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Microencapsulated Minerals

Mineral salts are added as a nutritional or functional ingredient in food. They are produced by chemical reactions to achieve clearly defined products with a very high purity and functionality. Numerous different combinations of anions and cations are possible. Most of these mineral salts have certain things in common: they have a noticeable impact on the taste of mineral fortified foods, can catalyze reactions like lipid oxidation in the food or interact with other food ingredients. In turn, these factors have an impact on the customers' acceptance and the shelf life of foods.

Taste of mineral salts

Taste properties of divalent salts are complex. Depending on the anion of the mineral salt, different taste profiles are possible. Taste profiles of calcium chloride, magnesium chloride and magnesium sulfate are characterized primarily by a bitter taste, with additional sensations described as salty, metallic, astringent, sour and sweet. Whereas calcium gluconate, calcium glycerophosphate and calcium lactate have lower salty and bitter responses than equimolar concentrations of calcium chloride.[1] The major oral quality of zinc salts like chloride, iodide, sulfate, bromide, acetate is astringency, followed by a little taste of bitter, salty, savory, sour and sweet. Beside these impressions, zinc is also a potent inhibitor of sweetness and bitterness.[2] Ferrous Sulfate is described as bitter, sour, sweet, astringent, and metallic as well as electric.[3] Metallic is a very typical description of iron salts.[4]

Reactivity of minerals

The fortification of foods and beverages with iron salts can lead to unacceptable changes in color and flavor in the final food. This is particularly true for highly bioavailable and soluble iron sources like ferrous sulfate or ferrous gluconate, which are commonly used to fortify foods. These iron sources tend to discoloration or browning of foodstuffs due to reactions with food components such as anthocyanins, flavanoids and tannins.[4, 5] Fat containing foods are even more critical in terms of iron fortification. The combination of iron salts and unsaturated fatty acids tends to lipid oxidation and to the production of off-flavors ("rancidity"). Furthermore, lipid oxidation causes changes in numerous quality attributes of foods, such as taste, texture, shelf life, appearance, and nutritional profile as well as potentially toxic reaction products.[4, 5, 6]

Less bioavailable, but more inert iron sources, such as ferric pyrophosphate have thus been commonly used to fortify foods such as infant cereals.[5]

Progress in the development of fatty foods with desirable nutritional and physical attributes depends on the availability of improved methods of controlling their oxidative stability.[6] Microencapsulation is a proper tool to protect the iron compound form the surrounding ingredients and vice versa.

Microencapsulation and coating procedure

In general, the microencapsulation procedure can be split into three different processes: physicochemical processes like liposomic entrapment, chemical processes like interfacial polymerization and physical processes like extrusion or spray drying.[7]

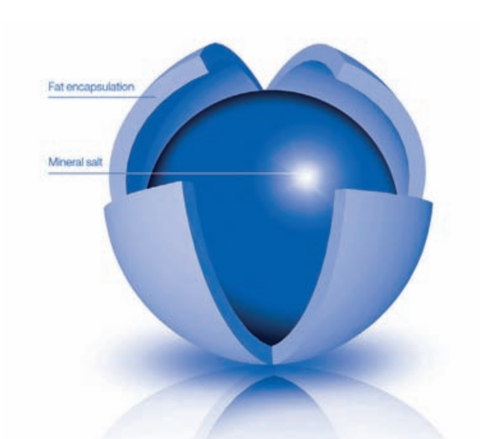
The microencapsulation process is used for the entrapment of sensitive food ingredients to protect them from temperature, moisture, light and interaction with incompatible ingredients and from undesired interactions. Other reasons for the microencapsulation of food ingredients are taste masking or controlled release properties.[7,8,9]

Microencapsulated products are mostly dry powders, which are much easier to handle compared to liquid products.

Spray drying is often used for the encapsulation of heat sensitive food ingredients like flavors, lipids and colorants as well as pharmaceuticals.[7,9] During this process an active ingredient is entrapped by a protective wall material due to a rapid evaporation of the solvent (often water). The success of the microencapsulation process relies on achieving high retention of the core material during processing and storage.

Maltodextrin is an often-used wall material for spray-dried microcapsules. It has film-forming properties and can therefore reduce the oxygen permeability of the wall matrix.[10,11] To improve these functions, the addition of other wall materials is common.

The easiest way to protect micro-particles or matrix-capsules is the coating process to achieve core-shell particles.[12] Different possibilities are known like dip coating, pan coating and fluidized bed coating.[8] Coating with the fluidized bed technology is an efficient way to apply a uniform coating layer onto solid particles. In conventional fluidized beds, the basic concept of fluidization relies on the compensation of the gravity force experienced by the particles by an upward moving air flow.[12] During their flight in the fluidized bed, the particles are continuously coated. The coating process is repeated until the desired coat thickness is reached.



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Hot-melt coatings such as hydrogenated vegetable oil, stearines, fatty acids, emulsifiers and waxes can be applied in the fluidized bed. Cool air is used to harden the carrier. Hot-melt ingredients release their contents by increasing the temperature (meltactivation) or physical breakage. The coating material made of lipids or waxes is destroyed by melting and the entrapped components such as salts or nutrients are released.[9] Lipid coatings may also be degraded by the action of lipases.[13]

Fat coatings are heat sensitive, which lead to a dissolution during the preparation of the infant cereal pap or drink powders with hot water. The reactions in the ready-to-use food are comparable to the reactions when the non-encapsulated product is used.[14]

Benefits in application

Encapsulated iron compounds can prevent color formation and fat oxidation reactions in stored wheat flour or corn flour while still maintaining high bioavailability. Depending on the thickness of the capsule as well as the coating material, the bioavailability of encapsulated ferrous sulfate was similar to ferrous sulfate in rats.[14]

Ferrous sulfate and ferrous fumarate are commercially available encapsulated with hydrogenated oils, but also with maltodextrin and ethyl cellulose.[14]

The coating provides a physical barrier between iron and the surrounding food matrix. It is an ideal method to prevent some of the unwanted sensory changes, like rancidity that can occur in iron-fortified foods. Due to the encapsulation of ferrous sulfate with hydrogenated soybean oil or mono and diglycerides iron-catalyzed fat oxidation reactions in stored wheat infant cereal can be prevented.[14]

Microcapsules prepared with cottonseed stearine (ratio of 0.10 g Fe solution/g lipid coat) have a good oxidative stability and low leakage of iron. Therefore, this coating material allow fortification of iron sensitive foods.[13] In addition, a dual fortification with two reactive ingredients like Iodide and ferrous sulfate is possible when the iron source is protected by an inert coating layer. This combination is useful to fight against both deficits by using only one food product like fortified salt. Without the coating layer, an oxidation of Iodide to I_2 will take place in the presence of ferrous ions and oxygen, and subsequently I_2 will be lost. Moreover, placing a physical barrier around the iron could prevent unacceptable yellow or brown off-colors.[15]

Dr. Paul Lohmann® offers the following *microencapsulated Mineral Salts*: Ferrous Fumarate | Ferrous Sulfate, dried | Copper(II) Gluconate | Copper(II) Sulfate 1-hydrate | Magnesium Oxide | Manganese(II) Sulfate 1-hydrate | Zinc Citrate | Zinc Oxide
Dr. Paul Lohmann® offers the following *Micro2 – micronized and microencapsulated – Mineral Salts*: Ferrous Sulfate, dried, Micro2 | Ferric Pyrophosphate, Micro2

In the GMP and FSSC 22000/ISO 22000 certified facilities, mineral salts are produced at quality levels stipulated by pharmacopoeias, regulatory food guidelines or tailored according to customers' specifications. Dr. Paul Lohmann® also carries out product and application development in close cooperation with customers. This includes the adaptation of chemical and physical parameters such as bulk density, wettability, particle size, purity or pH-value.

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