Part 1

Acidulants

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Food Additives Data Book, Second Edition. Edited by Jim Smith and Lily Hong-Shum.

NAME:	Acetic acid
CATEGORY:	Emulsifiers/Stabilisers/Chelating agents/pH control agents/Preservatives/Flavour enhancers and modifiers/ Solvents/Firming agents
FOOD USE:	Baked goods/Cereals and cereal products/Dairy products/Edible oils and fats/Fish, seafoods and products/Meat, poultry and eggs and products/Fruits, vegetables and nuts and products/Sugars, sugar preserves, and confectionery/Vinegar, pickles and sauces
SYNONYMS:	Ethanoic acid/Ethylic acid/Glacial acetic acid/Methane carboxylic acid/Monocarboxylic acid/Vinegar/ CAS 64-19-7/DOT 2789/2790/FEMA No. 2006
FORMULA:	CH_3COOH
MOLECULAR MASS IN Daltons:	60.05
ALTERNATIVE FORMS:	Calcium acetate; hydroxyacetic acid; manganese acetate; methyl acetate; potassium acetate; sodium acetate; zinc acetate
PROPERTIES AND APPEARANCE:	Clear, colourless liquid
BOILING POINT IN °C AT VARIOUS PRESSURES (INCLUDING 760 mmHg):	117.9
MELTING RANGE IN °C:	16.6
FLASH POINT IN °C:	43 (closed cup), 57 (open cup)
IONISATION CONSTANT AT 25°C:	1.76×10^{-5}
DENSITY AT 20°C (AND OTHER TEMPERATURES) IN g/L:	1.0492 @ 20°/4°C
HEAT OF COMBUSTION AT 25°C:	209.02 kcal/gram molecular weight
VAPOUR PRESSURE AT VARIOUS TEMPERATURES:	−17.2°C (1 mmHg) 17.5°C (10 mmHg) 43°C (40 mmHg) 63°C (100 mmHg) 99°C (400 mmHg) 118.1°C (760 mmHg)

PURITY %:	≥99.5 by weight	
HEAVY METAL CONTENT MAXIMUM IN ppm:	10	
ARSENIC CONTENT MAXIMUM IN ppm:	3	
SOLUBILITY % AT VARIOUS TEMPERATURE/pH COMBINATIONS:		
in water:	**@ 25°C**	Acid and its salts are freely soluble
in ethanol solution:	**@ 25°C**	Freely soluble
	@ 25°C	Potassium and sodium salts are freely soluble
	@ 25°C	Calcium salt is slightly soluble

FUNCTION IN FOODS:

Acetic acid is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Acetic acid can be used as an acidifier and flavouring agent in condiments such as mustard, catsup, salad dressings, sauces, canned fruits, and mayonnaise. It can be used to alter the acidity of acidified milk, acidified low-fat milk, acidified skim milk, meat and poultry products. It can also be used to alter the acidity of cold pack cheese food such that the pH does not exceed 4.5, and pasteurised process cheese (pH 5.3), cheese food (pH 5.0) and cheese spread (pH 4.0). It is a pickling agent in products such as sausages and pigs' feet, sweet and sour pickles, marinades and vinaigrettes. It is used to separate fatty acids and glycerol in rendered fats at a level sufficient for purpose. It assists in caramelisation. It is used as an emulsifier in the manufacture of hydroxylated lecithin. It can also be used to sanitise equipment and as a boiler water additive. Maximum levels recommended in foods are 0.25% for baked goods and baking mixes, 0.5% for chewing gum, fats and oils, 0.6% for meat products, 0.8% for cheese and dairy product analogues, 3.0% for gravies and sauces, 9.0% for condiments and relishes, and 0.15% for all other food categories when used in accordance with good manufacturing practices.

Calcium acetate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Calcium acetate can be used as a firming agent, pH control agent, processing aid, an acidity regulator, sequestrant, texturiser, thickener, and as an antirope agent in bakery products. It can also be a source of calcium. It acts as a stabiliser in sausage casings and as a stabiliser when salt migrates from food-packaging materials. Maximum levels recommended are 0.02% in cheese, 0.15% in sweet sauces, toppings and syrups, 0.2% in baked goods, baking mixes, gelatins, puddings and fillings, and 0.0001% in all other foods in accordance with good manufacturing practices.

Ethyl acetate can be used in accordance with good manufacturing practice as a solvent in the decaffeination of coffee and tea and in inks for marking fruits and vegetables.

Potassium acetate is used as a synthetic flavouring. It is also an acidity regulator and buffer.

Sodium acetate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Sodium acetate can be used as a pH control agent, flavouring agent and adjuvant, stabiliser and buffer in certain milk and meat products, and as a boiler additive for food-grade steam. Maximum levels recommended in foods are 0.007% in breakfast cereal, 0.05% in snack foods, soup mixes and sweet sauces, 0.12% in meat products and jams and jellies, 0.15% in hard candy, 0.2% in soft candy, 0.5% in fats and oils, 0.6% in grain products and snack foods. Sodium acetate is limited to 56 g per 45 kg (2oz per 100lb) to acidify artificially flavoured fruit jelly, preserves and jams.

Hydroxyacetic acid, manganese acetate, methyl acetate, and zinc acetate can be used as a component of adhesives.

TECHNOLOGY OF USE IN FOODS:

Acetic acid $pK_1 = 4.75$

Calcium and sodium acetate are hygroscopic.

Acetic acid is more effective in limiting bacterial and yeast growth than mould growth.

FOOD SAFETY ISSUES:

LD_{50} (mg/kg body weight) acetic acid: Mouse 4960 oral route; 525 intravenous route. Rat 3310–3530 oral route. Rabbit 1200 oral route; 1200 subcutaneous route; 1200 rectal route.

LD_{50} (mg/kg body weight) calcium acetate: Mouse 52 intravenous route. Rat 147 intravenous route.

LD_{50} (mg/kg body weight) sodium acetate: Mouse 3310 oral route; 380 intravenous route. Rat 3530–4960 oral route.

Acceptable daily intake for humans of acetic acid and its calcium, potassium and sodium salts is not limited.

LEGISLATION:

USA:

Acetic acid: 9 CFR 318.7, 381.147; 21 CFR 73.85, 131.111, 131.136, 131.144, 133.123, 133.124, 133.169, 133.173, 133.178,133.179, Part 145, 172.814, 178.1010, 184.1005
Calcium acetate: 21 CFR 181.29, 184.1185
Ethyl acetate: 21 CFR 73.1, 173.228
Hydroxyacetic acid: 21 CFR 175.105
Manganese acetate: 21 CFR 175.105
Methyl acetate: 21 CFR 175.105
Potassium acetate: 21 CFR 172.515
Sodium acetate: 21 CFR 150.141, 150.161, 173.310, 182.70, 184.1721
Zinc acetate: 21 CFR 175.105

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NAME:	Adipic acid
CATEGORY:	Chelating agents/pH control agents/Preservatives/Flavour enhancers and modifiers/Flour and baking additives
FOOD USE:	Baked goods/Dairy products/Edible oils and fats/Fish and seafoods and products/Meat, poultry and eggs and products/Fruit, vegetables and nuts and products/Beverages/Vinegar, pickles and sauces
SYNONYMS:	Acifloctin/Acinetten/Adilactetten/Adipinic acid/Hexanedioic acid/Molten adipic acid/1,4-Butanedicarboxylic acid/1,6-Hexanedioic acid/CAS 124-04-9/DOT 9077/FEMA No. 2011
FORMULA:	$HOOC(CH_2)_4COOH$
MOLECULAR MASS IN Daltons:	146.14
ALTERNATIVE FORMS:	Calcium adipate; magnesium adipate
PROPERTIES AND APPEARANCE:	White crystals or crystalline, non-hygroscopic powder
BOILING POINT IN °C AT VARIOUS PRESSURES (INCLUDING 760 mmHg):	337.5 (closed cup)
MELTING RANGE IN °C:	151.5–154
FLASH POINT IN °C:	196
IONISATION CONSTANT AT 25°C:	3.71×10^{-5} 3.87×10^{-6}
DENSITY AT 20°C (AND OTHER TEMPERATURES) IN g/L:	1.360 @ 25°/4°C
HEAT OF COMBUSTION AT 25°C:	668.29 kcal/gram molecular weight
VAPOUR PRESSURE AT VARIOUS TEMPERATURES:	159.5°C (1 mmHg) 191°C (5 mmHg) 205.5°C (10 mmHg) 222°C (20 mmHg) 240.5°C (40 mmHg) 265°C (100 mmHg) 337.5°C (760 mmHg)

PURITY %:	≥99.6
WATER CONTENT MAXIMUM IN %:	0.2
HEAVY METAL CONTENT MAXIMUM IN ppm:	10
ARSENIC CONTENT MAXIMUM IN ppm:	3
ASH MAXIMUM IN %:	≤0.002–0.02
SOLUBILITY % AT VARIOUS TEMPERATURE/pH COMBINATIONS:	
in water:	**@ 100°C** 160
	@ 20°C 1.4
in ethanol solution:	Freely soluble
FUNCTION IN FOODS:	Adipic acid is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Adipic acid can be used as a pH control agent, neutralising agent, leavening agent and flavouring agent. It can be used to alter the acidity of acidified milk, acidified low-fat milk and acidified skim milk, margarine or oleomargarine. It can be used as a sequestrant in oils and improves melting characteristics and texture of process cheese and cheese spreads. It is used in puddings and gelatin to improve set and maintain acidities within the range of pH 2.5–3.0. It is an excellent slow-acting leavening agent that supports the even release of carbon dioxide in baked goods. It increases the whipping quality of products containing egg white. It can be used in the production of resinous and polymeric coatings. Maximum levels recommended are 0.0004% for frozen dairy desserts, 0.005% for non-alcoholic beverages, 0.05% for baked goods and baking mixes, 0.1% for gravies, 0.3% for fats, oils and meat products, 0.45% for dairy product analogues, 0.55% for gelatin, puddings, and fillings, 1.3% for snack foods, 5% for condiments and relishes and 0.02% for other food categories when used in accordance with good manufacturing practices. Diisobutyl adipate can be used as a component of adhesives and a plasticiser for food packaging materials at levels not to exceed good manufacturing practices. Pentaerythritol adipate-stearate may be safely used as a lubricant in the fabrication of rigid and semi-rigid polyvinyl chloride and/or vinyl chloride–propylene copolymers used as articles or components of articles that contact food.
ALTERNATIVES:	Adipic acid is used as an acidulant in commercial baking powders to replace tartaric acid and cream of tartar and phosphates because adipic acid is non-hygroscopic.

TECHNOLOGY OF USE IN FOODS:

Adipic acid $pK_1 = 4.43$; $pK_2 = 5.41$

Adipic acid is four to five times more soluble than fumaric acid at room temperature and has the lowest acidity of any of the food acids. It imparts a slowly developing, smooth, mildly acid flavour and is essential in supplementing foods with delicate flavours. It is practically non-hygroscopic which is an advantage in prolonging the shelf-life of powdered products.

SYNERGISTS:

Adipic acid combined with sodium metabisulphite can be used in the preservation of sausages and other meat products.

FOOD SAFETY ISSUES:

LD_{50} (mg/kg body weight) adipic acid: Mouse 1900 oral route; 680 intravenous route; 275 intraperitoneal route. Rat 3600 oral route. Rabbit 2430–4860 oral route; 2430 intravenous route.

Acceptable daily intake for humans of adipic acid is limited conditionally up to 5 mg/kg body weight.

LEGISLATION:

USA:

Adipic acid: 9 CFR 318.7; 21 CFR 75.85, 131.111, 131.136, 131.144, 166.110, 175.300, 175.320, 177.1210, 177.2420, 177.2600, 178.3690, 184.1009

Diisobutyl adipate: 21 CFR 175.105, 181.27

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NAME:	Caprylic acid
CATEGORY:	Emulsifiers/Stabilisers/pH control agents/Preservatives/Flavour enhancers and modifiers/Anti-caking agents/ Antifoaming agent/Foaming agents/Glazing and coating agents
FOOD USE:	Baked goods/Dairy products/Edible oils and fats/Meat, poultry and eggs and products/Fruit, vegetables and nuts and products/Sugars, sugar preserves and confectionery
SYNONYMS:	C-8 acid/Hexacid 898/*n*-Caprylic acid/*n*-Octoic acid/*n*-Octylic acid/neo-fat 8/Octanoic acid/Octic acid/ 1-Heptanecarboxylic acid/CAS 124-07-2
FORMULA:	$CH_3(CH_2)_6COOH$
MOLECULAR MASS IN Daltons:	144.22
ALTERNATIVE FORMS:	Aluminum caprylate; calcium caprylate; cobalt caprylate; iron caprylate; magnesium caprylate; manganese caprylate; potassium caprylate; sodium caprylate
PROPERTIES AND APPEARANCE:	Colourless oily liquid
BOILING POINT IN °C AT VARIOUS PRESSURES (INCLUDING 760 mmHg):	239.3
MELTING RANGE IN °C:	16.5–16.7
IONISATION CONSTANT AT 25°C:	1.28×10^{-5}
DENSITY AT 20°C (AND OTHER TEMPERATURES) IN g/L:	0.9088 @ 20°/4°C
VAPOUR PRESSURE AT VARIOUS TEMPERATURES:	92.3°C (1 mmHg) 124°C (10 mmHg) 150.6°C (40 mmHg) 172.2°C (100 mmHg) 213.9°C (400 mmHg) 237.5°C (760 mmHg)
PURITY %:	99.6

WATER CONTENT MAXIMUM IN %:	10
HEAVY METAL CONTENT MAXIMUM IN ppm:	3
ARSENIC CONTENT MAXIMUM IN ppm:	0.1
SOLUBILITY % AT VARIOUS TEMPERATURE/pH COMBINATIONS:	
in water:	**@ 20°C** 0.068
in ethanol solution:	Freely soluble
FUNCTION IN FOODS:	Caprylic acid is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Caprylic acid can be used as a flavouring agent and adjuvant, lubricant, binder and defoaming agent. It can be used indirectly as an antimicrobial agent in cheese wrappers and as a coatingon fresh citrus fruits. It can also be used to assist in lye peeling. It is an indirect antimicrobial food additive when migrating to food from paper and paperboard products. It can be used as a sanitising solution on food processing equipment. Maximum levels recommended for specific products are 0.005% for fats and oils, frozen dairy desserts, gelatins, puddings, meat products and soft candy, 0.013% for baked goods and baking mixes, 0.016% for snack foods, 0.04% for cheeses, and 0.001% or less for other food categories. Aluminium, calcium, magnesium, potassium or sodium caprylate can be used as a binder, emulsifier and anti-caking agent when used in accordance with good manufacturing practices. The salts of caprylic acid can also be used in the production of resinous and polymeric coatings. Cobalt, iron or manganese caprylate can be used as a drier when migrating from food packaging material, with no limitation other than good manufacturing practices.
TECHNOLOGY OF USE IN FOODS:	Caprylic acid $pK_1 = 4.89$ Caprylic acid imparts a `sweat-like' or cheesy odour and buttery taste to foods. It is more inhibitory to a broad group of microorganisms at a lower concentration at around neutral pH than other acidulants.
FOOD SAFETY ISSUES:	LD_{50} (mg/kg body weight). Mouse 600 intravenous route. Acceptable intake for humans of caprylic acid is not limited.
LEGISLATION:	**USA:** Caprylic acid: 21 CFR 172.210, 172.860, 173.315, 173.340, 178.1010, 182.90, 184.1025 Cobalt caprylate: 21 CFR 181.25 Iron caprylate: 21 CFR 181.25 Manganese caprylate: 21 CFR 181.25

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NAME:	Citric acid
CATEGORY:	Emulsifiers/Stabilisers/Chelating agents/Nutritive additives/Antioxidants/pH control agents/Preservatives/ Flavour enhancers and modifiers/Solvents/Flour and baking additives/Anti-caking agents/Firming agents/ Glazing and coating agents
FOOD USE:	Baked goods/Dairy products/Edible oils and fats/Fish and seafoods and products/Meat, poultry and eggs and products/Fruit, vegetables and nuts and products/Beverages/Soft drinks/Sugar, sugar preserves and confectionery/Alcoholic drinks/Vinegar, pickles and sauces
SYNONYMS:	Aciletten/Boxylic acid/Citretten/Citro/2-Hydroxy-1,2,3-propanetricarboxylic acid/β-Hydroxytricarballyic acid/β-Hydroxytricarboxylic acid/CAS 77-92-9/FEMA No. 2306
FORMULA:	CH_2-(COOH)-C-(OH)(COOH)-CH_2-COOH
MOLECULAR MASS IN Daltons:	192.14
ALTERNATIVE FORMS:	Ammonium citrate; calcium citrate; dipotassium citrate; disodium citrate; ferric ammonium citrate; ferric citrate; ferrous citrate; iron ammonium citrate; isopropyl citrate; magnesium citrate; manganese citrate; monoglyceride citrate; monopotassium citrate; monosodium citrate; stearyl citrate; stearyl monoglyceridyl citrate; triethyl citrate; tripotassium citrate; trisodium citrate
PROPERTIES AND APPEARANCE:	Colourless, odourless, translucent crystals or as a white granular to fine crystalline powder
BOILING POINT IN °C AT VARIOUS PRESSURES (INCLUDING 760 mmHg):	Decomposition
MELTING RANGE IN °C:	153 (anhydrous form) 100 (monohydrate)
FLASH POINT IN °C:	100
IONISATION CONSTANT AT 25°C:	7.10×10^{-4} 1.68×10^{-5} 4.10×10^{-7}
DENSITY AT 20°C (AND OTHER TEMPERATURES) IN g/L:	1.665 (anhydrous form) 20°/4°C 1.542 (monohydrate) 20°/4°C

HEAT OF COMBUSTION AT 25°C IN J/kg:	468.6 (anhydrous form)
PURITY %:	≥99.5
WATER CONTENT MAXIMUM IN %:	0.5 (anhydrous form) 8.8 (hydrous form)
HEAVY METAL CONTENT MAXIMUM IN ppm:	10
ARSENIC CONTENT MAXIMUM IN ppm:	3
ASH MAXIMUM IN %:	0.05

SOLUBILITY % AT VARIOUS TEMPERATURE/pH COMBINATIONS:

in water:	**@ 10°C**	54.0	**@ 20°C**	59.2	**@ 30°C**	64.3	**@ 40°C**	68.6	**@ 50°C**	70.9
	@ 60°C	73.5	**@ 70°C**	76.2	**@ 80°C**	78.8	**@ 90°C**	81.4	**@ 100°C**	84.0
in ethanol solution:	**@ 25°C**	1 g/2 mL								

FUNCTION IN FOODS: Citric acid is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Citric acid is used as a curing accelerator, dispersing agent, sequestrant, and synergist for antioxidants. Citric acid can be used to alter the acidity of acidified milk, acidified low-fat milk, acidified skim milk, cultured milk, cultured low-fat milk, acidified skim milk, cultured skim milk, margarine and oleomargarine. It can also be used to alter the acidity of cold pack cheese food such that the pH does not exceed 4.5, pasteurised process cheese (pH 5.3), cheese food (pH 5.0), cheese spread (pH 4.0), and dry curd cottage cheese (pH 4.5–4.7). It can be used to alter the acidity of canned fruits, corn, artificially sweetened canned figs, canned peaches, and canned prune juice, artificially sweetened fruit jelly, fruit preserves, jams, meat and meat food products, and poultry. It controls acidity in pectin and alginate gels and reduces heat processing requirements by lowering pH. It enhances the flavour of citrus-based foods including canned sweetened apricots, cherries, pears, and chili con carne. Citric acid is a precursor to diacetyl and indirectly improves the flavour and aroma of a variety of cultured dairy products. It is limited to 0.15% by weight of the milk used or equivalent amount of sodium citrate as a flavour precursor or at 0.1% in sour cream and sour half-and-half. It assists in caramelisation. It can be used a plasticiser and an emulsifying agent to provide texture and improve melting characteristics in pasteurised processed cheese at a level not to exceed 3%. Citric acid is limited at 0.01% alone or in combination with antioxidants for any product containing antioxidants. It is approved for use in ice cream, sherbet and ices, beverages, and salad dressings. Citric acid singly or in combination with sodium acetate

can delay discoloration on fresh cuts of beef, lamb and pork at levels not to exceed 250 ppm or 0.14 mg/cm^2 (0.9 mg/sq inch) of product surface or exceed 500 ppm or 0.28 mg/cm^2 (1.8 mg/sq inch) of surface when in combination with ascorbic acid, erythorbic acid or sodium ascorbate. Citric acid may be used in cured products or in 10% solution used to spray surfaces of cured meats and meat food products prior to packaging to replace up to 50% of the ascorbic acid, erythorbic acid, sodium ascorbate or sodium erythorbate that is used. It is used to preserve cured colour of pork cuts during storage at a level not to exceed 30% in water solution used to spray surfaces of cured cuts prior to packaging. It can be used at levels not to exceed 0.001% in dry sausage, 0.01% in fresh pork sausage, and 0.01% in dried meats. Its use is limited at 0.003% for dry sausage in combination with antioxidants. Citric acid may be used to replace up to 50% of the ascorbic acid or sodium ascorbate in poultry to accelerate colour fixing and is limited at 0.01% alone or in combination with antioxidants in poultry fats to increase effectiveness of antioxidants. Its use is limited for French dressing, mayonnaise and salad dressing at 25% or less of the weight of the acids of the vinegar or diluted vinegar calculated as acetic acid. Citric acid can be added to grapes after fermentation or in combination with other acids after fermentation to correct deficiencies at a level not to exceed 9 g/L of finished wine. It may be added to adjust the acidity of citrus fruit juice or wine at a level not to exceed 9 g/L finished wine. It prevents cloudy precipitates and inhibits oxidation. Citric acid can be used to stabilise wine at a level not to exceed 5.8 lb per 1000 gallons ($\sim$ 120 mg/L).

Ammonium citrate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Ammonium citrate can be used as a stabiliser when migrating from food packaging material. It is used in the manufacture of adhesives and in the production of resinous and polymeric coatings. It can be used as a flavour enhancer, pH control agent and is used in non-alcoholic beverages and cheeses.

Calcium citrate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Calcium citrate can be used as a nutrient and dietary supplement, pH control agent, buffer, firming agent, and sequestrant. It improves the baking properties of flour. It can be used in infant formula. It can be used as an emulsifying agent in pasteurised process cheese, cheese food, and cheese spread at a limit of 3.0% and a gelling agent in artificially sweetened jelly, fruit preserves and jam. It is limited at 0.1% as a flavour precursor in sour cream and sour half-and-half.

Ferric ammonium citrate, ferric citrate and ferrous citrate are used as a nutrient supplement at levels not to exceed good manufacturing practices. It may also be used in infant formula.

Iron ammonium citrate is used as an anti-caking agent in salt for human consumption at a level not to exceed 25 ppm (0.0025%) in finished salt.

Isopropyl citrate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Isopropyl citrate can be used as a sequestrant, solvent and vehicle. It is used to protect flavour in margarine at a level of 0.02%, in non-alcoholic beverages, fats and oils at levels not to

exceed good manufacturing practices. It can be used to increase effectiveness of antioxidants in lard, shortening, oleomargarine, fresh pork sausage, and dried meats at a level of 0.02%.

Magnesium citrate is used in the production of resinous and polymeric coatings.

Manganese citrate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Manganese citrate can be used as a dietary supplement in baked goods, non-alcoholic beverages, dairy product analogues, fish products, meat products, milk products, poultry products, and infant formula. Monoglyceride citrate is used to increase effectiveness in lard, shortening, fresh pork sausage, and dried meats at a level not to exceed 0.02%. It is used to increase effectiveness of antioxidants in poultry fats at a level of 0.02%.

Monopotassium, dipotassium and tripotassium citrate, and monosodium, disodium and trisodium citrate are classified as stabilisers when migrating from food-packaging materials.

Potassium citrate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Potassium citrate can be used as sufficient for purpose in jelly, margarine, meat products, milk and wine. It can be used to acidify margarine or oleomargarine at a level sufficient for purpose. It is used in the production of resinous and polymeric coatings. It can be used as an emulsifying agent in pasteurised process cheese, cheese food and cheese spread at a limit of 3.0%. Its use is limited to 1.4 mg/kg (2 oz per 100 lb) in artificially sweetened fruit jelly, fruit preserves and jam. It is used as a pH control agent and sequestrant in the treatment of citrus wines at a level not to exceed 25 lb per 1000 gallons of wine (~50 mg/L).

Sodium citrate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Sodium citrate is used as a chelating agent in conjunction with phosphate buffers to prepare non-caking meat-salt mixtures and to provide heat and storage stability in condensed, evaporated and sterile concentrated milks. It can be used to accelerate colour fixing in cured and comminuted poultry or poultry products to replace up to 50% ascorbic acid or sodium ascorbate that is used. It can be used as an emulsifying agent in pasteurised process cheese, cheese food, and cheese spread at a limit of 3.0%. It can be used to acidify margarine or oleomargarine. It is a denuding agent in tripe. It is used in the production of resinous and polymeric coatings. Sodium citrate is limited at a concentration of 10% in solution to spray on the surface of cured cuts of meat prior to packaging. It is limited at 0.1% as a flavour precursor in sour cream and sour half-and-half. Its use is limited to 2oz/100lb (1.4 mg/kg) of artificially sweetened fruit jelly, fruit preserves and jams.

Stearyl citrate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Stearyl citrate can be used to protect flavour in margarine at 0.15%.

Stearyl monoglyceridyl citrate can be used as an emulsion or stabiliser in or with shortenings containing emulsifiers at a level sufficient for purpose.

Triethyl citrate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practice. It is used as a flavouring agent, solvent and vehicle and surface-active agent.

TECHNOLOGY OF USE IN FOODS:	Citric acid $pK_1 = 3.14$; $pK_2 = 4.77$; $pK_3 = 6.39$ Citric acid is more hygroscopic than adipic or fumaric acid and can create storage problems in powdered products. Citric acid is compatible with fruit and berry flavours; it imparts a clean, tart taste in hard candies. The salts of citric acid are commonly used as sequestrants. Sodium citrate is added to carbonated beverages to reduce the sharpness of acid taste and it imparts a cool, saline taste and aids in the retention of carbonation.
SYNERGISTS:	Citric acid acts with antioxidants to prevent rancidity by chelating metal ions. Sodium citrate in conjunction with phosphate buffers is used to prepare non-caking meat/salt mixtures.
FOOD SAFETY ISSUES:	LD_{50} (mg/kg body weight) citric acid. Mouse 5040–5790 oral route; 42–960 intravenous route; 961 intraperitoneal route; 2700 subcutaneous route. Rat 11 700 oral route; 725–884 intraperitoneal route; 5500 subcutaneous route. Rabbit 330 intravenous route. LD_{50} (mg/kg body weight) potassium citrate. Dog 167 intravenous route. LD_{50} (mg/kg body weight) sodium citrate. Mouse 44, intravenous route; 1460 intraperitoneal route. Rat 1210 intraperitoneal route. Rabbit 338 intravenous route. Acceptable daily intake for humans of citric acid and its calcium, potassium and sodium salts is not limited.
LEGISLATION:	**USA:** Citric acid: 21 CFR 73.85, 131.111, 131.112, 133.124, 133.125, 133.129, 133.147, 133.169, 133.170, 133.171, 133.173, 133.174, 133.176, 133.178, 133.179, 133.180, Part 145, 146.187, 150.141, 150.161, 161.190, 169.115, 169.140, 169.150, 173.165, 173.280, 184.1033 Ammonium citrate: 21 CFR 175.105, 175.300, 181.29, 184.1140 Calcium citrate: 21 CFR 133.169, 133.173, 133.179, 150.141, 150.161, 155.131 Dipotassium citrate: 21 CFR 181.29 Disodium citrate: 21 CFR 181.29 Ferric ammonium citrate: 21 CFR 184.1296 Ferric citrate: 21 CFR 184.1298 Ferrous citrate: 21 CFR 184.1307c Iron ammonium citrate: 21 CFR 172.430 Isopropyl citrate: 21 CFR 166.110, 184.1386 Magnesium citrate: 21 CFR 175.300 Manganese citrate: 184.1449 Monoglyceride citrate: 21 CFR 172.832

Monopotassium citrate: 21 CFR 133.169, 133.173, 133.179, 150.141, 150.161, 181.29, 184.1625;
Monosodium citrate: 21 CFR 131.112, 131.160, 133.179, 150.141, 150.161, 175.300, 181.29, 184.1751
Potassium citrate: 21 CFR 184.1625
Stearyl citrate: 21 CFR 166.110, 184.1851
Stearyl monoglyceridyl citrate: 21 CFR 172.755
Triethyl citrate: 21 CFR 175.300, 184.1911
Tripotassium phosphate: 21 CFR 181.29
Trisodium phosphate: 21 CFR 181.29

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NAME:	Dehydroacetic acid	
CATEGORY:	pH control agent/Preservatives	
FOOD USE:	Dairy products/Fruit, vegetables and nuts and products	
SYNONYMS:	DHA/DHS/Dehydracetic acid/Methylacetopyronone/Δ lactone/2-Acetyl-5-hydroxy-3-oxo-4-hexenoic acid/ 3-Acetyl-6-methyl-l, 2-pyran-2,4-dione/3-Acetyl-6-methyl-2,4-pyrandione/3-Acetyl-6-methyl-2*H*-pyran-2,4 (3*H*)-dione/3-Acetyl-6-methyl-pyrandione-2,4/CAS 520-45-6	
FORMULA:	$C_8H_8O_4$ (cyclic structure)	
MOLECULAR MASS IN Daltons:	168.16	
ALTERNATIVES FORMS:	Sodium dehydroacetate	
PROPERTIES AND APPEARANCE:	White or nearly white crystalline powder	
BOILING POINT IN °C AT VARIOUS PRESSURES (INCLUDING 760 mmHg):	269.9	
MELTING RANGE IN °C:	109–111	
DENSITY AT 20°C (AND OTHER TEMPERATURES) IN g/L:	5.8	
VAPOUR PRESSURE AT VARIOUS TEMPERATURES IN mmHg:	91.7°C (1 mm)	
PURITY %:	≥98.0	
HEAVY METAL CONTENT MAXIMUM IN ppm:	10	
ARSENIC CONTENT MAXIMUM IN ppm:	3	
ASH MAXIMUM IN %:	0.1	
SOLUBILITY % AT VARIOUS TEMPERATURE/pH COMBINATIONS:		
in water:	**@ 25°C**	<0.1

in vegetable oil:	**@ 25°C (olive oil)**	1.6
in propylene glycol:	**@ 25°C**	1 g/35 mL

FUNCTION IN FOODS:

Dehydroacetic acid and its sodium salt are GRAS when used in accordance with good manufacturing practices. Dehydroacetic acid is approved as a preservative for cut or peeled squash at levels not to exceed 65 ppm expressed as dehydroacetic acid remaining in or on squash. It is bacteriostatic at concentrations of 0.1–0.4% and fungistatic at concentrations of 0.005–0.1%. It can be used as a component of adhesives with no limitation other than good manufacturing practices. It can also be used as a fungistatic agent in cheese wrappers.

TECHNOLOGY OF USE IN FOODS:

Dehydroacetic acid $pK_1 = 5.27$

Dehydroacetic acid has one of the highest dissociation constants of the organic acids and remains effective at higher pH ranges than other acids.

It is twice as effective as sodium benzoate at pH 5.0 against *Saccharomyces cerevisiae*, and 25 times more effective against *Penicillium glaucum* and *Aspergillus niger*.

FOOD SAFETY ISSUES:

LD_{50} (mg/kg body weight). Rat 1000 oral route.

LEGISLATION:

USA:
Dehydroacetic acid: 21 CFR 172.130, 175.105

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NAME:	Fumaric acid
CATEGORY:	Emulsifiers/Stabilisers/Nutritive additives/Antioxidants/pH control agents/Preservatives/Flavour enhancers and modifiers/Flour and baking additives/Firming agent
FOOD USE:	Baked goods/Dairy products/Edible oils and fats/Meat, poultry and eggs and products/Fruit, vegetables and nuts and products/Beverages/Sugars, sugar preserves and confectionery/Alcoholic drinks
SYNONYMS:	Allomaleic acid/Boletic acid/2-butenedioc acid/Butenedioic acid/Lichenic acid/*trans*-Butenedioic acid/*trans*-1,2-ethylenedicarboxylic acid/(E)-butenedioic acid/(E)-1,2-ethylenedicarboxylic acid/CAS 110-17-8/DOT 9126/NSC-2752/U-1149/USAF EK-P-583
FORMULA:	$HOOC\text{-}(CH)_2\text{-}COOH$
MOLECULAR MASS IN Daltons:	116.07
ALTERNATIVES:	Calcium fumarate; ferrous fumarate; magnesium fumarate; potassium fumarate; sodium fumarate; sodium stearyl fumarate
PROPERTIES AND APPEARANCE:	White granules or crystalline powder
BOILING POINT IN °C AT VARIOUS PRESSURES (INCLUDING 760 mmHg):	290 (sublimes)
MELTING RANGE IN °C:	287
IONISATION CONSTANT AT 25°C:	9.30×10^{-4} 3.62×10^{-5}
DENSITY AT 20°C (AND OTHER TEMPERATURES) IN g/L:	1.635 @ 20°/4°C
HEAT OF COMBUSTION AT 25°C:	318.99 kcal/gram molecular weight
PURITY %:	≥99.5
WATER CONTENT MAXIMUM IN %:	0.5
HEAVY METAL CONTENT MAXIMUM IN ppm:	10
ARSENIC CONTENT MAXIMUM IN ppm:	3

ASH MAXIMUM IN %:	0.1						
SOLUBILITY % AT VARIOUS TEMPERATURE/pH COMBINATIONS:							
in water:	**@ 25°C**	0.63	**@ 40°C**	1.07	**@ 60°C**	2.4	**@ 100°C** 9.8
in vegetable oil (olive oil):	**@ 25°C**	Almost insoluble					
in ethanol solution (95%):	**@ 30°C**	5.76					

FUNCTION IN FOODS:

Fumaric acid is used at a level not in excess of the amount reasonably required to accomplish the intended effect. It can be found in pie fillings, refrigerated biscuit doughs, and maraschino cherries. Fumaric acid can be used as a pH control agent to alter the acidity of acidified milk, acidified low-fat milk, acidified skim milk, canned fruit, artificially sweetened fruit jelly, fruit preserves and jam. It increases the strength of gelatin gels and displays some antioxidant properties in fat-containing foods. It blends with certain flavouring compounds to intensify after-taste of a flavour in fruit juices. It is used as a component of adhesives and in the production of resinous and polymeric coatings at levels not to exceed good manufacturing practices. It can be used to accelerate colour fixing in cured, comminuted poultry, poultry products, meat or meat food products at a level of 0.065% (or 1oz/100lb) of the weight of the poultry, poultry by-products, meat or meat by-products before processing. Fumaric acid can be added to grapes after fermentation or in combination with other acids after fermentation to correct deficiencies at levels not to exceed 9 g/L finished wine. The fumaric acid can be added to stabilise wine at levels not to exceed 25 lb per 1000 gallons (~50 mg/L) and acid content of finished wine shall not exceed 3 g/L.

Calcium, ferrous, magnesium, potassium and sodium fumarates are a source of iron in foods and nutrient supplement in infant formula at levels consistent with good nutrition practice.

Sodium stearyl fumarate can be used as a dough conditioner in yeast-leavened bakery products at a level not to exceed 0.5% by weight of flour. It is used as a conditioning agent in dehydrated potatoes and processed cereals for cooking at levels not to exceed 1% by weight, and as a conditioning agent in starch-thickened or flour-thickened foods at levels not to exceed 0.2% by weight of the food. It is used as a stabilising agent in non-yeast-leavened bakery products at a level not to exceed 1% by weight of flour used.

ALTERNATIVES:

Fumaric acid can substitute for tartaric acid in beverages and baking powders and partially replace citric acid in fruit drinks.

TECHNOLOGY OF USE IN FOODS:

Fumaric acid $pK_1 = 3.03$; $pK_2 = 4.44$

Fumaric acid is one of the most acidic of the solid acids. Its low solubility in water limits its widespread use. Its slow rate of moisture absorption aids in extending the shelf-life of powdered products. It can eliminate excessive hardening and rubbery texture in alginate-based desserts.

It is compatible with fruit and berry flavour; imparts a tart metallic taste, and blends well with other acidulants without imparting a `burst' in flavour.

SYNERGISTS:

Complements sodium benzoate as a preservative in green foods and fish products.

FOOD SAFETY ISSUES:

LD_{50} (mg/kg body weight) fumaric acid. Rat 10 700 oral route.
LD_{50} (mg/kg body weight) disodium fumarate. Rat 3600–4800 oral route.
LD_{50} (mg/kg body weight) sodium fumarate. Rat 8000 oral route.
Acceptable daily intake for humans is limited unconditionally at 0–6 mg/kg body weight and conditionally at 6–10 mg/kg body weight.

LEGISLATION:

USA:
Fumaric acid: 381.147; 21 CFR 131.111, 150.141, 150.161, 172.350, 175.105, 175.300, 175.320; 176.180; 177.2420
Calcium fumarate: 21 CFR 172.350
Ferrous fumarate: 21 CFR 172.350, 184.1307d
Magnesium fumarate: 21 CFR 172.350
Potassium fumarate: 21 CFR 172.350
Sodium fumarate: 21 CFR 172.350
Sodium stearyl fumarate: 21 CFR 172.826

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NAME:	Glucono-delta-lactone
CATEGORY:	Chelating agents/pH control agents/Preservatives/Flour and baking additives
FOOD USE:	Baked goods/Dairy products/Meat, poultry and eggs and products/Fruit, vegetables and nuts and products
SYNONYMS:	D-gluconic acid-δ-lactone/D-gluconolactone/D-glucono-1,5-lactone
FORMULA:	$C_6H_{10}O_6$ (cyclic structure)
MOLECULAR MASS IN Daltons:	178.14
PROPERTIES AND APPEARANCE:	Fine, white, crystalline powder
MELTING RANGE IN °C:	153 (decomposition)
HEAVY METAL CONTENT MAXIMUM IN ppm:	<0.002
SOLUBILITY % AT VARIOUS TEMPERATURE/pH COMBINATIONS:	
in water:	59
in ethanol solution:	1
FUNCTION IN FOODS:	Glucono-δ-lactone is GRAS in the USA with no limitation other than good manufacturing practices. Glucono-δ-lactone can be used as a curing and pickling agent, leavening agent, pH control agent, and sequestrant and a binder. It can be used to alter the acidity of acidified milk, acidified low-fat milk, and acidified skim milk, meat and poultry products. It is used as a curing accelerator in cured, comminuted meat or meat food products at a level of 8 oz per 100 lb (~5 mg/kg) of meat or meat by-product where slowly lowered pH will increase the curing rate without shorting the emulsion. It serves as a replacement for bacterial starter cultures in fermented sausages. It is also used as a leavening agent and as a cleaning agent. It can be used as an ingredient in canned green beans and canned wax beans.
TECHNOLOGY OF USE IN FOODS:	Glucono-δ-lactone must undergo hydrolysis to gluconic acid before it can lower pH. Therefore, when used in the manufacture of cheese products the rate of pH is slowed.
FOOD SAFETY ISSUES:	LD_{50} (mg/kg body weight) glucono-δ-lactone. Rabbit 7630 intravenous route.

LEGISLATION:

USA:

Glucono-δ-lactone: 21 CFR 131.111, 155.120, 184.1318

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NAME:	Lactic acid
CATEGORY:	Emulsifiers/Stabilisers/Nutritive additives/pH control agents/Preservatives/Flavour enhancers and modifiers/ Solvents/Flour and baking additives/Humectants
FOOD USE:	Dairy products/Edible oils and fats/Fish and seafood and products/Meat, poultry and eggs and products/ Fruit, vegetables and nuts and products/Sugars, sugar preserves and confectionery/Alcoholic drinks/Vinegar, pickles and sauces
SYNONYMS:	Acetonic acid/Ethylidenelactic acid/Milk acid/1-Hydroxyethane 1-carbonylic acid/1-Hydroxyethane 1-carboxylic acid/2-Hydroxypropanoic acid/2-Hydroxypropionic acid/α-Hydroxypropionic acid/DL mixture CAS 598-82-3/L isomer CAS 79-33-4/D isomer CAS 10326-41-7
FORMULA:	$COOH\text{-}CHOH\text{-}CH_3$
MOLECULAR MASS IN Daltons:	90.08
ALTERNATIVE FORMS:	Butyl lactate; calcium lactate; ferrous lactate; potassium lactate; sodium lactate
PROPERTIES AND APPEARANCE:	Colourless or yellowish, syrupy, non-volatile, hygroscopic liquid
BOILING POINT IN °C AT VARIOUS	122 DL-lactic acid @ 15 mmHg
PRESSURES (INCLUDING 760 mmHg):	103 D-lactic acid @ 15 mmHg
MELTING RANGE IN °C:	52.8 D-lactic acid 16.8 DL-lactic acid 53 L-lactic acid
IONISATION CONSTANT AT 25°C:	8.4×10^{-4} @ 100°C
DENSITY AT 20°C (AND OTHER TEMPERATURES) IN g/L:	1.249 @ 15°C 1.2060 @ 21°/4°C (DL-lactic acid)
HEAT OF COMBUSTION AT 25°C:	326.8 kcal/gram molecular weight DL lactic acid
PURITY %:	≥95

HEAVY METAL CONTENT MAXIMUM IN ppm:	10
ARSENIC CONTENT MAXIMUM IN ppm:	3
ASH MAXIMUM IN %:	0.1%

SOLUBILITY % AT VARIOUS TEMPERATURE/pH COMBINATIONS:

in water:	**@ 25°C** Soluble	**@ 100°C** Quickly soluble
in ethanol solution (95%)	**@ 25°C** Almost insoluble	
in propylene glycol:	**@ 25°C** Soluble	

FUNCTION IN FOODS:

Lactic acid is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Lactic acid is used as an antimicrobial agent, curing and pickling agent, flavouring agent and flavour enhancer, pH control agent, solvent and vehicle, dough conditioner, thickener, and yeast food in bread. It has been used in the manufacture of angel food cake, canned fruits, meat food sticks, meringues, dry milk powders, sausage, canned vegetables, imitation sausages, jams, jellies, sherbets, confectionery products and whipped toppings. Lactic acid can be used to alter the acidity of acidified milk, acidified low-fat milk, acidified skim milk, margarine, oleomargarine, artificially sweetened fruit jelly, fruit preserves and jam, meat products and in brines for pickles and olives at a level sufficient for use. It can also be used to alter the acidity of cold pack cheese food such that the pH does not exceed 4.5, pasteurised process cheese (pH 5.3), cheese food (pH 5.0), cheese spread (pH 4.0), and dry curd cottage cheese (pH 4.5–4.7). It can be used as a sanitising agent on food processing equipment and as an antimicrobial spray on meat carcasses. A mixture of sodium alginate, calcium carbonate, lactic acid and calcium lactate can be used to bind ground and formed raw or cooked poultry pieces at a level not to exceed 1.55% of the product with the combination of lactic acid and calcium lactate at a level not to exceed 0.6% of product. Lactic acid and calcium lactate can be used in a mixture as a binder for restructured meat food products not to exceed a level of 0.3% of the product formulation. Lactic acid is used in the manufacture of hydroxylated lecithin used as an emulsifier. Lactic acid can be added to grapes after fermentation or in combination with other acids after fermentation to correct deficiencies at a level not to exceed 9 g/L in finished wine. It can be added to correct natural acid deficiencies in juice grape wine.

Butyl lactate is used as a component of adhesives at levels not to exceed good manufacturing practices.

Calcium lactate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Calcium lactate is a flavour enhancer, flavour agent or adjuvant, leavening agent, nutrient supplement, stabiliser and thickener. It can be used as a firming agent for apple slices and canned grapefruit at a level not to exceed 0.035% calcium by weight of the finished product, and to prevent discoloration

of fruit prior to thermal processing. It is used as a gelling agent in artificially sweetened fruit jelly, preserves, and jam. It ensures clarity in the brine of Spanish olives. It is used in salad dressings and marinades and in baking products. A mixture of sodium alginate, calcium carbonate, lactic acid and calcium lactate can be used to bind ground and formed raw or cooked poultry pieces at a level not to exceed 1.55% of the product with the combination of lactic acid and calcium lactate at a level not to exceed 0.6% of product. It can be used to bind and extend poultry products and is required at a rate of 10% of the binder if rennet-treated, calcium-reduced dried skim milk used or 25% of binder if rennet-treated sodium caseinate is used. Calcium lactate is used to protect flavour in cooked semi-dry and dry products including sausages, imitation sausage and non-specific meat food sticks at a level of 0.6% in product formulation.

Ferrous lactate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Ferrous lactate can be used as a dietary and nutrient supplement.

Potassium lactate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Potassium lactate is used as a flavour enhancer, flavouring agent or adjuvant, humectant and pH control agent. It can be used to acidify margarine and oleomargarine at a level sufficient for purpose. It can be used to flavour various poultry and poultry food products at a level not to exceed 2% of formulation.

Sodium lactate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Sodium lactate is used as a flavour enhancer, flavouring agent or adjuvant, pH control agent, denuding agent, emulsifier, hog scald agent, humectant, lye peeling agent, washing agent and cooked-out juices retention agent. It is used in biscuits, fruits, hog carcasses, meat products, nuts, sponge cake, Swiss roll, vegetables, and bottled water. It can be used to acidify margarine and oleomargarine at a level sufficient for purpose. It is limited in meat products where allowed to 5% of phosphate in pickle at a 10% pump level; and 0.5% of phosphate in product. It is used to flavour various poultry and poultry food products, meat and meat food products at a level not to exceed 2% of the formulation.

TECHNOLOGY OF USE IN FOODS:

Lactic acid $pK_1 = 3.08$

Manufactured in technical, food and USP grade in two concentrations: 50% and 88%.

SYNERGISTS:

Lactic acid acts synergistically with acetic acid as an antimicrobial preservative.

FOOD SAFETY ISSUES:

LD_{50} (mg/kg body weight) lactic acid. Mouse 4875 oral route. Rat 3730 oral route. Guinea pig 1810 oral route.

LD_{50} (mg/kg body weight) ferrous lactate. Mouse 147 oral route.

LD_{50} (mg/kg body weight) sodium lactate. Rat 2000 intraperitoneal route.

Acceptable daily intake for humans of lactic acid is not limited for lactic acid and its calcium, potassium, ammonium and sodium salts and is limited up to 100 mg/kg body weight for DL lactic acid.

Lactic acid and the calcium, potassium and sodium salt should not be used in infant foods and formulas in either the D(−) or DL form; acetic acid may be substituted.

LEGISLATION:

USA:

Lactic acid: 9 CFR 381.129; 21 CFR 131.111, 133.123,133.124, 133.125, 133.129, 133.169, 133.171, 133.173, 133.174, 133.176, 133.178, 133.179, 133.180, 150.141, 150.161, 172.814, 178.1010, 184.1061

Butyl lactate: 21 CFR 175.105

Calcium lactate: 9 CFR 381.129; 21 CFR 145.145, 150.141, 150.161, 184.1207

Ferrous lactate: 21 CFR 184.1311

Potassium lactate: 21 CFR 184.1639

Sodium lactate: 21 CFR 184.1768

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NAME:	Malic acid
CATEGORY:	Antioxidants/pH control agents/Preservatives/Flavour enhancers and modifiers
FOOD USE:	Baked good/Dairy products/Edible oils and fats/Meat, poultry and eggs and products/Fruit, vegetables and nuts and products/Beverages/Soft drinks/Sugars, sugar preserves and confectionery/Alcoholic drinks
SYNONYMS:	Hydroxybutanedioic acid/Hydroxysuccinic acid/Pomalous acid/1-Hydroxy-1,2-ethanedicarboxylic acid/L form CAS 97-67-6/DL form CAS 617-48-1
FORMULA:	HO-CH-(COOH)-CH_2-COOH
MOLECULAR MASS IN Daltons:	134.09
PROPERTIES AND APPEARANCE:	White or nearly white, crystalline powder or granules
BOILING POINT IN °C AT VARIOUS PRESSURES (INCLUDING 760 mmHg):	150 DL-malic acid 140 D- or L-malic acid
MELTING RANGE IN °C:	128 DL-malic acid 100 D- or L-malic acid
IONISATION CONSTANT AT 25°C:	3.9×10^{-4} 7.8×10^{-6}
DENSITY AT 20°C (AND OTHER TEMPERATURES) IN g/L:	1.601 (DL-malic acid) 1.595 (D- or L-malic acid) @ 20°/4°C
HEAT OF COMBUSTION AT 25°C IN J/kg:	317.37 (L malic acid)
PURITY %:	≥99
HEAVY METAL CONTENT MAXIMUM IN ppm:	20
ARSENIC CONTENT MAXIMUM IN ppm:	3
ASH MAXIMUM IN %:	0.1

SOLUBILITY % AT VARIOUS TEMPERATURE/pH COMBINATIONS:

in water:	**@ 20°C**	55.8 (DL), 36.3 (L)	**@ 25°C**	Very soluble
in ethanol solution (95%)	**@ 20°C**	45.53 DL malic acid	**@ 20°C**	86.60 L malic acid

FUNCTION IN FOODS:

Malic acid is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Malic acid may be used as a flavour enhancer, flavouring agent and adjuvant, and pH control agent. It can be used in sherbets and ices, candies, baked goods, canned fruits, fat, lard, shortening, fruit preserves, jams, jellies, gelatins, puddings, and beverages primarily for flavouring and acidification. Malic acid can be used to alter the acidity of acidified milk, acidified low-fat milk, acidified skim milk, and artificially sweetened fruit jelly, fruit preserves and jam. Maximum levels recommended are 0.8% in gelatin, pudding and fillings, 2.6% in jams and jellies, 3.0% in chewing gum and soft candy, 3.4% in non-alcoholic beverages, 3.5% in processed fruits and fruit juice, 6.9% in hard candy and 0.7% in all other foods to be used in accordance with good manufacturing practices. It is used to increase the effectiveness of antioxidants in poultry fats at a level of 0.01%. It is limited at 0.01% based on total weight in combination with antioxidants in lard and shortening. It can be used in French dressing, mayonnaise and salad dressing at a level not to exceed 25% of the weight of the acids of the vinegar or diluted vinegar calculated as acetic acid. It can be added to grapes prior to fermentation or in combination with other acids to correct deficiencies after fermentation at a level not to exceed 9 g/L. It can also be added to adjust the acidity in apples, apple juice or wine at a level not to exceed 9 g/L of finished wine. It can be used to correct natural acid deficiencies in juice or wine.

ALTERNATIVES:

Malic acid imparts the same degree of acidity as citric acid, but in lower amounts.

TECHNOLOGY OF USE IN FOODS:

Malic acid $pK_1 = 3.4$; $pK_2 = 5.11$

Malic acid does not have the same build-up of acid taste as other acids. It imparts a smooth tart taste with no burst of flavour and is compatible with fruit and berry flavour in hard candies. It provides excellent anti-browning properties in fruits.

The US Internal Revenue Service has specified the addition of malic acid to volatile fruit flavour concentrates containing 6–15% alcohol to render these products non-potable during transportation from manufacturer to winery.

SYNERGISTS:

Malic acid acts synergistically with antioxidants to prevent rancidity.

FOOD SAFETY ISSUES:

LD_{50} (mg/kg body weight) L malic acid. Rat 1600 oral route. Rabbit 5000 oral route.

LD_{50} (mg/kg body weight) sodium malate. Dog 1000 oral route.

Acceptable daily intake for humans of malic acid is not limited for malic acid but is limited at 100 mg/kg for DL malic acid. D and DL malic acids are not to be used in baby foods.

LEGISLATION:

USA:

Malic acid: 21 CFR 131.111, 150.141, 150.161, 169.115, 169.140, 169.150, 184.1069

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NAME:	Phosphoric acid
CATEGORY:	Emulsifiers/Stabilisers/Chelating agents/Nutritive additives/Antioxidants/pH control agents/Preservatives/ Flavour enhancers and modifiers/Flour and baking additives/Anti-caking agents/Firming agents
FOOD USE:	Baked goods/Cereals and cereal products/Dairy products/Edible oils and fats/Fish and seafood and products/ Meat, poultry and eggs and products/Beverages/Soft drinks/Sugars, sugar preserves and confectionery/ Alcoholic drinks/Vinegar, pickles and sauces
SYNONYMS:	Orthophosphoric acid/CAS 7664-38-2/DOT 1805
FORMULA:	$P(OH)_2$-OOH
MOLECULAR MASS IN Daltons:	98.0
ALTERNATIVE FORMS:	Phosphoric acid; ammonium phosphate, dibasic; ammonium phosphate, monobasic; ammonium potassium hydrogen phosphate; ammonium potassium phosphate; calcium glycerophosphate; calcium hexametaphosphate; calcium phosphate, dibasic; calcium phosphate, monobasic; calcium phosphate, tribasic; calcium pyrophosphate; ferric phosphate; ferric pyrophosphate; ferric sodium pyrophosphate; magnesium glycerophosphate; magnesium phosphate, dibasic; magnesium phosphate, monobasic; magnesium phosphate, tribasic; manganese glycerophosphate; potassium glycerophosphate; potassium phosphate, dibasic; potassium phosphate, monobasic; potassium pyrophosphate; potassium tripolyphosphate; sodium acid pyrophosphate; sodium aluminum phosphate; sodium metaphosphate; sodium phosphate, dibasic; sodium phosphate, monobasic; sodium phosphate, tribasic; sodium polyphosphate; sodium pyrophosphate; sodium tripolyphosphate; tetrasodium pyrophosphate
PROPERTIES AND APPEARANCE:	Colourless solution
MELTING POINT IN °C:	42.35
FLASH POINT IN °C	42.4
IONISATION CONSTANT AT 25°C:	7.52×10^{-3} 6.23×10^{-8} 2.2×10^{-13} (@ 18°C)

DENSITY AT 20°C (AND OTHER TEMPERATURES) IN g/L:	1.8741 (100% solution) 1.6850 (85% solution) 1.334 (50% solution) 1.0523 (10% solution)
VAPOUR PRESSURE AT VARIOUS TEMPERATURES:	0.0285 mmHg @ 20°C
PURITY %:	75–85%
HEAVY METAL CONTENT MAXIMUM IN ppm:	10
ARSENIC CONTENT MAXIMUM IN ppm:	2
SOLUBILITY % AT VARIOUS TEMPERATURE/pH COMBINATIONS:	
in water:	Soluble
in ethanol solution:	Soluble
FUNCTION IN FOODS:	Phosphoric acid is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Phosphoric acid can be used to alter the acidity of acidified milk, acidified low-fat milk, and acidified skim milk, margarine and oleomargarine, poultry, meat, and meat food products. It can be used to acidify cold pack cheese food such that the pH of the finished products is not below pH 4.5, pasteurised process cheese food (pH 5.3), pasteurised process cheese food (pH 5.0), pasteurised process cheese spread (pH 4.0) and dry-curd cottage cheese (4.5–4.7). It can be used as a synergist in combination with antioxidants in lard, shortening and poultry fat at a limit of 0.01%. It assists in caramelisation. It can be used as a sanitiser on food processing equipment. Ammonium phosphate, dibasic is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Ammonium phosphate, dibasic can be used as a pH control agent, processing aid, firming agent, and leavening agent. It is found in baked goods, alcoholic beverages, condiments, and puddings. It is used as a yeast nutrient in wine production and to start secondary fermentation of sparkling wines at a level not to exceed 8 lb per 1000 gallons (~16 mg/L). Ammonium phosphate, monobasic is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Ammonium phosphate, monobasic can be used as a pH control agent, and dough strengthener. It is found in baked goods, baking powder, frozen desserts, margarine,

whipped toppings and yeast food. It is used as a yeast nutrient in wine production and to start secondary fermentation of sparkling wines at a level not to exceed 8 lb per 1000 gallons (16 mg/L).

Ammonium potassium hydrogen phosphate can be used as an indirect additive as a component of adhesives intended for use in packaging and in the production of resinous and polymeric coatings in packaging materials.

Ammonium potassium phosphate can be used as an indirect additive in the production of resinous and polymeric coatings in packaging materials.

Calcium glycerophosphate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Calcium glycerophosphate can be used as a dietary and nutrient supplement. It is found in gelatins, puddings and fillings. It can be used as an indirect additive in the production of resinous and polymeric coatings in packaging materials.

Calcium hexametaphosphate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Calcium hexametaphosphate is used as a sequestrant.

Calcium phosphate, dibasic is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Calcium phosphate, dibasic is used as a dietary and nutrient supplement, dough conditioner, stabiliser, yeast food in baked foods, cereal products, and dessert gels. It can be used as an indirect additive in the production of resinous and polymeric coatings in packaging materials.

Calcium phosphate, monobasic is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Calcium phosphate, monobasic is used as a dietary and nutrient supplement, dough conditioner, firming agent, leavening agent, sequestrant, stabiliser, yeast food in cereals, and dough. It can be used as an acidulant in baking powders and wheat flours or as a mineral supplement for foods. It can be used in artificially sweetened fruit jelly, fruit preserves and jams as a gelling agent. It is limited in bread, rolls and buns to not more than 0.75 part for each 100 parts by weight of flour used. It can be used as an indirect additive in the production of resinous and polymeric coatings in packaging materials.

Calcium phosphate, tribasic is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Calcium phosphate, tribasic can be used as a dietary supplement, nutrient, stabiliser in cereals, desserts, flour, lard, and dry vinegar. It can be used in clarifying sugar syrups and as an anti-caking agent in table salt. It can be used to preserve colour during dehydration processing in mechanically deboned chicken to be dehydrated at a level not to exceed 2% of the mechanically deboned chicken prior to dehydration. It can be used as an aid in rendering animal fats. It can be used as an indirect additive in the production of resinous and polymeric coatings in packaging materials.

Calcium pyrophosphate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Calcium pyrophosphate can be used as a dietary and nutrient supplement.

Ferric phosphate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. It is used as a dietary and nutrient supplement.

Ferric pyrophosphate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Ferric pyrophosphate can be used as a dietary and nutrient supplement.

Ferric sodium pyrophosphate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Ferric sodium pyrophosphate is used as a dietary supplement.

Magnesium glycerophosphate can be used as a stabiliser when migrating from food packaging material. It can be used as an indirect additive in the production of resinous and polymeric coatings in packaging materials.

Magnesium phosphate, dibasic is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Magnesium phosphate, dibasic is used as a pH control agent and a dietary and nutrient supplement. It can be used as an indirect additive in the production of resinous and polymeric coatings in packaging materials.

Magnesium phosphate, monobasic can be used as an indirect additive in the production of resinous and polymeric coatings in packaging materials.

Magnesium phosphate, tribasic is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Magnesium phosphate, tribasic is used as a pH control agent, stabiliser and nutrient supplement. It can be used as an indirect additive in the production of resinous and polymeric coatings in packaging materials.

Manganese glycerophosphate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Manganese glycerophosphate can be used as a dietary supplement.

Potassium glycerophosphate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Potassium glycerophosphate can be used as a dietary supplement and as a stabiliser when migrating from food packaging material.

Potassium phosphate, dibasic is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Potassium phosphate, dibasic can be used as a sequestrant in the preparation of non-dairy powdered coffee creamers. It is used as an emulsifier in pasteurised process cheese, cheese food, and cheese spread at a level not to exceed 3.0% of the weight of the finished products. It can be used to decrease the amount of cooked-out juices in meat food products at a level of 5% of phosphate in pickle, at 10% in pump level, and 0.5% of phosphate in product only (clear solution may be injected into product) or in poultry at a limit of 0.5% of total poultry product. It can be used to remove feathers from poultry carcasses.

Potassium phosphate, monobasic is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Potassium phosphate, monobasic can be used to decrease the amount of cooked-out juices in meat food products at a level of 5% of phosphate in pickle, at 10% in pump level, and 0.5% of phosphate in product only (clear solution may be injected into product) or in poultry at a limit of 0.5% of total poultry product.

Potassium pyrophosphate can be used to decrease the amount of cooked-out juices in meat food products at a level of 5% of phosphate in pickle, at 10% in pump level, and 0.5% of phosphate in product only (clear solution may be injected into product) or in poultry at a limit of 0.5% of total poultry product.

Potassium tripolyphosphate is used as a boiler water additive. It can be used to decrease the amount of cooked-out juices in meat food products at a level of 5% of phosphate in pickle, at 10% in pump level, and 0.5% of phosphate in product only (clear solution may be injected into product) or in poultry at a limit of 0.5% of total poultry product.

Sodium acid pyrophosphate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Sodium acid pyrophosphate is used as an emulsifier in pasteurised process cheese, cheese food, and cheese spread at a level not to exceed 3.0% of the weight of the finished products. It can be used as a sequestrant. It can be used as a curing accelerator to accelerate colour fixing in frankfurters, wieners, Vienna, bologna, garlic bologna, knockwurst and similar products not to exceed alone or in combination with other curing accelerators 8 oz per 100 lb (~5 mg/kg) of meat or meat and meat by-products nor 0.5% in finished product. It can be used to decrease the amount of cooked-out juices in meat food products at a level of 5% of phosphate in pickle, at 10% in pump level, and 0.5% of phosphate in product only (clear solution may be injected into product) or in poultry at a limit of 0.5% of total poultry product. It can be used to remove hair from hog carcasses and feathers from poultry carcasses.

Sodium aluminum phosphate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Sodium aluminum phosphate can be used as an emulsifier in pasteurised process cheese, cheese food, and cheese spread at a level not to exceed 3.0% of the weight of the finished products.

Sodium metaphosphate (hexametaphosphate) is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Sodium metaphosphate is used as a starch modifying agent, sequestrant and texturiser. It is used in fish, lima beans, peanuts and canned peas. It is used as an emulsifier in pasteurised process cheese, cheese food, and cheese spread at a level not to exceed 3.0% of the weight of the finished products. It is used as a stabiliser and thickener in French dressing. It can be used in artificially sweetened fruit jelly, fruit preserves and jam at a level not to exceed 8 oz per 100 lb (~5 mg/kg) of the finished food. In meat food products it can be used in combination with sodium tripolyphosphate to protect flavour in fresh beef, beef for further cooking, cooked beef, beef patties, meat loaves, meat toppings and similar products derived from pork, lamb, veal, mutton and goat meat which are cooked or frozen after processing at a level not to exceed 0.5% of total product. It can be used to decrease the amount of cooked-out juices in meat food products at a level of 5% of phosphate in pickle, at 10% in pump level, and 0.5% of phosphate in product only (clear solution may be injected into product) or in poultry at a limit of 0.5% of total poultry product. It can be used to remove hair from hog carcasses. It is an indirect additive when migrating to food from paper and paperboard products.

Sodium phosphate, dibasic is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Sodium phosphate, dibasic can be used as a boiler water additive, sequestrant, texturiser, a dietary and nutrient supplement and buffer in coffee whiteners, cream sauce, evaporated milk, instant pudding and whipped products. It is used as an emulsifier in pasteurised process cheese, cheese food, and cheese spread at a level not to exceed 3.0% of the weight of the finished products. It can be used in artificially sweetened fruit jelly, fruit preserves and jam at a level not to exceed 2 oz per 100 lb (~1 mg/kg) of the finished food. It can be used to decrease the amount of cooked-out juices in meat food products at a level of 5% of phosphate in pickle, at 10% in pump level, and 0.5% of phosphate in product only (clear solution may be injected into product) or in poultry at a limit of 0.5% of total poultry product. It can be used to remove hair from hog carcasses and feathers from poultry carcasses. It can be used as an indirect additive in the production of resinous and polymeric coatings in packaging materials.

Sodium phosphate, monobasic is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Sodium phosphate, monobasic can be used as a boiler water additive, a sequestrant, dietary and nutrient supplement. It is used as an emulsifier in pasteurised process cheese at a level not to exceed 3.0% of the weight of finished products. It can be used in artificially sweetened fruit jelly, fruit preserves and jam at a level not to exceed 2 oz per 100 lb (~1 mg/kg) of the finished food. It can be used to decrease the amount of cooked-out juices in meat food products at a level of 5% of phosphate in pickle, at 10% in pump level, and 0.5% of phosphate in product only (clear solution may be injected into product) or in poultry at a limit of 0.5% of total poultry product. It can be used to remove feathers from poultry carcasses at a level sufficient for use. It can be used in the production of resinous and polymeric coatings and as a stabiliser when migrating from packaging materials.

Sodium phosphate, tribasic is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Sodium phosphate, tribasic is used as a boiler water additive, sequestrant, buffer, and dietary and nutrient supplement. It is used in cereals and evaporated milk. It is used as an emulsifier in pasteurised process cheese, cheese food, and cheese spread at a level not to exceed 3.0% of the weight of the finished products. It can be used in artificially sweetened fruit jelly, fruit preserves and jam at a level not to exceed 2 oz per 100 lb (~1 mg/kg) of the finished food. It is a denuding agent in tripe at a level sufficient for purpose. It can be used to remove hair from hog carcasses and feathers from poultry carcasses. It can be used in the production of resinous and polymeric coatings and as a stabiliser when migrating from packaging materials. It can be used as an aid in rendering animal fats.

Sodium polyphosphate can be used in combination with sodium tripolyphosphate and sodium metaphosphate to protect flavour in fresh beef, beef for further cooking, cooked beef, beef patties, meat loaves, meat toppings and similar products derived from pork, lamb, veal, mutton and goat meat which are cooked or frozen after processing at a level not to exceed 0.5% of total product. It can be used to decrease the amount of cooked-out juices

in meat food products at a level of 5% of phosphate in pickle, at 10% in pump level, and 0.5% of phosphate in product only (clear solution may be injected into product) or in poultry at a limit of 0.5% of total poultry product.

Sodium pyrophosphate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Sodium pyrophosphate can be used as a sequestrant. It can be used to decrease the amount of cooked-out juices in meat food products at a level of 5% of phosphate in pickle, at 10% in pump level, and 0.5% of phosphate in product only (clear solution may be injected into product) or in poultry at a limit of 0.5% of total poultry product. It can be used to remove hair from hog carcasses and feathers from poultry carcasses. It can be used as an indirect additive in the production of resinous and polymeric coatings in packaging materials.

Sodium tripolyphosphate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Sodium tripolyphosphate is used as a sequestrant, texturiser used in angel food cake mix, desserts, gelling juices, canned ham, lima beans, meringues and canned peas. In meat food products it can be used alone or in combination with sodium metaphosphate and sodium polyphosphate to protect flavour in fresh beef, beef for further cooking, cooked beef, beef patties, meat loaves, meat toppings and similar products derived from pork, lamb, veal, mutton and goat meat which are cooked or frozen after processing at a level not to exceed 0.5% of total product. It can be used to decrease the amount of cooked-out juices in meat food products at a level of 5% of phosphate in pickle, at 10% in pump level, and 0.5% of phosphate in product only (clear solution may be injected into product) or in poultry at a limit of 0.5% of total poultry product. It can be used to remove hair from hog carcasses and feathers from poultry. It can be used as a substance migrating to food from paper and paperboard products.

Tetrasodium pyrophosphate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Tetrasodium pyrophosphate can be used as a sequestrant and boiler water additive. It is used as an emulsifier in pasteurised process cheese, cheese food, and cheese spread at a level not to exceed 3.0% of the weight of the finished products. It can be used to remove feathers from poultry carcasses at a level sufficient for use. It is used as a substance when migrating to food from cotton and cotton fabrics used in dry packaging and can be used as an indirect additive in the production of resinous and polymeric coatings in packaging materials.

TECHNOLOGY OF USE IN FOODS: Phosphoric acid $pK_1 = 2.12$; $pK_2 = 7.21$; $pK_3 = 12.67$

SYNERGISTS: Phosphoric acid increases the effectiveness of antioxidants in lard and shortening.

FOOD SAFETY ISSUES: LD_{50} (mg/kg body weight) phosphoric acid. Rat 1530 oral route.

Acceptable daily intake for humans of phosphoric acid is up to 70 mg/kg body weight.

LEGISLATION:

USA:

Phosphoric acid: 21 CFR 131.111, 133.124, 133.129, 133.169, 133.173, 133.179, 178.1010, 182.1073
Ammonium phosphate, dibasic: 21 CFR 184.1141b
Ammonium phosphate, monobasic: 21 CFR 184.1141a
Ammonium potassium hydrogen phosphate: 21 CFR 175.105, 175.300, 181.29
Ammonium potassium phosphate: 21 CFR 175.300
Calcium glycerophosphate: 21 CFR 175.300, 181.29, 184.1201
Calcium hexametaphosphate: 21 CFR 182.6203
Calcium phosphate, dibasic: 21 CFR 175.300, 181.29, 182.1217, 182.8217
Calcium phosphate, monobasic: 21 CFR 150.141, 150.161, 175.300, 181.29, 182.1217, 182.6215, 182.8217
Calcium phosphate, tribasic: 21 CFR 175.300, 182.1217, 182.8217
Calcium pyrophosphate: 21 CFR 182.8223
Ferric phosphate: 21 CFR 184.1301
Ferric pyrophosphate: 21 CFR 184.1304
Magnesium glycerophosphate: 21 CFR 175.300, 181.29
Magnesium phosphate, dibasic: 21 CFR 175.300, 181.29, 184.1434
Magnesium phosphate, monobasic: 21 CFR 175.300, 181.29,
Magnesium phosphate tribasic: 21 CFR 175.300, 184.1434
Potassium phosphate, dibasic: 21 CFR 133.169, 133.173, 133.179, 182.6285
Potassium tripolyphosphate: 21 CFR 173.310
Sodium acid pyrophosphate: 21 CFR 133.169, 133.173, 133.179, 182.1087
Sodium aluminum phosphate: 21 CFR 133.169, 133.173, 133.179, 182.1781
Sodium metaphosphate: 21 CFR 133.169, 133.173, 133.179, 150.141, 150.161, 169.115, 182.90, 182.6760, 182.6769
Sodium phosphate, dibasic: 21 CFR 133.169, 133.173, 133.179, 150.141, 150.161, 173.310, 175.300, 182.1778, 182.6290, 182.6778, 182.8778
Sodium phosphate, monobasic: 21 CFR 133.169, 133.173, 133.179, 150.141, 150.161, 173.310, 182.1778, 182.6085, 182.8778
Sodium phosphate, tribasic: 21 CFR 133.169, 133.173, 133.179, 150.141, 150.161, 173.310, 182.1778, 182.6778, 182.8778
Sodium tripolyphosphate: 21 CFR 173.310, 182.1810, 182.90, 182.6810
Tetrasodium pyrophosphate: 21 CFR 133.169, 133.173, 133.179, 173.310, 181.29, 182.70, 182.6787, 182.6789

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NAME:	Propionic acid
CATEGORY:	Antioxidants/pH control agents/Preservatives/Flavour enhancers and modifiers
FOOD USE:	Baked goods/Dairy products/Meat, poultry and eggs and products/Beverages/Sugars, sugar preserves and confectionery
SYNONYMS:	Carboxyethane/Ethane carboxylic acid/Ethylformic acid/Metacetonic acid/Methylacetic acid/Propanoic acid/Prozoin/Pseudoacetic acid/CAS 79-09-4/DOT 1848
FORMULA:	CH_3-CH_2-COOH
MOLECULAR MASS IN Daltons:	74.08
ALTERNATIVE FORMS:	Calcium propionate; dilauryl thiopropionic acid; potassium propionate; sodium propionate; thiopropionic acid
PROPERTIES AND APPEARANCE:	Oily liquid (propionic acid) White, free-flowing powder (salts)
BOILING POINT IN °C AT VARIOUS PRESSURES (INCLUDING 760 mmHg):	4.6 (1 mmHg) 85.8 (100 mmHg) 122.0 (400 mmHg) 141.1 (760 mmHg)
MELTING POINT IN °C:	−21.5
FLASH POINT IN °C:	58
IONISATION CONSTANT AT 25°C:	1.34×10^{-5}
DENSITY AT 20°C (AND OTHER TEMPERATURES) IN g/L:	0.99336 @ 20°/4°C 0.998 @ 15°/4°C
HEAT OF COMBUSTION AT 25°C:	365.03 kcal/gram molecular weight
VAPOUR PRESSURE AT VARIOUS TEMPERATURES:	4.6°C (1 mmHg) 39.7°C (10 mmHg) 65.8°C (40 mmHg) 85.8°C (100 mmHg)

	122.0°C (400 mmHg) 141.1°C (760 mmHg)
PURITY %:	≥99.5
WATER CONTENT MAXIMUM IN %:	0.15
HEAVY METAL CONTENT MAXIMUM IN ppm:	10
ARSENIC CONTENT MAXIMUM IN ppm:	3
ASH MAXIMUM IN %:	0.01
SOLUBILITY % AT VARIOUS TEMPERATURE/pH COMBINATIONS:	
in water:	**@ 100°C** Sodium salt, 150 **@ 100°C** Calcium salt, 58.8
in vegetable oil:	**@ 25°C** Soluble
in ethanol solution (95%)	**@ 25°C** Sodium propionate, 4 **@ 25°C** Calcium propionate, insoluble
FUNCTION IN FOODS:	Propionic acid is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Propionic acid can be used as a flavouring agent and as an antifungal agent to control mould growth on the surface of cheese and buffer and inhibits rope formation in baked goods. Maximum levels recommended are 0.3% in cheese products, 0.32% in flour and in white bread and rolls, 0.38% in whole wheat products. Calcium propionate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Calcium propionate can be used as an antimycotic agent when migrating from food packaging material for cold-pack cheese or cheese food, pasteurised process cheese or cheese food, and pasteurised process cheese spread at a level not to exceed 0.3% alone or in combination with sodium propionate. It is used as an antifungal agent to control mould growth on the surface of cheese and butter and inhibits rope formation in baked goods. It can be used in confections and frostings, gelatins, puddings fillings, jams and jellies. Maximum levels recommended for use as a preservative are 0.3% alone or in combination with sodium propionate based on the weight of the flour used in the fresh pie dough, cold pack cheese, pasteurised process cheese food, pasteurised process cheese spread, 0.32% alone or in combination with sodium propionate based on the weight of the flour in pizza crust, and 0.1% by weight of artificially sweetened fruit jelly, fruit preserves and jams. It is not limited in bread, rolls or buns. It can be used as a yeast nutrient.

Dilauryl thiopropionic acid is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Dilauryl thiopropionic acid is used as a chemical preservative when the total content of antioxidants does not exceed 0.02% of the fat or oil content.

Potassium propionate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Potassium propionate is used as an antifungal agent to control mould growth on the surface of cheese and butter and inhibits rope formation in baked goods. It can be used in baked goods, non-alcoholic beverages, soft candy, cheese, frostings, confections, fresh pie, fillings, gelatins, jams, jellies, meat products, pizza crust, and puddings.

Sodium propionate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Sodium propionate can be used as a flavouring agent and an antimycotic agent when migrating from food packaging material for cold-pack cheese or cheese food, pasteurised process cheese or cheese food, and pasteurised process cheese spread at a level not to exceed 0.3% alone or in combination with calcium propionate. It is used as an antifungal agent to control mould growth on the surface of cheese and butter and inhibits rope formation in baked goods. It can be used in baked goods, non-alcoholic beverages, cheeses, confections and frostings, gelatins, puddings, fillings, jams and jellies, meat products and soft candy. Maximum levels recommended for use as a preservative are 0.3% alone or in combination with calcium propionate based on the weight of the flour used in the fresh pie dough, cold pack cheese, pasteurised process cheese food, and pasteurised process cheese spread, 0.32% alone or in combination with calcium propionate based on the weight of the flour in pizza crust, 0.1% by weight of artificially sweetened fruit jelly, preserves and jams. It is not limited in bread, rolls or buns.

Thiodipropionic acid is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Thiodipropionic acid is used as a chemical preservative when the total content of antioxidants does not exceed 0.02% of the fat or oil content.

TECHNOLOGY OF USE IN FOODS:

Propionic acid $pK_1 = 4.87$

Propionic acid has a pungent sour odour and taste, and is limited in use by its sensory properties.

The salts of propionic acid have a slight cheese-like flavour. The sodium salt is more soluble than the calcium form. The salts are readily incorporated into powdered mixes.

Propionates may be added to bread dough without interfering with leavening since there is little or no effect on yeast growth. Sodium propionate is recommended for use in chemically leavened products since calcium interferes in the leavening action. Calcium propionate is preferred for use in bread and rolls because calcium propionate contributes to the enrichment of the product.

FOOD SAFETY ISSUES:

LD_{50} (mg/kg body weight) of propionic acid. Mouse 625 intravenous route. Rat 2600–3500 oral route.

LD_{50} (mg/kg body weight) calcium propionate. Rat 3340 oral route; 580–1020 intravenous route.

LD_{50} (mg/kg body weight) sodium propionate. Mouse 2100 subcutaneous route. Rat 5100 oral route; 1380–3200 intravenous route. Rabbit 1640 cutaneous route.

Acceptable daily intake for humans of propionic acid and its calcium, potassium and sodium salts is not limited.

LEGISLATION:

USA:

Propionic acid: 21 CFR 172.515, 184.1081

Calcium propionate: 9 CFR 318.7, 381.147; 21 CFR 133.123, 133.124, 133.169, 133.173, 133.179, 136.110, 136.115, 136.130, 136.160, 136.180, 150.141, 150.161, 181.23, 184.1081, 184.1221

Dilauryl thiopropionic acid: 21 CFR 182.3109, 182.3280

Potassium propionate: 9 CFR 318.7, 381.147

Sodium propionate: 9 CFR 318.7; 21 CFR 133.123, 133.124, 133.169, 133.173, 133.179, 150.141, 150.161, 181.23, 184.1784

Thiodipropionic acid: 21 CFR 181.24, 182.3109

Thiopropionic acid: 21 CFR 182.3280

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NAME:	Sodium diacetate
CATEGORY:	Chelating agents/pH control agents/Preservatives/Flavour enhancers and modifiers
FOOD USE:	Baked goods/Dairy products/Edible oils and fats/Meat, poultry and eggs and products/Sugars, sugar preserves and confectionery
SYNONYMS:	Dykon/Sodium acid acetate/Sodium hydrogen diacetate/CAS 126-96-5
FORMULA:	CH_3-COONa-CH_3-COOH · xH_2O
MOLECULAR MASS IN Daltons:	142.09, anhydrous
ALTERNATIVE FORMS:	Calcium diacetate
PROPERTIES AND APPEARANCE:	White, hygroscopic crystalline solid
BOILING POINT IN °C AT VARIOUS PRESSURES (INCLUDING 760 mmHg):	235
MELTING POINT IN °C:	58
PURITY %:	≥39 to ≤41 acetic acid; ≥58 to ≤60 sodium acetate
WATER CONTENT MAXIMUM IN %:	≤2
HEAVY METAL CONTENT MAXIMUM IN ppm:	≤10
ARSENIC CONTENT MAXIMUM IN ppm:	≤3
SOLUBILITY % AT VARIOUS TEMPERATURE/pH COMBINATIONS:	
in water:	**@ 25°C** 100
FUNCTION IN FOODS:	Sodium diacetate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Sodium diacetate can be used as a preservative in butter and wrapping materials, pH control agent, flavouring agent and adjuvant. It inhibits bread mould and rope-forming bacteria in bakery products and has little effect on baker's yeast. It delays mould growth in cheese spreads at concentrations

of 0.1–2% and in malt syrups at 0.5%. Maximum levels recommended are 0.05% in snack foods, soup, and soup mixes (commercial), 0.1% in fats, oils, soft candy, and meat products, 0.25% in gravies and sauces, and up to 0.4% in baked goods and baking mixes.

Calcium diacetate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. It is used as a sequestrant, preservative, pH control agent, flavouring agent and adjuvant.

TECHNOLOGY OF USE IN FOODS:

Sodium diacetate $pK_1 = 4.75$

Effective at pH of 3.5–4.5 to control mould growth in animal feed and silage.

FOOD SAFETY ISSUES:

Acceptable daily intake for humans of sodium diacetate is limited conditionally up to 15 mg/kg body weight.

LEGISLATION:

USA:
Sodium diacetate: 21 CFR 184.1754
Calcium diacetate: 21 CFR 182.6197

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NAME:	Succinic acid
CATEGORY:	pH control agents/Preservatives/Flavour enhancers and modifiers/Flour and baking additives
FOOD USE:	Baked goods/Dairy products/Edible oils and fats/Meat, poultry and eggs and products/Beverages/Sugars, sugar preserves and confectionery/Vinegar, pickles and sauces
SYNONYMS:	Amber acid/Butanedioic acid/Ethylenesuccinic acid/1,2-Ethanedicarboxylic acid/1,4-Butanedioic acid/CAS 110-15-6
FORMULA:	$HOOC\text{-}(CH_2)_2\text{-}COOH$
MOLECULAR MASS IN Daltons:	118.09
ALTERNATIVE FORMS:	Succinic acid, diethyl ester; succinic anhydride
PROPERTIES AND APPEARANCE:	Colourless or white crystals
BOILING POINT IN °C AT VARIOUS PRESSURES (INCLUDING 760 mmHg):	235 (decomposition)
MELTING RANGE IN °C:	185–190
IONISATION CONSTANT AT 25°C:	6.89×10^{-5} 2.47×10^{-6}
DENSITY AT 20°C (AND OTHER TEMPERATURES) IN g/L:	1.564 @ 20°/4°C 1.572 @ 25°/4°C
HEAT OF COMBUSTION AT 25°C:	356.36 kcal/gram molecular weight
PURITY %:	$\geq$90.0
HEAVY METAL CONTENT MAXIMUM IN ppm:	10
ARSENIC CONTENT MAXIMUM IN ppm:	3

ASH MAXIMUM IN %:	0.025
SOLUBILITY % AT VARIOUS TEMPERATURE/pH COMBINATIONS:	
in water:	**@ 25°C** 7.7 **@ 100°C** 100
in ethanol solution:	1 g/100 mL
in propylene glycol:	1 g/18.5 mL
FUNCTION IN FOODS:	Succinic acid is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Succinic acid is a flavour enhancer and pH control agent. It can be used to alter the acidity of acidified milk, acidified low-fat milk, and acidified skim milk. It readily combines with proteins in modifying the plasticity of doughs and aids in the production of edible fats with desired thermal properties. It is used in gelatin desserts and cake flavourings. It is also used as a component of polymeric resins. Maximum levels recommended are 0.0061% in meat, 0.084% in condiments and relishes, and 2.6% in jams and jellies. Succinic acid, diethyl ester is used as a flavouring agent with no limitation other than good manufacturing practices. Succinic anhydride is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Succinic anhydride is used as a dehydrating agent for the removal of moisture from foods and it imparts stability to dry mixes. It also aids in the controlled release of carbon dioxide during leavening. It is used in the esterification of food starch at a level not to exceed 4%. Sodium dioctyl sulphosuccinate can be used as a flavouring agent in dry beverage mixes not to exceed 75 parts per million of the finished beverage. It can also be used as a stabiliser in evaporated milk, cottage cheese, cream cheese, pasteurised Neufchatel. It can also be used as a wetting agent and in paper and paperboard used in food grade packaging.
TECHNOLOGY OF USE IN FOODS:	Succinic acid $pK_1 = 4.16$; $pK_2 = 5.61$ Succinic acid is odourless and has a slightly bitter and acid taste. It is non-hygroscopic with a slow taste build-up. It can extend the shelf-life of dessert powders, without damaging flavour.
FOOD SAFETY ISSUES:	LD_{50} (mg/kg body weight) succinic acid. Rat 2260 oral route. Acceptable daily intake for humans of succinic acid is not limited.
LEGISLATION:	**USA:** Succinic acid: 21 CFR 131.111, 184.1091 Succinic acid, diethyl ester: 21 CFR 172.515 Succinic anhydride: 21 CFR 175.300 Dioctyl sodium sulfosuccinate: 21 CFR 131.130, 133.133, 133.162, 133.178, 172.83, 172.520, 172.810, 176.170, 176.180

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NAME:	Tartaric acid
CATEGORY:	Emulsifiers/Stabilisers/Chelating agents/pH control agents/Preservatives/Flavour enhancers and modifiers/ Flour and baking additives/Anti-caking agents/Firming agents/Humectants
FOOD USE:	Baked goods/Dairy products/Edible oils and fats/Fish and seafoods and products/Meat, poultry and eggs and products/Fruit, vegetables and nuts and products/Beverages/Soft drinks/Sugars, sugar preserves and confectionery/Alcoholic drinks
SYNONYMS:	Dihydroxybutanedioic acid/2,3-Dihydroxybutanedioic acid/2,3-Dihydroxysuccinic acid/ *d*-α,β-Dihydroxysuccinic acid/L form CAS 87-69-4
FORMULA:	$HOOC\text{-}(CHOH)_2\text{-}COOH$
MOLECULAR MASS IN Daltons:	150.09
ALTERNATIVE FORMS:	Diethyl tartrate; potassium acid tartrate; potassium bitartrate; sodium potassium tartrate; sodium tartrate
PROPERTIES AND APPEARANCE:	Colourless to translucent crystals, or a white, fine to granular crystalline powder
MELTING RANGE IN °C:	168–170
IONISATION CONSTANT AT 25°C:	1.04×10^{-3} 4.55×10^{-5}
DENSITY AT 20°C (AND OTHER TEMPERATURES) IN g/L:	1.7598 @ 20°/4°C
HEAT OF COMBUSTION AT 25°C:	275.1 kcal/gram molecular weight 274.7 kcal/gram molecular weight (L form) 272.6 kcal/gram molecular weight (D, L anhydrous form)
PURITY %:	≥99.7
WATER CONTENT MAXIMUM IN %:	0.5
HEAVY METAL CONTENT MAXIMUM IN ppm:	10
ARSENIC CONTENT MAXIMUM IN ppm:	3

ASH MAXIMUM IN %: 0.05

SOLUBILITY % AT VARIOUS TEMPERATURE/pH COMBINATIONS:

in water: **@ 0°C** 115 **@ 10°C** 126 **@ 20°C** 139 **@ 30°C** 156 **@ 40°C** 176 **@ 50°C** 195
@ 60°C 217 **@ 70°C** 244 **@ 80°C** 273 **@ 90°C** 307 **@ 100°C** 343

in ethanol solution: 1 g/3 mL

FUNCTION IN FOODS: Tartaric acid is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. Tartaric acid is used as a firming agent, flavour enhancer, flavouring agent, humectant, sequestrant, and pH control agent. It is used to alter the acidity of acidified milk, acidified low-fat milk, acidified skim milk, margarine, oleomargarine, meat and poultry products, artificially sweetened fruit jelly, fruit preserves and jams. It can be used in fruit jams, jellies, preserves, sherbets, grape-flavoured beverages, and canned fruits. It can be used as a dip (1–3%) for meat carcasses to lower microbial populations. Tartaric acid salts are used to control the degree of acidity in soft drinks and as a flavour enhancer, particularly in lime and grape-flavoured beverages. Tartaric acid can be used to reduce the pH of wine or juice, but not below pH 3.0. It can be added prior to fermentation of grapes or in combination with other acids after fermentations to correct deficiencies at a level not to exceed 9 g/L finished wine. It can be used to correct natural acid deficiencies in grape juice/wine and to reduce the pH value where ameliorating material is used in the production of grape wine.

Potassium acid tartrate (cream of tartar) is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. It can be used as an anti-caking and leavening agent, antimicrobial or pH control agent, formulation and processing aid, humectant, stabiliser and thickener and surface-active agent. It is used in baked goods, candy, crackers, confections and frostings, gelatins and puddings, jams, jellies, and margarine. Its use is limited in wine at 25 lb/1000 gallons (*ca*. 50 mg/kg). It is limited at 2 oz/100 lb (*ca*. 1 mg/kg) of finished product or artificial sweetened fruit jelly, preserves and jam.

Potassium bitartrate can be used to stabilise grape wine at a level not to exceed 35lb/1000 gallons (*ca*. 70 mg/kg) of grape wine.

Sodium potassium tartrate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. It acts as a pH control agent, and sequestrant in cheese, jams, jellies and margarine. It is limited as an emulsifier at a level not to exceed 3.0% of pasteurised process cheese, cheese food and cheese spread. It is limited at 2 oz/100 lb (*ca*. 1 mg/kg) of finished product or artificial sweetened fruit jelly, preserves and jam.

Sodium tartrate is GRAS for miscellaneous and general-purpose usage in the USA with no limitation other than good manufacturing practices. It functions as a pH control agent in fats, oils, jams and jellies. It is limited as

an emulsifier at a level not to exceed 3.0% of pasteurised process cheese, cheese food and cheese spread. It is limited at 2 oz/100 lb (*ca*. 1 mg/kg) of finished product of artificial sweetened fruit jelly, fruit preserves and jam.

TECHNOLOGY OF USE IN FOODS:

Tartaric acid $pK_1 = 2.98$; $pK_2 = 4.34$

Tartaric acid has a sharp or bitter tart taste and is the most soluble of all acidulants.

When blended with citric acid, tartaric acid contributes tartness to sour apple and wild cherry flavours.

SYNERGISTS:

Tartaric acid acts with antioxidants to prevent rancidity.

FOOD SAFETY ISSUES:

LD_{50} (mg/kg body weight) tartaric acid. Mouse 4960 oral route; 485 intravenous route. Rat 3310–3530 oral route. Dog 5000 oral route.

Acceptable daily intake for humans of L tartaric acid and its potassium and sodium salt is limited conditionally up to 30 mg/kg body weight.

LEGISLATION:

USA:
Tartaric acid: 21 CFR 131.111, 150.141, 150.161, 184.1099
Potassium acid tartrate: 21 CFR 150.141, 150.161, 184.1077
Potassium bitartrate: 21 CFR 184.1077
Sodium potassium tartrate: 21 CFR 133.169, 133.173, 133.179, 150.141, 150.161, 184.1804
Sodium tartrate: 21 CFR 133.169, 133.173, 133.179, 150.141, 150.161, 184.1801

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