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Tasteless magnesium fortification

Overcoming the unpleasant flavour of magnesium preserving high solubility

Magnesium fortification of foods and beverages has been like trying to square a circle for a long time: Highly soluble magnesium compounds usually come along with a bitter, hence objectionable taste. Dr. Paul Lohmann GmbH KG, a German chemical company specialized in the production of mineral organic and inorganic salts for pharmacy as well as food and food supplement industry, now introduced a highly soluble magnesium citrate, which is marginally altering the taste of supplementing products.

For successful fortification of food with minerals several requirements have to be met: In addition to fulfilling the regulations for food processing the selected formulation needs to be bioavailable and the influence – also in terms of taste or flavour – on the original product has to be negligible or at least minimized. Studies have proven that the taste of magnesium in some of its highly soluble inorganic salts, e.g. magnesium chloride or sulphate, is bitter and astringent.[i] Thus, the feasibility of magnesium compounds comprising inorganic anions for mineral supplementation in food or beverage formulations is limited, even though the high solubility correlates with a high bioavailability[ii].

Overcoming challenges such as the interfering objectives of high solubility and neutral taste is the core business of Dr. Paul Lohmann GmbH KG. The product portfolio of the German company comprises various qualities and purities of compounds designed for the fortification of food and for the use in food supplements. Dr. Paul Lohmann GmbH KG is not only supplying the compounds in qualities according to different national regulations, but also in tailored form adapted for the application in food fortification, e.g. as microencapsulated powders, in a direct compressible grade for the processing of tablets, or in form of customized premixes.

Additionally, Dr. Paul Lohmann GmbH KG puts special emphasis on highly soluble magnesium compounds – namely citrates, but also lactates, gluconates and bisgly-

cinates – which are permitted for a wide range of applications (see Table 1). Due to advanced synthesis methods and sophisticated processing it was possible to develop highly soluble magnesium compounds causing no or only faint taste impressions. The newly introduced magnesium citrate allows the dissolution of more than 2 g magnesium – according to 20 g of the citrate – in 100 g of water within a reasonable time span and with only a faint flavour. Taking into account the recommended daily intake of magnesium our product enables the production of small-volume mineral shots or gels, since the amount of water required for the dissolution of magnesium is significantly reduced.

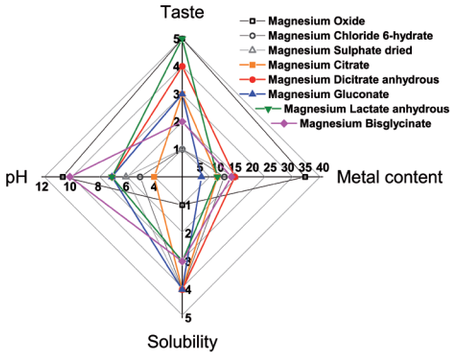

Fig. 1: Overview of different mineral salts and their fundamental properties

Metal content in weight-%, pH in solution (or dispersion), taste (1: bitter/astringent, 2: slightly bitter/astringent, 3: sweet/sour, 4: slightly sweet/sour, 5: neutral) and solubility (1: < 1g/l; 2: 1 to 10 g/l; 3: 10 to 100 g/l; 4: > 100 g/l)

Mineral supplement formulations are often sold in form of effervescent tablets or powders, which are dissolved in water at the point of use. Powder residues in the solution arising from low and slow dissolution provoke an unpleasant mouth feeling and thus hamper the large-scale application in food technology. With the newly available magnesium citrate an organic salt is available that dissolves completely before the evolving of gas bubbles from the effervescent powder comes to an end. Herewith the product also fulfils the parameters required for the use in instant beverages.

Other properties governing the use of different magnesium compounds in food and beverage industry are the change of the pH-value upon dissolution and the metal content in the mineral salt. Figure 1 gives an overview of different magnesium salts. It illustrates quantities of four fundamental properties for each compound: Metal content, pH in solution (or dispersion) and – especially important in food technology – taste and solubility, both encoded in several categories. Following this routine a magnesium compound ideally feasible for tasteless magnesium fortification would span a net following the outer parts of the given grid except for the pH-value after dissolution.

Taste as complex sensory perception

Taste in everyday life is solely induced by just one compound. Outside the laboratory the gustatory system responds to numerous stimuli interacting with each other.[iii] Breslin et al. investigated the interaction of salty with bitter flavour. Their results indicate that the bitter taste of magnesium sulphate – one of the highly soluble magnesium compounds comprising an inorganic anion – cannot be strongly suppressed by combining it with the saltiness of sodium chloride. Other common bitter stimuli such as caffeine, quinine or urea were evaluated much less bitter upon degustation in combination with sodium chloride.[iv]

To overcome the unpleasant taste impression induced by the interaction of magnesium or calcium ions with the according taste receptor cells the combination of the named metal cations with organic anions has proven to be feasible. Lawless et al.[v] found that for calcium the bitter and salty taste impression of salts comprising organic anions, e. g. lactate, gluconate or glycerophosphate, was significantly reduced. The exact mechanism behind this observation has not been clarified up to now.

Magnesium in physiology – Requirements and deficiency

Studies reveal that the daily magnesium intake is insufficient for up to 50 % of adolescents and young adults in Germany[vi]. Other numbers state that up to 15 % of the overall population suffers from hypomagnesia[vii]. Recommended values for daily magnesium intake differ slightly from country to country as shown in Table 2. In the second half of 2015 the European Food Safety Authority was going to publish evidence based values for Adequate Intake (AI) of magnesium, which have been at the stage of public consultation when this paper was finished[viii].

Table 2: Recommended dietary allowances for magnesium

US Reference Daily Intake (RDI)	400 mg
US Dietary Reference Intake (RDI*)	420 mg
EU Recommended Daily Allowance (RDA)	375 mg
D-A-CH Recommendations*	400 mg

*Highest values of recommended intake

With an average amount of 24 g in a 70-kg adult, magnesium exceeds sodium, potassium and calcium in terms of the quantity of physiologically important minerals. Nearly two third of the magnesium is bound together with calcium in the form of hydroxyl apatite in bones and teeth. In case of hypomagnesia the deficit is balanced from the reservoir in the bones presumably supporting the demineralisation of the bones and thus the development of osteoporosis.[ix] Furthermore, magnesium is an essential co-factor in more than 300 enzymes taking part in practically all areas of the metabolism: muscle contraction, protein and nucleic acid synthesis, storage and release of hormones and neurotransmitters and the energy exchange in the respiratory chain.[x] An adequate magnesium supply is known to have positive effect on health, especially on bones, cell division, muscle function, nervous system, and the reduction of tiredness and fatigue (referring to the European regulation on health claims made on foods from 2006[xi]).

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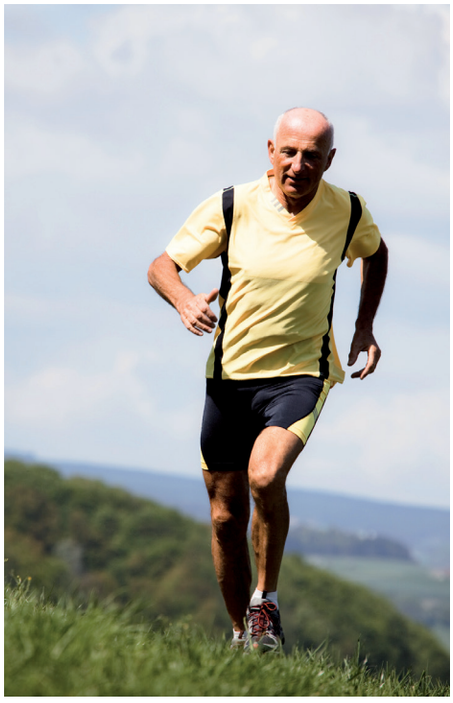
In general, severe magnesium deficiency comes along with symptoms in the central nervous system such as tremor, nervous disorders, hyperactivity, migraine and sensitivity to noise, in the gastrointestinal tract such as obstipation and intestinal cramps and finally in the cardiovascular system such as perfusion disorders, vascular spasms of heart and blood vessels and cardiac arrhythmias.[xii] Some of mentioned symptoms related to cramps and spasms arise from muscle excitation by calcium without the appropriate relaxation mechanism. Magnesium is a physiological calcium antagonist and suppresses the flow of calcium into muscle cells. This hampers the neuromuscular excitability and enables muscular relaxation. This explains why hypomagnesia can cause spasms and tensions in muscles.[xiii]

From a manufacturers point of view highly soluble magnesium salts offer a wide scope of applications, ranging from magnesium fortification in beverages via the use in food supplements to administration in dietary products for consumers with special needs such as infants or people suffering from chronical diseases. Table 1 displays the permitted uses for a selection of soluble magnesium compounds available at Dr. Paul Lohmann GmbH KG. The products offer the chance to dissolve appropriate amounts of magnesium in small volumes with no or only minor influence on the flavour. The production of food supplement mineral shots as well as near-water bever-

Table 1: By regulation permitted uses of highly soluble organic magnesium salts

Permitted Use	Magnesium Citrate/Dicitrate	Lactate	Gluconate	Bisglycinate
Food	x	x	x	
Dietetic Foods	x	x	x	x
Infant formulae and follow-on formulae	x		x	
Processed cereals-based foods and baby foods for infants and young children	x	x	x	
Food supplements	x	x	x	x



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ages gets within range, which in turn will provide one way to offer people the chance to cope with a possible magnesium deficiency. Manufacturers may choose from numerous customized compounds for the application in magnesium fortification, such as magnesium citrate, magnesium hydrogen citrate, acidic magnesium citrate, different formulations of trimagnesium dicitrate from the water free to the 14-hydrate compound, or the trimagnesium dicitrate in a direct compressible grade.

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