemic test in patients with migraine with aura confirms “the importance of Magnesium for the maintenance of normal glutamatergic transmission via NMDA receptors (including calcium channels of this receptor).”[8] The recent research shows that the amino acid–bounded Magnesium Glycinate is able to increase brain Magnesium levels at higher dosage[9], thus to improve the electrolytic imbalance and remove one of the triggers out of migraine equation.[8]

### Improved sleep quality

Magnesium has been demonstrated to exert a beneficial effect on sleep onset and maintenance, as well as ameliorating fatigue, which manifests as a result of sleep deprivation.[10] Therefore, the combination of Magnesium and Glycine offers a unique synergetic effect on the quality of sleep. Glycine is a non-essential amino acid that passes into the brain passively and acts on N-methyl-D-aspartate type glutamate receptors in the suprachiasmatic nucleus (the center of the circadian rhythm) resulting in vasodilatation and subsequently decreased central body temperature which has impact on improving sleep quality.[11]

### Muscle relaxation - Leg cramps

Leg cramps are common during pregnancy. Approximately 30-45% of pregnant women experience leg cramps which are often happen at night and disrupt sleep. Magnesium Bisglycinate has shown efficiency in reducing leg cramps in pregnant women.[12]

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## Magnesium Carbonate

### Stomach protection

Dyspepsia is a medical term used to describe a group of symptoms that originate from the upper gastrointestinal tract. These symptoms may include abdominal pain or discomfort, heartburn, fullness, bloating, early satiety, excessive belching, or nausea after eating. Dyspepsia can occur in isolation (non-ulcer dyspepsia) or in conjunction with various disorders such as gastritis, peptic ulcer disease, or gastro-oesophageal reflux disease which occur in upper gastrointestinal tract.[13] Conventional antacids, such as aluminum hydroxide and aluminum phosphate, exhibit limited absorption. No toxic effects from aluminum have been reported to date. However, due to concerns about the chronic intake of small amounts of aluminum, Magnesium carbonate is considered a more therapeutically relevant alternative in aluminum-free preparations.[14]

## Magnesium Citrate

### Prevention and treatment of kidney stones

Nephrolithiasis, commonly known as kidney stones, is a prevalent disorder of the urinary tract that typically affects individuals between the ages of 40 and 60. The condition is characterized by the formation of crystalline mineral deposits in the kidneys or urinary tract, which can cause severe abdominal pain and may necessitate urgent medical intervention. Nephrolithiasis is a frequent cause of unscheduled admissions in urological practice. Various preventative measures, including increased fluid intake and oral citrate supplementation, have been employed to alter the chemical composition of urine and reduce the risk of stone formation.[15]
Apart from its enhanced absorption rate in comparison with inorganic sources of Magnesium[16] - Citrate Salts own unique ability to inhibit growth and aggregation of Calcium Oxalate and Calcium Phosphate crystals in urine, which are responsible for creation of kidney stones. Citrates not only prevent new stone formation but also reduce further growth of already existing stones by alteration of ion activity of both Calcium Oxalate and Calcium Phosphate. In addition, intestinal complex formation between Calcium and Citrate may reduce Calcium excretion by urine.[14]

### Bowel movements stimulation

Constipation is a disorder of the gastrointestinal tract characterized by infrequent or difficult passage of stool, often accompanied by pain and discomfort. The condition can be influenced by a variety of factors, including genetic predisposition, low dietary fiber intake, inadequate fluid consumption, reduced mobility, hormonal imbalances, medication side effects, and anatomical variations. These factors can disrupt the normal functioning of the bowel and lead to constipation.[17] Magnesium Citrate acts as a laxative via osmotic effects, by retaining fluids in the colon, which soften the stool thus help to clear the colon more easily.[18]

### Muscle acidosis prevention

During periods of intense physical activity, the accumulation of hydrogen ions (H+) in skeletal muscle can contribute to the development of muscle fatigue. This condition, characterized by a decline in muscle force or power output, can negatively influence the exercise performance.[19] Citrate increases circulating Bicarbonate, therefore $H^+$ efflux out of the working muscle is increased, which contributes to muscle acid-base balance and improves exercise capacity and performance under various conditions such as initial training status, exercise task, intensity of training, etc.[20] It was found that Magnesium Citrate in higher doses is also very efficient in elevating the Magnesium concentration in muscle tissue.[9]

## Magnesium Malate

### Energy restoration

Malate is one of the intermediate of the citric acid cycle – a central metabolic pathway utilized by aerobic organisms for the catabolism of fuel molecules.[21] The concentration of Malate anions in the mitochondrial matrix plays a crucial role in regulating the rate of ATP production. Malate anions are transported across the inner mitochondrial membrane via a dicarboxylate transport system. An increase in the supply of Malate can activate ATP production from the citric acid cycle through anaplerotic reactions (chemical reactions that form intermediates of a metabolic pathway), leading to a significant reduction in the sensation of fatigue. This enhanced ATP production also results in an increase in the rate of oxidative ATP synthesis during exercise and an accelerated recovery of phosphocreatine levels following exercise, indicating a greater contribution of oxidative ATP synthesis to energy production.[22] Additionally absorption of Magnesium from Magnesium Malate is one of the highest from organic Magnesium Salts and Magnesium level remained high for an extended period of time in the serum.[23]

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## Magnesium Malate

### Fibromyalgia symptoms relieve

Stress and low levels of Magnesium in the blood, have been shown to have a potentiating effect on each other when they co-occur. This means that the presence of one factor can exacerbate the effects of the other, leading to a heightened physiological response. Hypomagnesemia, has been linked to a variety of stressful conditions, including chronic fatigue syndrome, headache induced by light, audiogenic (acoustic) stress, cold stress, physical stress, and fibromyalgia.[24] Fibromyalgia (FM) is a chronic condition that is not well understood. It is characterized by widespread musculo-skeletal pain, fatigue, sleeping disorders, memory, attention and cognitive difficulties etc...[25] Administration of high doses of a combination of malic acid and Magnesium over an extended period of time has been shown to significantly reduce the severity of pain and tenderness measures.[26]

## Magnesium Oxide

### Sustainable Slow Magnesium Release

It is well known that solubility of a Magnesium Salt is of importance for the bioavailability. The animal and humans studies also conform that bioavailability of organic Magnesium compounds is higher than bioavailability of inorganic ones. But in many cases higher absorption is followed by higher excretion of the Mineral. The quantity of Magnesium salt present in the intestinal tract plays a crucial role in regulating the absorption of Mg2+ from dietary sources. This is due to the importance of passive paracellular Mg2+ absorption, a process by which Mg2+ ions are transported across the intestinal epithelium via tight junctions between adjacent cells.[27] Therefore the insoluble Magnesium Oxide with high Mineral content represent slow - but steady released source of Magnesium and it is also efficient in restoring blood Magnesium levels in plasma and red blood cells than organic Magnesium Salts.[28]

## Magnesium Taurate

### Cell protection

Taurine is a naturally occurring beta-sulfonic amino acid. It occurs particularly in excitatory tissues such as heart, brain, skeletal muscles and retina. Taurine plays several roles in normal physiological functions in the human body and is vital for individual's overall health. Among its functions are intracellular osmoregulation, antioxidation and it has cytoprotective properties. Furthermore, taurine is a major constituent of bile. Beneficial effects of taurine in various diseases including diseases of muscles, central nervous system, diabetes and cardiovascular diseases have been reported.[29]

### Anti-ageing

Promising studies have been published demonstrating anti-ageing effects of taurine. Low level of taurine is one of the driving forces in the aging process of humans and animals. A study in women aged 55-70 years were supplemented with taurine and a reduction of oxidative stress markers was observed. Taurine may help to control oxidative stress during aging process.[30] A recent study provides evidence that taurine maintains health in aged animal models. The tested animals were healthier and longer life span of some animal groups was observed.[31]

### Cardiovascular health

Taurine has been reported to be beneficial for cardiovascular health. It can reduce high blood pressure, risk of diabetes and cardiovascular disease.[32] In diabetic persons it helps to reduce glycemic indices such as HbA1c and fasting blood sugar.[33] Several studies suggest that taurine improves cardiac performance of individuals suffering heart failure.[34] Magnesium Taurate can improve heart rhythm[35] and blood pressure.[36, 37] In terms of bioavailability, Magnesium Taurate is one of the most efficient organic magnesium salts for quickly replenishing magnesium deficiency, not only in plasma but also in erythrocytes.[38]

# Diversity of Magnesium Salts

## Each Magnesium Salts has Unique Qualities

Chemical structure of Magnesium Salt has strong influence not only on physical properties, interactions and absorption but can also bring additional gains for the health. There is a possibility to profit from all the benefits, which the different forms of Magnesium can offer. We are introducing our two solutions, which can satisfy the demands for high Magnesium content, improved absorption properties and other advantages.

## Magnesium Premixes – The Mix makes the Difference

Each of the above-described Magnesium Salts has its specific features. They support different functions of the body and may immediately effective or delayed. The premixes combine the advantages of different Salts in a single product and optimize the supply with the Mineral Magnesium.

### Premix 5-Salt – Magnesium

The Premix 5-Salt – Magnesium is a mixture of five different organic and inorganic Magnesium compounds. It includes Magnesium Bisglycinate, TriMagnesium Dicitrate, Magnesium Malate and Magnesium Ascorbate as well as Magnesium Oxide.

### Premix SiX MiX

The Premix SiX MiX – Magnesium is a selection of six organic and inorganic Magnesium compounds. It includes Magnesium Bisglycinate, highly soluble Magnesium Citrate, Magnesium Malate and Magnesium Ascorbate as well as Magnesium Carbonate and Magnesium Oxide for high dosage applications.

Due to the varying solubility and pH-value of the different Magnesium compounds, the premixes have good effectiveness and are well tolerated. For physiological use, a mixture of several compounds with different solubility profiles is decidedly advantageous. Our Magnesium premixes are designed for the use in capsules or in powder form, simplifying manufacturing processes.

**Curious? Please contact us**

Dr. Paul Lohmann®

# Diversity of Magnesium Salts

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