It's in the details.

JOST

MINERAL GUIDE

Reference Guide to Jost Mineral Compounds

Jost Chemical Co. manufactures a line of mineral compounds that are used in the nutritional supplement, clinical nutrition, pharmaceutical and food markets. This reference guide highlights several key points to consider when formulating a product: **Solubility**, **Metal Content** and **Taste**.

The mineral salts discussed in the guide include Ca, Cu, Fe, Mg, Mn, and Zn. Also included in the guide are K and Na. The Mineral Guide also lists information on JOSTCOTE® Microencapsulated Products.

Additional factors that play a role in mineral selection are referenced at end of the guide.

Generally, the mineral salts in each chart are arranged by descending solubility and increasing metal content.

Jost's products are manufactured under cGMP guidelines in our FDA registered facility in St. Louis, Missouri. Our products are Kosher/ HALAL certified, non-GMO, non-allergenic, BSE/TSE free, and free of residual solvents.

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Calcium

Salt[1]	Solubility %[2,3]	Calcium Content %	Taste[4]
Calcium Lactate Anhydrous	3.1^{0}-7.9^{30}	18.0-18.6	Exothermic, Sharp
Calcium Fumarate Anhydrous	2	23.0-29.9	Neutral
Calcium Citrate Malate	1.5	20.0-26.0	Neutral
Calcium Malate Anhydrous	0.8^{0}-$1.2^{37.5}$	20.0-23.5	Slightly Salty
Calcium Hydroxide	0.185^{0}-0.077^{100}	51.6-54.7	Biting
Calcium Magnesium Citrate	0.10	Ca 13.0-15.0 : Mg 3.5-4.5	Neutral
Calcium Citrate Tetrahydrate	0.10	20.5-21.2	Neutral
Calcium Succinate Monohydrate	0.004	22.0-25.0	Salty, Strong Aftertaste
Calcium Phosphate Tribasic Anhydrous (TCP)	0.002	34.0-40.0	Neutral
Calcium Carbonate Anhydrous	0.0014	39.4-40.5	Neutral
Calcium Phosphate Dibasic Anhydrous (DCPA)	Insoluble	28.8-30.9	Neutral

1. Generally arranged by descending solubility and increasing metal content.
2. Solubility in percent. Superscript is temperature; if no superscript, 25°C.
3. CRC Handbook and Merck Index are the main sources of this information.
4. Taste profiles developed by Jost personnel and are subjective.

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Copper

Salt[1]	Solubility %[2,3]	Copper Content %	Taste[4]
Copper Sulfate Pentahydrate	31.6^{0}-203.3^{100}	24.9-26.8	Sharp, Bitter
Copper Gluconate Anhydrous	30	13.7-14.3	Mild, Sweet
Copper Sulfate Anhydrous	14.3-75.4^{100}	39.2-40.0	Sharp, Bitter
Copper Citrate Hemi-Trihydrate	Insoluble	36.0-37.8	Mild
Basic Copper Carbonate	Insoluble	57.4	Neutral
Copper Oxide Anhydrous	Insoluble	78.7-80.7	Mild

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Iron

Salt[1]	Solubility %[2,3]	Iron Content %	Taste[4]
Ferric Ammonium Citrate Brown	Very Soluble	16.5-18.5	Strong
Ferrous Ammonium Sulfate Hexahydrate	20-34.2[70]	13.5-14.2	Strong
Ferrous Gluconate Dihydrate	9[28]-60[80]	USP 10.9-11.9 EP 11.8-12.5	Salty, Bitter
Ferrous Lactate Dihydrate	2-8.5[100]	19-22	Mild
Ferrous Fumarate Anhydrous	0.14	30.3-33.2	Neutral
Ferric Phosphate Hydrate	Insoluble, 0.67[100]	26.0-32.0	Stings, Hot, Slightly Sour
Ferrous Citrate Dibasic Monohydrate	Insoluble	20.0-22.0	Mild
Ferric Citrate x-Hydrate	Insoluble	16.5-20.0	Mild

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Magnesium

Salt[1]	Solubility %[2,3]	Magnesium Content %	Taste[4]
Magnesium Ascorbate x-Hydrate	72	6.1-6.6	Neutral, Slightly Tart
Magnesium Sulfate Heptahydrate	71	9.6-12.2	Stings, Hot
Magnesium Sulfate Dried	68	12.7-16.2	Stings, Hot
Magnesium Citrate Tribasic Anhydrous[7]	15	14.5-16.4	Neutral
Magnesium Aspartate Dibasic Anhydrous	14.5	14.2-15.7	Strong
Magnesium Gluconate Hydrate[5]	8	5.7-6.0	Slightly Tart
Magnesium Lactate Anhydrous[6]	3.5	11.8-12.2	Mild, Sweet, Slightly Spicy
Magnesium Lactate Dihydrate	$3.3\text{-}16.7^{100}$	10.0-10.4	Mild, Sweet, Slightly Spicy
Magnesium Malate Trihydrate	2	11.3-11.8	Neutral
Magnesium Citrate Tribasic x-Hydrate	$0.4\text{-}2.8^{95}$	11.2-12.0	Neutral
Magnesium Phosphate Dibasic Trihydrate	Slightly Soluble	13.4-14.0	Neutral
Magnesium Phosphate Tribasic Pentahydrate	Insoluble	20.2-20.9	Neutral

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3. CRC Handbook and Merck Index are the main sources of this information.
4. Taste profiles developed by Jost personnel and are subjective.
5. Jost's Magnesium Gluconate is typically a dihydrate.
6. Calculated based on dihydrate solubility.
7. After initial dissolution, anhydrous Magnesium Citrate reprecipitates as the hydrated form.

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Manganese

Salt[1]	Solubility %[2,3]	Manganese Content %	Taste[4]
Manganese Sulfate Monohydrate	50	31.8-33.2	Mild
Manganese Gluconate Dihydrate	17	11.0-11.9	Mild
Manganese Lactate Dihydrate	10	20.0-20.8	Mild
Manganese Citrate Decahydrate	<1	22.0-23.9	Neutral
Manganese Ascorbate Dihydrate	Insoluble	12.5-14.0	Very Bitter

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Potassium

Salt[1]	Solubility %[2,3]	Potassium Content %	Taste[4]
Potassium Gluconate Anhydrous	300	15.7-17.2	Mild Metallic
Potassium Phosphate Dibasic	167	44.9	Mild Salty, Exothermic
Potassium Carbonate Anhydrous	112^{20}-156^{100}	56.3-56.9	Mild Salty, Exothermic
Potassium Phosphate Monobasic	$33\text{-}83.5^{90}$	28.7	Very Salty, Metallic
Potassium Nitrate	13.3^{6}-247^{100}	38.7	Very Salty, Metallic
Potassium Sulfate	12	44.2-45.3	Very Salty, Metallic

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Sodium

Salt[1]	Solubility %[2,3]	Sodium Content %	Taste[4]
Sodium Phosphate Dibasic Anhydrous	Very Soluble	32.4	Exothermic, Salty
Sodium Acetate Trihydrate	119	16.5-17.3	Salty, Cool
Sodium Nitrate Anhydrous	$92.1\text{-}180^{100}$	27.0	Endothermic, Salty
Sodium Phosphate Tribasic Dodecahydrate	88	18.06-18.52	Salty, Hot
Sodium Phosphate Monobasic Anhydrous	76	19.2	Hurts Tongue, Salty
Sodium Formate	$50.5^{25.5}$	33.1	Salty
Sodium Phosphate Monobasic Monohydrate	$59.9^{0}\text{-}427^{100}$	16.7	Very Salty
Sodium Sulfate Decahydrate	$11^{0}\text{-}92.7^{30}$	14.3	Very Salty

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Sodium *(continued)*

Salt[1]	Solubility %[2,3]	Sodium Content %	Taste[4]
Sodium Phosphate Dibasic Heptahydrate	104^{40}	17.1-17.5	Salty, Slightly Acidic
Sodium Phosphate Dibasic Dihydrate	100^{50}-117^{80}	29.8	Salty
Sodium Succinate Anhydrous	21.45^{0}	13.9-14.3	Burns, Slightly Salty
Sodium Bisulfate Monohydrate	28.6-100^{100}	16.7	Hurts Tongue, Very Salty
Sodium Pyrophosphate Decahydrate	5.41^{0}-93.1^{100}	19.0-21.5	Burns, Slightly Salty
Sodium Sulfate Anhydrous	42.5^{100}	32.4	Very Salty
Sodium Carbonate Monohydrate	33-52^{100}	37.1	Salty
Sodium Carbonate Anhydrous	7.1-45.5^{100}	43.4	Exothermic, Salty

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Zinc

Salt[1]	Solubility %[2,3]	Zinc Content %	Taste[4]
Zinc Ascorbate	45-65[85]	14.3-15.8	Burns, Tastes Burnt
Zinc Sulfate Heptahydrate	36.7	22.5-24.7	Strong After Taste, Hurts Tongue, Sour
Zinc Sulfate Monohydrate	36.7	36.1-36.6	Exothermic, Biting, Bitter
Zinc Gluconate Hydrate[5]	13	12.3-14.6	Mild, Faint Taste
Zinc Lactate Dihydrate	1.7-17[100]	22.0-24.0	Mild, Faint Taste
Zinc Citrate Dihydrate	Slightly Soluble	31.3-32.1	Neutral
Zinc Phosphate Tribasic Tetrahydrate	Insoluble	41.9 – 43.7	Neutral
Zinc Oxide Low Pb	Insoluble	78.7-80.7	Neutral

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4. Taste profiles developed by Jost personnel and are subjective.
5. Jost's Zinc Gluconate is typically a dihydrate.

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JOSTCOTE® Microencapsulated Products

Salt[1]	Solubility %[2,3]	Mineral Content %	Taste[4]
JOSTCOTE® Microencapsulated Copper Gluconate 20%	Insoluble	2.5-3.4	Neutral
JOSTCOTE® Microencapsulated Ferrous Fumarate 60%	Insoluble	16.4-21.4	Neutral
JOSTCOTE® Microencapsulated Ferrous Sulfate Dried 60%	Insoluble	18.0-21.6	Neutral
JOSTCOTE® Microencapsulated Magnesium Oxide 40%	Insoluble	19.2-26.7	Neutral
JOSTCOTE® Microencapsulated Manganese Sulfate 50%	Insoluble	14.7-18.2	Neutral
JOSTCOTE® Microencapsulated Reduced Iron 70%	Insoluble	67.0-73.0	Neutral
JOSTCOTE® Microencapsulated Zinc Oxide 50%	Insoluble	38.2-44.4	Neutral

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Categories to Consider When Choosing Mineral Compounds

Animal Origin
Jost products are BSE/TSE free and no animal products come into our facility.

Bioavailability
Not all mineral compounds are equally bio-available. Literature searches may be required.

Bulk Density
For processing reasons, the bulk density may dictate the choice of the compound.

cGMP
GMP manufacturing provides mandated assurance that the requisite systems and procedures are in place to document and ensure product integrity, quality, consistency, safety, and traceability from raw material receipt to finished product distribution.

Color
Color can reflect product quality and stability.

Effectiveness
Citrates, Gluconates, Lactates, Ascorbates, Fumarates and Malates are commonly recognized as preferred mineral sources for nutritional supplements.

GMO-Origin
For political and health reasons, concern for GMO has limited the use of certain raw materials.

Heavy Metal Content
Limitation of heavy metals is key. The industry trend is a 1- 5 ppm maximum for Hg, Pb, Cd, and As. Limitations of less than 5 ppm maximum are also often required for Al, Mn, and Cr.

Interaction with Other Molecules
Some salts can be strong oxidizing agents and will therefore interact with other molecules in premixes or in solutions. For instance, iron is very reactive with Vitamin C.

Kosher or HALAL Certification
Market globalization has pushed international standards to comply with the various cultural obligations.

Mineral Content
Mineral content is provided as a % range and is described according to hydration level. When formulating it is important to know a compound's "as-is" mineral content. Some mineral compounds are simply blends and not fully reacted thus inhibiting their stability in formulations. Jost only manufactures fully reacted mineral salts.

Monographs
The USP, EP and FCC monographs establish agreed upon specifications and test methods for products. Some suppliers use the term "Purified" to describe products when no monograph is available. Jost defines "Purified" as meeting specifications that are equivalent to USP, had there been a monograph.

Nutritional Claims
Many claims in the nutritional supplement literature are not supported by either clinical or scientific studies.

Odor
Odor may reflect the raw material quality and can impact the final product acceptance level.

Particle Size
Particle size is a major consideration in solid dosage process controls, taste, formulation stability of slurry, and solubility concerns. If a salt is insoluble an ultrafine particle size can help keep the salt suspended in liquid.

Particle Size Consistency
A consistent particle size allows for repeatability of manufacturing.

pH
pH range is a major consideration for stability of the end product, taste and process considerations.

Price and Production Costs
Mineral content per price can be a clear factor in the choice of product.

Residual Solvents
For Pharma applications, the amount of some residual solvents are highly regulated.

Shelf Life/Retest Date
Jost ensures our products are stable up to a specified retest date when the product is stored in the original, unopened container under normal warehouse conditions.

Solubility
Solubility plays a key role, especially for powders being mixed into a liquid.

Taste
Citrates, Gluconates, Lactates and Malates generally have a neutral or mild taste.

Tolerance
Many Sulfates, Chlorides or Fumarates are not easily tolerated by the body as they can impact the gastric pH.

USP, NF, FCC, EP, ACS, Custom
The application of the product will determine which grade will be preferred.

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