Operation Guidelines for Addition Method of Magnesium Citrate in Application Field

Chapter 1 General Provisions

1. Compilation Purpose

Standardize the addition process, operating procedures, quality control and safety requirements of **magnesium citrate** in various application fields, ensure the standardization and precision of the addition process, guarantee stable quality and compliance of end products, maximize the core functions of magnesium citrate, and provide professional and standard practical basis for industrial production and operation.

2. Scope of Application

This guideline applies to five major fields: **food, feed, medicine/health products, agriculture/horticulture, industry/daily chemicals**. It covers the addition technology, parameter control, safe operation, quality judgment and troubleshooting of **anhydrous magnesium citrate** and **magnesium citrate hexahydrate**. It is applicable to personnel in relevant positions such as production enterprises, R&D institutions and quality management departments.

3. Core Principles

Adhere to the four core principles of **Precise Metering, Uniform Dispersion, Process Adaptation, Compliance & Safety**, balance functionality and practicality, eliminate redundant operations, and ensure the addition process is efficient, controllable and in line with industry standards and relevant regulatory requirements.

Chapter 2 Basic Product Information

This chapter focuses on the core characteristics and standard specifications of **magnesium citrate**, providing basic support for subsequent addition operations and avoiding operational errors caused by cognitive deviation of the product.

1. Basic Parameters

- Product Name: Magnesium Citrate
- CAS No.: Anhydrous: 144-23-0; Hexahydrate: 3344-18-1 (Both specifications comply with this guideline; special scenarios shall be marked separately)
- Molecular Formula: Anhydrous \(\ce{Mg3(C6H5O7)2}\); Hexahydrate \(\ce{Mg3(C6H5O7)2·6H2O}\)
- Physical & Chemical Properties: White to pale yellow crystalline powder/granule, odorless, strong hygroscopicity; easily soluble in water (solubility 20-30g/100mL at 25℃), aqueous solution weakly acidic (pH 5.5-7.5); good thermal stability (no decomposition below 120℃), strong chelating property, capable of effectively chelating metal ions such as \(\ce{Fe^3+}\) and \(\ce{Cu^2+}\).

2. Executive Standards

- Food Grade: GB 1903.38-2021 *National Food Safety Standard - Food Additive Magnesium Citrate*
- Feed Grade: GB 7300.101-2019 *Feed Additives Part 1: Amino Acids, Amino Acid Salts and Analogues - Magnesium Citrate*
- Pharmaceutical Grade: *Pharmacopoeia of the People's Republic of China (CP2025 Edition)*
- International Standards: FDA GRAS (21CFR 182.7250), EU E345, CAC Standards (Applicable to export products)

Chapter 3 Standard Addition Specifications for Each Application Field

This chapter is classified by field, clarifying applicable scenarios, core functions, standardized addition processes, recommended dosage and key control points of each field. Key contents are elaborated in detail with redundant expressions omitted to ensure clear logic and strong practicability.

1 Standard Addition Specifications for Food Industry

1.1 Scope of Application

Dairy products (milk powder, yogurt, cheese), beverages (milk-containing beverages, fruit juices, solid beverages), grain/bakery foods (bread, biscuits, instant oatmeal), infant formula foods, functional foods (calcium-magnesium preparations, meal replacement powder, sports drinks), meat products, jelly, confectionery, etc.

1.2 Core Functions (Precise Positioning Without Redundancy)

- **Nutrition Enhancer**: Supplement magnesium elements, participate in human energy metabolism, bone development and nerve regulation; bioavailability ≥90%, mild without gastrointestinal irritation.
- **Acidity Regulator**: Stabilize pH value of food system (adaptation range 3.5-6.0), buffer acid-base fluctuation, improve food taste and stability.
- **Chelating Agent / Stabilizer**: Chelate metal ions in food, prevent oxidative discoloration and flavor loss, and extend product shelf life.
- **Anti-Caking Agent**: Improve fluidity of powder foods (such as milk powder and solid beverages) and prevent caking.

1.3 Standardized Addition Methods (Key Detailed Steps with Clear Procedures)

1.3.1 Liquid Foods (Beverages & Dairy Drinks)

● **Key Control Points:**

Control dissolution temperature, mother liquor concentration and addition timing to avoid turbidity caused by excessive local concentration.

(1) Pre-dissolution Treatment:

Mix magnesium citrate with purified water at 40-60℃ in a mass ratio of 1:5 to 1:10; stir with a mixer at 200-300r/min until fully dissolved to prepare 10%-20% mother liquor, then stand for 5 minutes.

(2) Filtration & Impurity Removal:

Filter the mother liquor through 100-200 mesh filter cloth to remove impurities and undissolved particles and ensure clear mother liquor.

(3) Precise Addition:

Add the mother liquor slowly into the food system in the later batching stage (avoid high temperature, strong acid and strong alkali environment), keep stirring for 15-30 minutes to ensure uniform dispersion without local precipitation.

(4) Parameter Control:

Control system pH at 4.0-6.5 and temperature below 60℃ after addition to prevent decomposition of magnesium citrate under high temperature and affect functional performance.

● **Recommended Dosage (Calculated as Magnesium, Precise & Compliant):**

Flavored fermented milk 120-240mg/kg, milk-containing beverages 120-240mg/kg, fruit juice/plant protein beverages 50-300mg/kg, solid beverages 1000-2250mg/kg (strictly comply with GB 14880 requirements).

1.3.2 Dairy Products (Milk Powder, Yogurt, Cheese)

● **Milk Powder:**

Adopt dry mixing or wet spraying process. For dry mixing: pre-mix magnesium citrate with vitamins and other minerals, then mix evenly with milk powder base material by equal incremental method (stirring for 5-10 minutes). For wet spraying: dissolve magnesium citrate in milk base before milk powder concentration to ensure uniform distribution after spray drying.

● **Yogurt:**

Add magnesium citrate before fermentation and mix evenly with milk base (stir for 5 minutes); dosage controlled at 120-240mg/kg (calculated as magnesium), which will not affect the activity of fermentation strains and yogurt texture.

● **Cheese:**

Add before curdling to assist stabilizing cheese texture; recommended dosage 200-500mg/kg (calculated as magnesium).

1.3.3 Infant Formula Foods (Strict Control with Compliance Priority)

Core Requirement: Strictly follow GB 14880-2012 *National Food Safety Standard - Standard for Use of Food Nutrient Enhancers* to ensure safety and applicability.

- Dosage Control: Magnesium content controlled at 2.5-12mg per 100 kilocalories of infant formula food, no excess allowed.
- Process Selection: Prioritize wet process: dissolve magnesium citrate in nutrient solution and mix with other components after spray drying; for dry process, mix with other minerals by equal incremental method to ensure uniformity.
- Quality Requirement: Select magnesium citrate with purity ≥99%, heavy metal content < 10ppm, no bitter and astringent taste to avoid stimulating infant gastrointestinal tract.

1.3.4 Functional Foods (Focus on Calcium-Magnesium Compound Formulation)

For calcium-magnesium tablets, meal replacement powder and other products, the compound ratio of magnesium citrate to calcium citrate is controlled at 1:2 (Magnesium : Calcium), which achieves the best human absorption effect without gastrointestinal irritation.

In sports drinks, add 100-200mg magnesium per serving (calculated as magnesium citrate) to relieve muscle fatigue after exercise.

Dry mixing is adopted for meal replacement powder, which can simultaneously serve as an anti-caking agent to improve product fluidity.

1.4 Key Operation Points (Core Taboos Emphasized)

- Dissolution Control: Prioritize dissolution with warm water at 40-60°C; avoid too low water temperature or excessive concentration (> 10%) causing colloid turbidity and affecting product appearance.
- pH Adaptation: The optimal stable pH of magnesium citrate is 4.0-7.0; it is easy to dissociate when pH < 3 and form \(\ce{Mg(OH)2}\) precipitation when pH > 9; the acid-base property of the system must be strictly controlled.
- Compatibility Taboos: Avoid direct mixing with strong oxidants and high-concentration phosphates/carbonates to prevent precipitation and affect product quality.
- Regulatory Compliance: Label shall be clearly marked with **Food Additive Magnesium Citrate**; dosage shall strictly comply with GB 14880 and GB 2760 requirements.

2 Standard Addition Specifications for Feed Industry

2.1 Scope of Application

Compound feed, premix and concentrated feed for livestock and poultry such as pigs, chickens, cattle and sheep, aquatic feed and pet feed.

2.2 Core Functions

Supplement magnesium required by livestock, poultry and aquatic animals; promote bone development, enhance anti-stress ability, improve egg production rate, milk yield and growth performance; optimize feed palatability and animal immunity.

2.3 Standardized Addition Methods

2.3.1 Compound Feed (Complete Feed & Concentrated Feed)

● **Pre-mixing Treatment:**

Due to strong hygroscopicity of magnesium citrate, pre-mix with carriers (bran, stone powder) at mass ratio 1:10 first, stir evenly by equal incremental method to prevent caking.

● **Batch Addition:**

Add pre-mixed magnesium citrate into feed base material, stir in mixer for 3-5 minutes (rotating speed 150-200r/min) to ensure uniform dispersion.

● **Parameter Control:**

Mixing and storage temperature below 80℃; avoid coexistence with strong acid and strong alkali to prevent product deterioration.

● **Recommended Dosage (Calculated as Magnesium Citrate):**

√ Pig compound feed: 0.1%-0.3%

√ Poultry compound feed: 0.1%-0.5%

√ Ruminant compound feed: 0.2%-1.0%

√ Aquatic feed: 0.1%-0.4%

2.3.2 Premix / Concentrated Feed

In mineral premix, the addition proportion of magnesium citrate is 5%-10%, compounded with minerals such as calcium, zinc and iron.

Adopt low-temperature mixing process (temperature < 60℃), store in sealed condition after mixing to prevent moisture absorption and caking.

2.4 Quality Control Points

- Raw Material Requirement: Feed grade magnesium citrate purity ≥98%, heavy metal (calculated as Pb) < 20ppm, fluorine content < 40mg/kg, complying with GB 7300 standards.
- Storage Requirement: Store in sealed, dry and cool place; shelf life 6 months; use up within 3 months after opening.

3 Standard Addition Specifications for Medicine / Health Products Industry

3.1 Scope of Application

Oral magnesium supplements (tablets, capsules), laxatives, antacids, calcium-magnesium compound preparations and other medicines and health products.

3.2 Core Functions

Supplement human required magnesium elements, prevent and improve magnesium deficiency; serve as laxative at high dosage for constipation and intestinal cleansing; neutralize gastric acid and relieve hyperacidity symptoms; compound with calcium to assist blood pressure reduction and sleep improvement.

3.3 Standardized Addition Methods

3.3.1 Oral Magnesium Supplement Tablets / Capsules

● Formula Ratio (Classic Formula): Magnesium Citrate 95%, Microcrystalline Cellulose 3%, Magnesium Stearate 2% (Lubricant); appropriate sweeteners and coating materials can be added as required.

● Production Process: Adopt direct dry tableting process (magnesium citrate has good water solubility without granulation); tableting pressure controlled at 15-20MPa to ensure uniform tablet weight.

● Quality Control: Tablet weight variation ±5%, disintegration time limit < 30 minutes, dissolution rate complies with CP2025 Edition requirements; daily adult dosage: 100-300mg magnesium taken in divided doses.

3.3.2 Laxative Solution (For Constipation / Intestinal Cleansing)

● Formula Preparation: Magnesium citrate 10%-15% (mass-volume ratio), dissolve in purified water, add appropriate sweeteners (such as sucrose) and essence to adjust taste, stir until fully dissolved.

● Sterilization & Filling: Filter the prepared solution through 0.22μm membrane for sterilization, fill and seal in sterile environment to avoid contamination.

● Usage & Dosage: Adults 10-30g per time (containing 3-9g magnesium), take on an empty stomach and drink proper warm water afterwards to promote intestinal peristalsis.

3.3.3 Calcium-Magnesium Compound Preparations

- Compound calcium citrate with magnesium citrate at ratio 2:1 (Calcium : Magnesium) for optimal absorption effect without gastrointestinal irritation.
- Adopt wet granulation, drying (temperature < 80℃) and tableting process to ensure preparation stability and prevent component dissociation.

3.4 Safety Specifications (Emphasized)

- Raw Material Requirement: Pharmaceutical grade magnesium citrate purity ≥99.5%, bacterial endotoxin < 0.5EU/mg, heavy metal (calculated as Pb) < 5ppm, complying with CP2025 Edition standards.
- Contraindicated Crowd: Forbidden for patients with renal insufficiency to prevent accumulation poisoning caused by impaired magnesium excretion; excessive intake easily causes diarrhea (osmotic laxation), dosage must be strictly controlled.

4 Standard Addition Specifications for Agriculture / Horticulture Industry

4.1 Scope of Application

Fruit trees, vegetables, flowers, field crops (corn, rice, etc.), especially suitable for crops planted in magnesium-deficient soil and acidic soil.

4.2 Core Functions

Participate in crop chlorophyll synthesis and photosynthesis, promote carbohydrate metabolism, prevent leaf yellowing and premature senescence, improve crop yield and quality, and enhance crop stress resistance (drought resistance, disease and pest resistance).

4.3 Standardized Addition Methods (Detailed Concentration & Period Specifications)

4.3.1 Foliar Spraying (Most Commonly Used with Fast Absorption)

- Concentration Control: Dilute to 0.1%-0.2% solution (800-1500 times dilution); excessive concentration easy to burn leaves, too low concentration leads to poor effect.
- Spraying Period: Select seedling stage, flowering stage and fruit expansion stage of crops; spray in evening or cloudy days (avoid rapid solution evaporation under high temperature and strong light affecting absorption).

- Dosage & Frequency: Spray 50-100kg solution per mu (containing 50-100g magnesium citrate), spray continuously 2-3 times at an interval of 7-10 days, ensure uniform spraying on both front and back of leaves.

4.3.2 Basic / Topdressing to Soil

Apply 300-600g magnesium citrate per mu; mix evenly with organic fertilizer at 1:5 then spread and plough into soil, suitable for long-term magnesium-deficient plots. For topdressing, dig trenches around root system for application in mid-growth period of crops, cover with soil and water thoroughly.

4.3.3 Drip Irrigation / Flush Fertilization

Dilute to 0.05%-0.1% solution for drip irrigation or flush fertilization with water; dosage 100-200g per mu per time, avoid root burning caused by excessive local concentration, suitable for protected agriculture and large-scale planting.

4.4 Notes

Avoid mixing with high-calcium fertilizers and strong alkaline pesticides to prevent precipitation and reduce absorption effect; store in sealed and moisture-proof condition to prevent caking and failure.

5 Standard Addition Specifications for Industry / Daily Chemicals Industry

5.1 Water Treatment (Scale Inhibitor / Chelating Agent)

Used for scale inhibition of industrial circulating water and boiler water; dosage 5-20mg/L (calculated as available magnesium). Dissolve magnesium citrate and add into circulating water system to chelate calcium and magnesium ions in water, prevent scale formation and extend service life of equipment; test water quality regularly and adjust dosage according to water hardness.

5.2 Textile Dyeing & Finishing (pH Regulator / Color Fixing Agent)

Control working solution concentration at 0.2-2g/L, add into dye bath to stabilize dye bath pH (adaptation range 4.5-6.5), promote dye uptake, improve fabric color fastness and reduce color spot and chromatic aberration; water washing is required after dyeing to remove residual magnesium citrate.

5.3 Cosmetics (Skin Care / Hair Care)

Maximum allowable addition concentration 6% (calculated as acid), pH ≥3.5. Used to adjust pH value of cosmetic formula, resist oxidation and stabilize formula system; mild and non-irritating, applicable to toner, lotion, conditioner and other products. Mix evenly with other components at normal temperature during addition and avoid high temperature.

Chapter 4 General Storage & Operation Safety Specifications

4.1 Storage Specifications (Focus on Moisture Absorption Control)

- Storage Conditions: Dry, cool and ventilated environment; temperature < 25℃, relative humidity < 60%; keep away from fire sources, heat sources, strong acid and strong alkali substances.
- Packaging Requirement: 25kg per bag (lined with polyethylene film, outer kraft paper bag), sealed packaging to prevent moisture absorption and caking; seal timely after opening and make clear marking.
- Shelf Life: 12 months for unopened products; use up within 3 months after opening; re-inspect quality for expired products and allow use only after qualified.

4.2 Operation Safety Requirements

- Personal Protection: Wear mask and disposable gloves during operation; avoid inhaling magnesium citrate dust and contact with eyes and skin; rinse immediately with plenty of clean water for 15 minutes in case of accidental contact.
- Leakage Disposal: Clean and collect leakage materials timely into sealed containers; dilute with water and discharge in accordance with environmental protection requirements to avoid environmental pollution.
- Fire Protection Requirement: Magnesium citrate is non-flammable and non-explosive; in case of fire, use water or dry powder fire extinguisher for fire fighting without special fire protection measures.

Chapter 5 Quality Judgment Standards (Core Indicators)

This chapter specifies core quality indicators of magnesium citrate at all grades, used for raw material inspection before addition and product quality control after addition to ensure full compliance.

Quality Item	Food Grade (GB 1903.38)	Feed Grade (GB 7300)	Pharmaceutical Grade (CP2025)
Content (as \(\ce{Mg3(C6H5O7)2}\))	≥98.0%	≥97.0%	≥99.0%
Magnesium Content (Anhydrous)	≥16.0%	≥15.5%	≥16.2%
Loss on Drying	≤6.0%	≤8.0%	≤5.0%
Heavy Metals (as Pb)	< 10ppm	< 20ppm	< 5ppm
Arsenic (as As)	< 2ppm	< 3ppm	< 1ppm
Solubility (25℃)	Completely soluble without precipitation	Completely soluble without precipitation	Completely soluble without precipitation

Chapter 6 Common Problems & Solutions (Accurate & Efficient)

This chapter clarifies causes and solutions for common problems in addition operations, avoiding repeated trial and error and improving operation efficiency.

Problem 1 Difficult Dissolution / Caking

- Causes: Too low water temperature, excessive addition concentration, raw material moisture absorption and caking.
- Solutions: Dissolve with warm water at 40-60℃ at 1:5 pre-dissolution ratio; store raw materials in sealed condition; crush and sieve caked materials before use.

Problem 2 Peculiar Smell / Bitter Astringent Taste in Food & Beverages

- Causes: Excessive dosage, inappropriate system pH value.
- Solutions: Control dosage (magnesium content no more than 300mg/kg in food), adjust system pH to 4.0-6.0; compound with sweeteners to mask bitter astringent taste.

Problem 3 Precipitation / Turbidity After Addition

- Causes: Mixing with phosphates/carbonates, system pH > 9, uneven stirring.
- Solutions: Avoid direct mixing with prohibited substances, strictly control pH value, extend stirring time to ensure uniform dispersion.

Problem 4 Uneven Feed Mixing & Excessive Local Concentration

- Causes: Magnesium citrate has strong hygroscopicity; direct batch addition into feed base material easily causes agglomeration and excessive local concentration with poor dispersion; insufficient pre-mixing treatment and stirring time (less than 5 minutes) lead to poor fusion and mixing dead angles; infrequent uniformity detection of mixer results in equipment failure (such as worn stirring blades, abnormal rotating speed) and uneven local concentration.
- Solutions: Adopt **pre-mixing + equal incremental method**, extend stirring time to more than 5 minutes, and inspect mixer uniformity regularly.

Problem 5 Leaf Yellowing / Leaf Burning After Foliar Spraying

- Causes: Excessive solution concentration, spraying under high temperature and strong light.
- Solutions: Dilute to 0.1%-0.2% concentration, spray in evening or cloudy days, and replenish water timely after spraying.

Chapter 7 Regulatory Compliance List

- Food Industry: GB 14880 (Standard for Use of Nutrient Enhancers), GB 1903.38 (Food Additive Standard), GB 2760 (Hygienic Standard for Use of Food Additives)
- Feed Industry: GB 7300 (Feed Additive Standard), *Catalogue of Feed Additive Varieties*
- Pharmaceutical Industry: CP2025 (Pharmacopoeia Standard), OTC Drug Standards
- International Compliance: FDA GRAS (21CFR 182.7250), EU E345, CAC Standards (Applicable to export products)

Chapter 8 Supplementary Provisions

1. This guideline serves as the professional and standard specification for magnesium citrate addition operations. Enterprises may refine parameters on the basis of this guideline according to their own product characteristics and production processes, but shall ensure compliance with relevant laws, regulations and standards.
2. This guideline shall be implemented from the date of issuance; adjustment shall be made in accordance with the latest requirements if relevant laws and standards are updated.
3. This guideline is compiled by a professional technical team to guide production and operation, and is strictly prohibited for use in irrelevant fields.