MAGNESIUM SULFATE
Chemical and Technical Assessment

Revised by Madduri V. Rao, Ph.D. for the 68th JECFA
(Original prepared by Yoko Kawamura, Ph.D. for the 63rd JECFA)

1. Summary

Magnesium sulfate was evaluated by the Committee at its 63rd meeting. The outstanding information on functional uses other than nutrient supplement as well as information on commercial use of anhydrous magnesium sulfate and magnesium sulfate was requested for evaluation by the 68th JECFA meeting.

Magnesium sulfate is commercially available as heptahydrate, monohydrate, anhydrous or dried form containing the equivalent of 2 - 3 waters of hydration. Magnesium sulfate occurs naturally in seawater, mineral springs and in minerals such as kieserite and epsomite. Magnesium sulfate heptahydrate is manufactured by dissolution of kieserite in water and subsequent crystallization of the heptahydrate. Magnesium sulfate is also prepared by sulfation of magnesium oxide. It is produced with one or seven molecules of water of hydration or in a dried form containing the equivalent of about 2 - 3 waters of hydration. Magnesium sulfate is available as brilliant colourless crystals, granular crystalline powder or white powder with a bitter salty cooling taste. Crystals effloresce in warm, dry air. It is freely soluble in water, very soluble in boiling water, and sparingly soluble in alcohol.

Magnesium sulfate is used as a nutrient, firming agent and flavour enhancer. It is also used as a fermentation aid in the processing of beer and malt beverages. No food uses have been identified for the anhydrous form of magnesium sulfate.

2. Description

Magnesium sulfate occurs with one (monohydrate), seven (heptahydrate), or no (anhydrous) molecules of water of hydration. The C.A.S. numbers of magnesium sulfates are 7487-88-9 (anhydrous), 14168-73-1 (monohydrate), 10034-99-8 (heptahydrate), and 15244-36-7 (dried). The chemical formulae for magnesium sulfate are $MgSO_4$ (anhydrous) and $MgSO_4.xH_2O$ (hydrated forms), and the molecular weights are 120.36 (anhydrous), 138.38 (monohydrate), and 246.47 (heptahydrate). The monohydrate and heptahydrate forms occur in nature as the minerals kieserite and epsomite, respectively. Dried magnesium sulphate, which contains 62 to 70% of $MgSO_4$ and the equivalent of approximately 2 to 3 waters of hydration, is prepared by heating the heptahydrate until approximately 25% of its weight is lost. Anhydrous magnesium sulphate (obtained by ignition) contains not less than 99.0% and not more than 100.5% of $MgSO_4$. Synonyms of magnesium sulphate include Epsom salts, Magnesii Sulfas, Magnesium Sulfuricum Heptahydricum, Magnesium Sulphate, Sal Amarum, Sel Anglais, and Sel de Seditz. The structural formula for magnesium sulphate heptahydrate is illustrated in Figure 1.

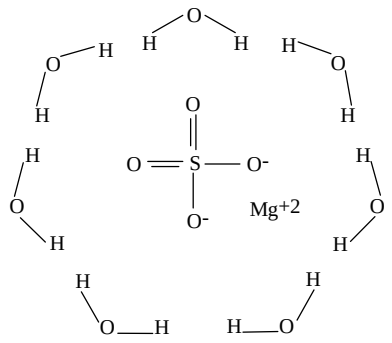

Figure 1. Structural formula of magnesium sulfate heptahydrate

Magnesium sulfate heptahydrate is a white, crystalline powder, or brilliant colourless crystals, usually needle-like. It is freely soluble in water, more rapidly soluble in boiling water, and practically insoluble in alcohol.

Magnesium sulfate heptahydrate is primarily intended for use in bottled water products as a flavour enhancer however, it is also used as a nutrient in salt replacers, carbonated diet soft drink beverages, sports drinks and enhanced (fortified) water beverages and as a fermentation aid in the production of beer and malt beverages. Magnesium sulphate heptahydrate has a bitter, saline, cooling taste. No food uses of anhydrous magnesium sulphate or magnesium sulfate monohydrate have been identified.

3. Manufacturing

The raw material used in the manufacture of magnesium sulfate heptahydrate is the mineral kieserite. Kieserite, an almost white salt that is slowly soluble in cold water and more easily soluble in hot water, forms naturally in marine evaporate deposits where seawater has been concentrated and exposed to prolonged evaporation. A typical analysis of kieserite reveals 15.0% magnesium (25% as magnesium oxide, 75% as magnesium sulfate), 20.0% sulfur (as sulphate), up to 2.5% chlorides, and 12% water. When not stored in closed containers, specimens of kieserite will absorb water from the air and be converted to magnesium sulfate heptahydrate.

Magnesium sulfate is produced from sea water, mineral spring and minerals such as kieserite and epsomite, or by reacting magnesium oxide with sulphuric acid. Manufacturing methods include the following:

3.1 From Mineral Kieserite

Kieserite, an almost white salt, that forms naturally in marine evaporate deposits where seawater has been concentrated and exposed to prolonged evaporation. The mineral Kieserite is dissolved in water or hot water and the target product is crystallized. The material is separated from the mother liquor by centrifugation, dried and sieved.

3.2 Reaction of magnesium oxide and sulfuric acid

Magnesium oxide is prepared by igniting magnesium hydroxide (obtained from sea water) or ignition of magnesite ore (consists of $MgCO_3$). The magnesium oxide formed is then reacted with sulfuric acid to produce magnesium sulfate. The target product is recrystallized for higher purity.

4. Chemical Characterization

4.1 Composition of Magnesium Sulphate Heptahydrate

Magnesium sulfate heptahydrate is isolated via crystallization in the heptahydrate form with a minimum chemical purity of 99.5% (w/w) following ignition. It also contains trace levels of other mineral components. Magnesium sulfate heptahydrate is stable in moist air under 48°. While, in dry air, it is effloresce to lose water of crystallization and become hexahydrate at room temperature, monohydrate over 68° and anhydrous at 200 - 300°. Magnesium sulfate is partially decomposed to magnesium oxide over 450°.

4.2 Possible Impurities (including degradation products)

Magnesium sulfate heptahydrate is manufactured by a direct chemical process, during which there are no isolated intermediates. Potential impurities of the final magnesium sulphate heptahydrate product are limited to those that originate from the starting material, and include various metals such as, zinc, selenium, arsenic, iron and lead, and chloride. It also contains small concentrations of other acidic and alkaline materials such as sulphites and oxides.

4.3 Analytical Methods

The assay method for magnesium sulfate is based the method derived from the Food Chemicals Codex, Fifth Edition and relies on the formation of a magnesium complex with disodium EDTA. The identification and purity tests are based on the methods published in Combined Compendium of Food Additive Specifications (FAO JECFA Monographs 1, Volume 4, 2006).

4.4 Rationale for Proposed Specifications

The proposed specification has a specific assay for the presence of magnesium sulfate (dried form) combined with a parameter such as Loss on drying which measures the amount of water that would be derived from the heptahydrate form. Other specification parameters restrict the presence of impurities such as heavy metals.

5. Functional Uses

Magnesium sulfate is used as a nutrient for magnesium. It is also used as a flavour enhancer in bottled water in the U.S.A., and as a firming agent in soybean curd in Japan.

Magnesium sulfate heptahydrate is primarily intended to be used as a flavour enhancer in bottled water products. Additional functions include those as a nutrient used primarily in salt-replacer products, dietary supplements, carbonated diet soft drink beverages, sports drinks and enhanced (fortified) water beverages and as a processing aid (fermentation aid in malting and brewing of beer, ale and malt beverages).

6. Reactions and Fate in Foods

In general, it has been shown that fibre and some fibre-associated compounds (*e.g*., phytate, polyphenols and organic acids) have chelating effects, and can thus bind or form insoluble complexes with metallic cations, including magnesium (Rossander et al., 1992; IOM, 1997). Magnesium sulfate is not expected to have an effect on other nutrients under the intended conditions of use.

7. References

Breslin, P.A., and Beauchamp, G.K., 1995. Suppression of bitterness by sodium: Variation among bitter taste stimuli. Chem. Senses, 20, 609-623.

CDC (2003) *Intake of Calories and Selected Nutrients for the United States Population, 1999-2000. The National Health and Nutrition Examination Survey (NHANES)*, Centers for Disease Control and Prevention (CDC), National Center for Health Statistics (NCHS); U.S. Department of Health and Human Services. Available at: http://www.cdc.gov/nchs/data/nhanes/databriefs/calories.pdf

Combined Compendium of Food Additive Specifications, FAO JECFA Monographs 1, Volume 4 (2006). Food and Agriculture Organization of United Nations (FAO). Available at: http://www.fao.org/docrep/009/a0691e/a0691e00.htm

Committee on Food Chemicals Codex, 2004. Magnesium sulfate. In: *Food Chemicals Codex (FCC)*, 5th Ed., Washington, DC: National Academies Press, 266.

Council of Europe, 2002. Magnesium Sulphate Heptahydrate. In: *European Pharmacopoeia (EP)*, 4th Ed., Strasbourg: Council of Europe (COE), European Treaty Series, No. 50, 1517-1518.

Delwiche, J., and Breslin, P., 2000. Prop tasting and sensitivity to other bitters. Abstr. Pap. Am. Chem. Soc., 219, AGFD 120.

Delwiche, J.F., Buletic, Z., and Breslin, P.A., 2001. Covariation in individuals' sensitivities to bitter compounds: Evidence supporting multiple receptor/transduction mechanisms. Percept. Psychophys., 63, 761-776.

EPA, 2000. Estimated Per Capita Water Ingestion in the United States. U.S. Environmental Protection Agency (EPA), Office of Water; Washington, DC. [EPA-822-R-00-008]. Available at: http://www.epa.gov/waterscience/drinking/percapita/Text.pdf.

Hashimoto, S., Fujita, M., Furukawa, K. and Minami, J., 1987. Indices of drinking water concerned with taste and health. J. Ferment. Bioeng., 65, 185-192.

IMI Lifestyle Products Pte Ltd., 2006. Pansalt. Available at: http://www.imi.com.sg/index.htm.

IOM, 1997. Magnesium. In: *Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride*, Washington, DC: National Academy Press (NAP), National Academy of Sciences, Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, Food and Nutrition Board, Institute of Medicine, 190-249. Available at: http://books.nap.edu/openbook.php?record_id=5776&page=190.

IOM (2004) Sodium. In: *Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate*, Washington, DC: National Academy Press (NAP). National Academy of Sciences, Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, Food and Nutrition Board, Institute of Medicine, 269-423. Available at: http://books.nap.edu/openbook.php?record_id=10925&page=269.

Karpannen, H., 1979. *Rational of New Salt (Mineral Salt)*, Finland: Vientipaino Oy. Cited in: Pietinen et al., 1981.

Ministry of Health and Welfare, Japan, 2000. Magnesium sulfate. In: *Japan's Specifications and Standards for Food Additives (JSFA)*, Tokyo, 233.

Nitta, M., 1970. Analysis of similarity between taste quality and glossopharyngeal nerve response in toad. Tohoku. J. Exp. Med., 101, 257-269.

NRC, 1989. *1987 Poundage and Technical Effects Update of Substances Added to Food (1970-1987)*, Washington, DC: U.S. Food and Drug Administration (U.S. FDA) / National Research Council, National Academy of Sciences, Committee on Food Additives Survey Data, Food and Nutrition Board, Institute of Medicine, 340-341.

Oetzel, G.R., and Barmore, J.A., 1992. Palatability of anionic salts fed in a concentrate mix. J. Dairy. Sci., 75, 297.

Pietinen, P., Ruotsalainen, P., Tanskanen, A., and Puska, P., 1981. Sodium intake reduction in volunteer families by using a salt substitute and nutrition counselling. Ann. Nutr. Metab., 25, 371-380.

Rossander L., Sandberg, A.-S., and Sandstrom, B., 1992. The influence of dietary fibre on mineral absorption and utilization. In: Schweizer, T.F. & Edwards C.A., eds. *Dietary Fibre -- A Component of Food. Nutritional Function in Health and Disease,* London/New York: Springer Verlag / International Life Science Institute (ILSI Europe), ILSI Human Nutrition Reviews, 197-216.

Skandhan, K.P., Mehta, Y.B., and Bhatt, K.V., 1980. Threshold value and reaction time for different modalities. Indian J. Med. Sci., 34, 1-7.

Smith; D.V., 1997. Basic anatomy and physiology of taste. In: Seiden, A.M., ed., *Taste and Smell Disorders (Rhinology And Sinusology),* New York: Thieme Medical Publishers, 128-145.

Smith, D.V., Van Buskirk, R.L., Travers, J.B., and Bieber, S.L., 1983. Coding of taste stimuli by hamster brain stem neurons. J. Neurophysiol., 50, 541-558.

Suzuki, I. *et.al.* ed. 1999. Magnesium sulfate. In: *Practical Guide of Japan's Specifications and Standards for Food Additives*, 7th Ed., Tokyo, Hirokawa Shoten, D-1437-1439.

USDA, 2000. 1994-1996, 1998 Continuing Survey of Food Intakes by Individuals (CSFII) and Diet and Health Knowledge Survey (DHKS). U.S. Department of Agriculture (USDA), Riverdale, Maryland. PB2000-500027.