We Add Quality to the World of Nutrition.

Animal Nutrition
Technical Information
2009

BASF Nutrition – the healthy decision.
Dear Customer,

In response to the high interest shown in the technical information on animal nutrition, we have prepared a revised edition with many new and interesting features.

This handbook is a comprehensive source of information on our animal nutrition products, which include vitamins, carotenoids, enzymes, organic acids, omega-6 fatty acids, and more. Here you can find details about their role in animal nutrition, together with dosage recommendations, and plenty of useful background information besides. The intention behind it is to give you all the help you need in your daily feed business.

This user guide also contains a collection of single technical information data sheets available for each of our animal nutrition products. They provide chemical and physical data, information on product stability, and possible applications.

The data supplied are those valid at the time of printing (April 2009).

With vitamins, carotenoids, enzymes, organic acids, omega-6 fatty acids, and more, BASF provides one of the widest ranges of feed additives for the feed and pet food industries. The products serve as micronutrients, colorants, digestibility enhancers, preservatives, and ensiling agents. BASF’s feed additives are suited for use with all major farm and domestic animal species. They enable its customers to improve their pet food with a view to maximum animal health and well-being.

BASF has been active for decades in the field of animal nutrition. During this time, BASF has become one of the leaders in the feed industry, supplying high-quality products throughout the world. All activities are centered round product safety and efficacy. All products are the result of responsible research, combined with extensive technical knowledge in the fields of synthesis, biotechnology, and formulation. You can depend on BASF’s expertise in all matters of modern animal nutrition.

BASF Nutrition – the healthy decision.
BASF's feed additives make your choice easier:

SAFETY  BASF products meet the highest safety standards and regulatory requirements worldwide.

QUALITY  BASF supplies products of excellent purity, stability, and performance. The product quality is constant and reproducible. BASF applies the highest quality management standards possible.

TRACEABILITY  BASF provides full transparency about its feed additives and the raw materials used in production via GTNet® – flexibly and independently accessible for customers at any time and anywhere in the world.

SUSTAINABILITY  BASF integrates ecological and social responsibility into its business activities and makes sustainability quantifiable via independently certified eco-efficiency analyses.

RELIABILITY  BASF is an absolutely reliable supplier in all matters. BASF has an integral supply chain and logistics management – regional distribution centers allow high supply reliability in major markets. Customer service centers are available in all regions and in major countries.

INNOVATION  BASF constantly develops new product formulations that target the current and future needs of the feed and pet food industries. Recently, the omega-6 fatty acid “Lutrell® pure” was launched as a feed additive for ruminants.

COMMITMENT  BASF is a world leader in feed additives forming the best team in the industry, and fully committed to the feed and pet food industries.

BASF Nutrition – the healthy decision.

www.nutrition.basf.com
www.set-initiative.com
Abbreviations

BHT = 3,5-di-tert-butyl-4-hydroxytoluene
CWD = Cold-water-dispersible
DCP = Di-calcium phosphate
FTU = Natuphos phytase unit
G = Granulate
I.U. = International unit
L = Liquid
MCP = Mono-calcium phosphate
TGU = Thermostable endo-glucanase unit
TS = Thermostable
TXU = Thermostable endo-xylanase unit
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Vitamins

Vitamins are organic substances which are necessary for maintaining all body functions (growth, health, fertility, performance). As a rule, the animal body cannot synthesize these natural biologically active substances itself, which is why they must be supplied with the feed. Vitamins are thus considered as essential (vitaly necessary) micro-nutrients. Each individual vitamin performs particular tasks which cannot be performed in the same way by another vitamin.

Modern intensive livestock farming and the related productivity of the animal processing industry have only been made possible by the specific and requirement-related supply of vitamins to the animals via adequate and economical compound feeds. Daily amounts of a few mg or µg are sufficient to regulate the utilization of nutrients (carbohydrates, fats, proteins, and minerals). The use of sufficient vitamin supplements makes it possible to prevent growth disorders, juvenile diseases, fertility disorders, and performance reductions of all kinds, and thus to achieve higher profitability in livestock production. The costs of this vitaminization are low in relation to the wide range of benefits.

Without exception, the vitamins used in animal nutrition are produced on an industrial scale by means of chemical and biotechnological processes. They correspond to the naturally occurring vitamins, are equivalent to their activity, and often even superior owing to special formulations. In some cases, their stability has been increased by special protective processes.
Vitamin A

Unit of measurement
1 International
Unit (I.U.) = 0.3 µg of vitamin A alcohol
= 0.344 µg of vitamin A acetate
= 0.55 µg of vitamin A palmitate
= 0.359 µg of vitamin A propionate

Occurrence
Vitamin A (retinol) occurs only in feeds of animal origin such as fish liver oil, whole milk, fish meal and the like. In vegetable feeds, only the precursors of vitamin A (provitamins), the carotenoids, are present. Of these, β-carotene represents over 90%. Sources rich in β-carotene are in particular green plants such as grass, clover, lucerne, and, of the root crops, carrots. All other vegetable products such as cereals, maize, potatoes, beet, and remains from their processing contain only a little or no β-carotene. With passage of the growing season and depending on the harvesting conditions, the preservation and the storage time, the carotene content in the plants decreases. In order to meet the requirement in practical feeding, only grazing or fresh green fodder is important. The animal can convert the various carotenoids into vitamin A to a differing extent, there being various routes (theoretically three) for the conversion.

The utilization of the carotenoids is dependent, among other things, on the form of binding, the animal species, and the carotene and vitamin A supply status. In the case of ruminants, with a supply of vitamin A which is approximately able to cover the requirements, a conversion rate of β-carotene to vitamin A of 6:1 [1.8 µg of β-carotene give about 0.3 µg of vitamin A alcohol (= 1 I.U. of vitamin A)] can be assumed. Cats are not able to convert β-carotene into vitamin A. They are therefore dependent on the supply of vitamin A.

Physiological importance
Vitamin A is a protective substance for the entire ectoderm and important for the development, the protection, and the regeneration of skin and mucosa. Vitamin A has a special function in the visual process. In this process, retinol in the retina of the eye forms retinal, which is condensed with the lysine residue of the protein opsin to give aldimine and thus forms the light receptor rhodopsin (visual purple).

This light receptor is important for twilight and night vision. Vitamin A is additionally of great importance for growth, skeletal development, and fertility of the animals. By means of higher doses of vitamin A, the formation of antibodies can be increased and the resistance of the body can be improved. Vitamin A contributes substantially to the ability of cell membranes and various enzymes to function. It is thus involved in the regulation of carbohydrates, fat, and protein metabolism. In the young animal, vitamin A is particularly necessary for preventing growth disorders, while in the older animal body the epithelial protective function has great importance.
Deficiency symptoms
An undersupply of vitamin A leads to disorders of growth and bone formation, to pathological changes in skin and mucosa and, to an impairment of visual ability (night blindness). In addition to an increased susceptibility to diseases, disorders in the reproductive process (lack of fertility, sterility, malformation of the fetuses) also occur.

Toxicity
Animals tolerate relatively high doses of vitamin A. The “no effect level” of repeated high doses of vitamin A is, depending on the species of animal, in the range from 5,000 to 10,000 I.U. of vitamin A per kg of body weight and per day. The safety factor is 10 to 30 compared with the physiological requirement. A toxic effect with the possibility of cases of death can occur on repeated administration of 100,000 I.U. and more of vitamin A per kg of body weight.

Dosage recommendations
The dosage recommendations are given per kg feed on the assumption that the animals (pigs/chicken) are fed mainly with complete feed. If, in addition to the basic ration, a supplementary feed is administered (cows/horses, etc.), the recommendations apply per animal and day. The vitamin dosage in the feed is dependent on the following factors:

- Species, breed, and desired use of the animal
- Age of the animal
- Performance of the animal
- Feed composition
- Environmental influences

In addition, an extra supplementation should be administered to increase the body’s defenses, especially for young animals.

The dosage recommendations focus on a high performance level of the animals, typically found in Western Europe or North America. The recommended vitamin dosages are also appropriate in other regions, because the extreme environmental conditions there often constitute stress factors for the animals. Under special circumstances/requirements, it might be advantageous to exceed the given dosage recommendations.

### Pigs
per kg complete feed (88% dry matter)

<table>
<thead>
<tr>
<th>Category</th>
<th>Dosage Range (I.U.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piglets, prestarter</td>
<td>15,000 – 20,000 I.U.</td>
</tr>
<tr>
<td>Piglets, starter</td>
<td>12,000 – 20,000 I.U.</td>
</tr>
<tr>
<td>Grower</td>
<td>10,000 – 12,000 I.U.</td>
</tr>
<tr>
<td>Finisher</td>
<td>8,000 – 10,000 I.U.</td>
</tr>
<tr>
<td>Breeding sows</td>
<td>16,000 – 20,000 I.U.</td>
</tr>
<tr>
<td>Breeding boars</td>
<td>12,000 – 20,000 I.U.</td>
</tr>
</tbody>
</table>

### Poultry
per kg complete feed (88% dry matter)

<table>
<thead>
<tr>
<th>Category</th>
<th>Dosage Range (I.U.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chickens, starter</td>
<td>12,000 – 15,000 I.U.</td>
</tr>
<tr>
<td>Chickens, pullets</td>
<td>8,000 – 10,000 I.U.</td>
</tr>
<tr>
<td>Laying hens</td>
<td>8,000 – 12,000 I.U.</td>
</tr>
<tr>
<td>Breeding hens</td>
<td>12,000 – 15,000 I.U.</td>
</tr>
<tr>
<td>Broiler</td>
<td>8,000 – 12,000 I.U.</td>
</tr>
<tr>
<td>Turkeys, starter</td>
<td>10,000 – 14,000 I.U.</td>
</tr>
<tr>
<td>Turkeys, grower</td>
<td>8,000 – 12,000 I.U.</td>
</tr>
<tr>
<td>Turkeys, finisher</td>
<td>8,000 – 12,000 I.U.</td>
</tr>
<tr>
<td>Turkeys, breeding animals</td>
<td>12,000 – 15,000 I.U.</td>
</tr>
<tr>
<td>Ducks/geese</td>
<td>10,000 – 13,000 I.U.</td>
</tr>
</tbody>
</table>
### Ruminants and horses

<table>
<thead>
<tr>
<th>Category</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calves, milk replacers (per kg feed)</td>
<td>20,000 – 25,000 I.U.</td>
</tr>
<tr>
<td>Cows, breeding</td>
<td>30,000 – 50,000 I.U.</td>
</tr>
<tr>
<td>Beef bulls</td>
<td>40,000 – 70,000 I.U.</td>
</tr>
<tr>
<td>Dairy cows</td>
<td>80,000 – 140,000 I.U.</td>
</tr>
<tr>
<td>Sheep/goats</td>
<td>4,000 – 8,000 I.U.</td>
</tr>
<tr>
<td>Foals (per 100 kg live weight per day)</td>
<td>10,000 – 12,000 I.U.</td>
</tr>
<tr>
<td>Saddle horses (per 100 kg live weight per day)</td>
<td>6,000 – 8,000 I.U.</td>
</tr>
<tr>
<td>Racing horses and breeding horses (per 100 kg live weight per day)</td>
<td>12,000 – 15,000 I.U.</td>
</tr>
</tbody>
</table>

### Pets and fish

<table>
<thead>
<tr>
<th>Category</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dogs</td>
<td>8,000 – 12,000 I.U.</td>
</tr>
<tr>
<td>Cats</td>
<td>15,000 – 20,000 I.U.</td>
</tr>
<tr>
<td>Rabbits</td>
<td>8,000 – 12,000 I.U.</td>
</tr>
<tr>
<td>Minks</td>
<td>8,000 – 12,000 I.U.</td>
</tr>
<tr>
<td>Cold water fish</td>
<td>7,000 – 9,000 I.U.</td>
</tr>
<tr>
<td>Warm water fish</td>
<td>8,000 – 10,000 I.U.</td>
</tr>
<tr>
<td>Shrimps</td>
<td>10,000 – 12,000 I.U.</td>
</tr>
</tbody>
</table>
**Lutavit® A 500 Plus**

**Active ingredient**
Vitamin A acetate (retinyl acetate)

**PRD-No.**
30040362

**Article**
50011048 25 kg plastic bag

**Specification**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Content</th>
<th>at least 500,000 I.U. of vitamin A per g (HPLC)</th>
</tr>
</thead>
</table>


**Other chemical and physical data**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss on drying</td>
<td>at most 5%</td>
</tr>
<tr>
<td>Formulation</td>
<td>powder</td>
</tr>
<tr>
<td>Particle size</td>
<td>at least 97% &lt; 0.63 mm</td>
</tr>
<tr>
<td>Bulk density</td>
<td>about 0.6 g/cm³</td>
</tr>
</tbody>
</table>

Composition: vitamin A is incorporated in finely dispersed form in a matrix of gelatin and carbohydrates and stabilized with antioxidants.

Solubility: insoluble in cold and hot water.

**Stability**

Lutavit A 500 Plus, Lutavit A 1000 Plus, as well as Lutavit A/D₃ 1000/200 Plus and Lutavit A 500 S are stabilized (coated) vitamin products. Lutavit A 500 Plus, Lutavit A 1000 Plus, and Lutavit A/D₃ 1000/200 Plus are more stable to external influences.

The following factors guarantee a good stability:

a) Esterification of retinol with acetic acid to give the more stable retinyl acetate.
b) Addition of a combination of antioxidants and other stabilizing agents.
c) Incorporation of the vitamin A droplets in micro-disperse form in a gelatin-carbohydrate matrix by means of a special spray and formulation technique.
d) A special final treatment makes the product insoluble in hot water. This gives additional protection for vitamin A against vapor content, pressure, and temperature in feeds. As a result of this additional treatment, the particle shape is retained and good stability is guaranteed.

For good flowability and to avoid lump formation, the dry powder particles are additionally treated with an anti-caking agent.

The stability of vitamin A in mixed and mineral feeds or premixes has to be assessed as somewhat less than in the commercial product. Especially in mixtures of active mineral ingredients, the stability of vitamin A can be impaired by a trace element content, which is often high. Above all, hydrates of trace elements contribute to reduced vitamin A stability, which can be further affected by a high moisture content of the total mixture. Even technological processes in the formulation of mixed feeds such as pelleting and extrusion exert a negative influence on the stability of vitamin A.

The product has a storage life of 15 months in the unopened original packaging.
Application
Lutavit A 500 Plus is suitable for all types of vitamin blends, premixes, mineral, and mixed feeds. The flowability and mixing behavior of the products is excellent and guarantees homogeneous mixing in all types of feed.

Dosage recommendations
Please refer to “Vitamins — Vitamin A.”

Note
Vitamin A exists in a biologically highly active form. The processing of the powder should therefore be carried out with the customary care in terms of occupational hygiene following the instructions in the safety data sheet.
**Lutavit® A 500 S**

**Active ingredient**
Vitamin A acetate (retinyl acetate)

**PRD-No.**
30040363

**Article**
50053284 25 kg bag in box

**Specification**
Content at least 500,000 I.U. of vitamin A per g (photometrically according to USP)


**Other chemical and physical data**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss on drying</td>
<td>at most 3%</td>
</tr>
<tr>
<td>Formulation</td>
<td>powder</td>
</tr>
<tr>
<td>Particle size</td>
<td>at least 97% &lt; 0.6 mm</td>
</tr>
<tr>
<td>Bulk density</td>
<td>about 0.5 g/cm³</td>
</tr>
<tr>
<td>Composition</td>
<td>vitamin A is incorporated in finely dispersed form in a matrix of milk constituents and gelatin and stabilized with antioxidants</td>
</tr>
<tr>
<td>Solubility</td>
<td>dispersible in cold water</td>
</tr>
</tbody>
</table>

**Stability**
Lutavit A 500 Plus, Lutavit A 1000 Plus, as well as Lutavit A/D₃ 1000/200 Plus and Lutavit A 500 S are stabilized (coated) vitamin products. Lutavit A 500 Plus, Lutavit A 1000 Plus, and Lutavit A/D₃ 1000/200 Plus are more stable to external influences. The product has a storage life of 15 months in the unopened original packaging.

**Application**
Lutavit A 500 S is suitable for all types of vitamin blends, premixes, mineral, and mixed feeds. The flowability and mixing behavior of the products is excellent and guarantees homogeneous mixing in all types of feed.

Lutavit A 500 S is very easily dispersible in cold water. The milky emulsion formed is stable. The mixing behavior of the powder in premixes and feeds is excellent. Because of its high particle number and good dispersibility in water, the product is especially highly suitable for:
1. Milk replacers for piglets, calves, and other animals.
2. Water-dispersible multivitamin mixtures, which are administered directly by means of the drinking water.

**Dosage recommendations**
Please refer to “Vitamins — Vitamin A.”

**Note**
Vitamin A exists in a biologically highly active form. The processing of the powder should therefore be carried out with the customary care in terms of occupational hygiene following the instructions in the safety data sheet.
Active ingredient
Vitamin A acetate (retinyl acetate)

PRD-No.
30140185

Article
50369967 20 kg plastic bag

Specification
Content at least 1,000,000 I.U. of vitamin A per g (HPLC)


Other chemical and physical data
Loss on drying at most 5%
Formulation powder
Particle size at least 97% < 0.63 mm
Bulk density about 0.55 g/cm³
Composition vitamin A is incorporated in finely dispersed form in a matrix of gelatin and carbohydrates and stabilized with antioxidants
Solubility insoluble in cold and hot water

Stability
Lutavit A 500 Plus, Lutavit A 1000 Plus, as well as Lutavit A/D₃ 1000/200 Plus and Lutavit A 500 S are stabilized (coated) vitamin products. Lutavit A 500 Plus, Lutavit A 1000 Plus, and Lutavit A/D₃ 1000/200 Plus are more stable to external influences.

The following factors guarantee a good stability:
a) Esterification of retinol with acetic acid to give the more stable retinyl acetate.
b) Addition of a combination of antioxidants and other stabilizing agents.
c) Incorporation of the vitamin A droplets in micro-disperse form in a gelatin-carbohydrate matrix by means of a special spray and formulation technique.
d) A special final treatment makes the product insoluble in hot water. This gives additional protection for vitamin A against vapor content, pressure, and temperature in feeds. As a result of this additional treatment, the particle shape is retained and good stability is guaranteed.

For good flowability and to avoid lump formation, the dry powder particles are additionally treated with a anti-caking agent.

The stability of vitamin A in mixed and mineral feeds or premixes has to be assessed as somewhat less than in the commercial product. Especially in mixtures of active mineral ingredients, the stability of vitamin A can be impaired by a trace element content, which is often high. Above all, hydrates of trace elements contribute to reduced vitamin A stability, which can be further affected by a high moisture content of the total mixture. Even technological processes in the formulation of mixed feeds such as pelleting and extrusion exert a negative influence on the stability of vitamin A.

The product has a storage life of 12 months in the unopened original packaging at a storage temperature < 15 °C.
Application
Lutavit A 1000 Plus is suitable for all types of vitamin blends, premixes, mineral, and mixed feeds. The flowability and mixing behavior of the products is excellent and guarantees homogeneous mixing in all types of feed.

Dosage recommendations
Please refer to “Vitamins — Vitamin A.”

Note
Vitamin A exists in a biologically highly active form. The processing of the powder should therefore be carried out with the customary care in terms of occupational hygiene following the instructions in the safety data sheet.
Lutavit® A/D₃ 1000/200 Plus

Active ingredients
Vitamin A acetate (retinyl acetate)
Vitamin D₃ (cholecalciferol)

PRD-No.
30157862

Article
50369596 20 kg plastic bag

Specification
Content at least 1,000,000 I.U./g of vitamin A (HPLC)
at least 200,000 I.U./g of vitamin D₃ (HPLC)


Other chemical and physical data
Loss on drying at most 5%
Formulation powder
Particle size at least 97% < 0.63 mm
Bulk density about 0.55 g/cm³
Composition vitamin A and D₃ are incorporated in finely dispersed form in a matrix of gelatin and carbohydrates and stabilized with antioxidants
Solubility insoluble in cold and hot water

Stability
The product should be stored cool and protected from light. In the unopened original packaging it can be kept for 12 months at 15 °C.

Application
Suitable as a supplement for all types of feed. Processing and homogeneous dispersion in mixed and mineral feeds, premixes, and the like is excellent. From the nutritive physiology point of view, the vitamin A:vitamin D₃ ratio of 5:1 in the products also permits use in all species of animals. If another vitamin A:vitamin D₃ ratio is necessary in the diet than is present in Lutavit A/D₃, the dosage of the product should be geared to the vitamin D₃ content of the mixture and a vitamin A preparation (Lutavit A 500/A 1000 Plus) should be used additionally. Other information on the physiological importance of these vitamins can be gathered from “Vitamins.”

Dosage recommendations
Please refer to “Vitamins — Vitamin A.”

Note
The vitamins exist in a biologically highly active form. The processing of the powder should therefore be carried out with the customary care in terms of occupational hygiene. Very high vitamin A and D₃ doses can be toxic. The instructions of the safety data sheet for vitamin A and D₃ are to be observed.
Vitamin A-Palmitate
Oily Veterinary

Active ingredient
Vitamin A palmitate (retinyl palmitate)

PRD-Nos. Articles
30041041 Vitamin A-Palmitate 1.7 Mio IU/G stabilized with BHT
56283178 25 kg plastic bucket
30041032 Vitamin A-Palmitate 1.7 Mio IU/G unstab.
55857164 25 kg plastic bucket
30041040 Vitamin A-Palmitate 1.0 Mio IU/G stabilized with BHT
55800030 25 kg plastic bucket

Specification

Other chemical and physical data
Identification blue coloration with antimony tri-chloride in chloroform (Car-Price test) or by thin layer chromatography (Ph. Eur.)
Formulation liquid
Solubility soluble in hydrocarbons, chloro-hydrocarbons, ethers, fats and oils. The solvents should not contain peroxides. Insoluble in water.
Acid number not more than 2.0 (Ph. Eur.)
Peroxides corresponds to Ph. Eur.

Stability
The product should be stored cool and protected from light. In the unopened original packaging it can be kept for 9 months at 20 °C and 24 months at 8 – 15 °C.

Use
For the preparation of liquid vitamin A preparations for oral and parenteral use. In aqueous preparations, the use of solubilizers, for example Cremophor® EL or Cremophor RH 40, is necessary. The corresponding mixing ratios between Cremophor RH 40 and Cremophor EL with vitamin A palmitate are to be taken from the figure.

A sterilization of the final preparation is necessary for parenteral use.
Pharmacopeia
The products correspond to the applicable monograph of Ph. Eur., USP, and FCC.

Dosage recommendations
Please refer to “Vitamins — Vitamin A.”

Note
As the products may have partly crystallized, before use and before sampling, the products should be heated (60 °C) and homogenized. The instructions of the safety data sheet are to be observed.
Active ingredient
Vitamin A palmitate (retinyl palmitate)

PRD-No.
30041042  stabilized with BHT

Article
55800030  25 kg plastic bucket

Specification

Other chemical and physical data
Formulation  liquid
Solubility  soluble in hydrocarbons, chloro-hydrocarbons, ethers, fats and oils. The solvents should not contain any peroxides. Insoluble in water.

Stability
The product should be stored cool and protected from light. In the unopened original packaging it can be kept for 9 months at 20 °C and 24 months at 8 – 15 °C.

Use
For liquid vitamin A preparations for oral use. In aqueous formulations, the use of solubilizers, for example Cremophor® EL or Cremophor RH 40, is necessary. The corresponding mixing ratios of Cremophor EL or Cremophor RH 40 with vitamin A palmitate are to be taken from the technical information for Vitamin A-Palmitate Oily Veterinary. When processing non-stabilized vitamin A palmitate, it is recommended to add antioxidants (e.g., butylhydroxytoluene, butylhydroxyanisole, dl-α-tocopherol).

Dosage recommendations
Please refer to “Vitamins — Vitamin A.”

Note
As the products may have partly crystallized, before use and before sampling the products should be heated (60 °C) and homogenized. The instructions of the safety data sheet are to be observed.
Vitamin A-Propionote 2.5 Mio IU/G stabilized with BHT

Active ingredient
Vitamin A propionate (retinyl propionate)

PRD-No.
30041062

Article
55796320 25 kg plastic bucket

Specification
Content at least 2.5 million I.U. of vitamin A/g (according to USP and Ph. Eur.)


Other chemical and physical data
Identification blue coloration with antimony trichloride in chloroform (Carr-Price test) or by thin layer chromatography

Formulation liquid

Solubility soluble in hydrocarbons, chlorohydrocarbons, ethers, fats and oils. The solvents should not contain any peroxides. Insoluble in water

Acid number not more than 2.0 (Ph. Eur.)

Peroxides corresponds to Ph. Eur.

Stability
The product should be stored cool and protected from light. In the unopened original packaging it can be kept for 6 months at 20 °C and 24 months at 8 – 15 °C.

Use
For the preparation of liquid vitamin A preparations for oral and parenteral administration. The use of the propionic acid ester of vitamin A is recommended particularly if the tendency of the acetate and palmitate to crystallize during processing has an interfering effect. Suitable for highly concentrated formulations in water with solubilizers such as, Cremophor® EL or Cremophor RH 40. The corresponding mixing ratios of Cremophor EL or Cremophor RH 40 with vitamin A propionate are to be taken from the technical information for Vitamin A Palmitate Oily Veterinary.

A sterilization of the final preparation is necessary for parenteral use.

Pharmacopeia
The product corresponds to the applicable monograph of Ph. Eur. and USP.

Dosage recommendations
Please refer to “Vitamins — Vitamin A.”

Note
Since the product may have crystallized before use and before sampling, the product should be heated (60 °C) and homogenized. The instructions of the safety data sheet are to be observed.
Vitamin B$_2$

Occurrence
Animal feeds, especially milk products such as whey powder and skimmed milk, are rich in vitamin B$_2$. Good vitamin B$_2$ sources are additionally alfalfa-meal and feeding yeast. Relatively poor sources of vitamin B$_2$ are cereals, milling by-products, root crops, and vegetable protein feeds.

Physiological importance
Vitamin B$_2$ is involved as a coenzyme in a whole series of oxidation and reduction enzymes which are summarized under the name flavoproteins, and is of importance for the transfer of hydrogen atoms. It thus intervenes, also like various other vitamins of the B complex, as a coenzyme in protein, fat, and nucleic acid metabolism. Vitamin B$_2$ is additionally involved in the visual process.

Deficiency symptoms
Vitamin B$_2$ deficiency leads to retardation of growth, poor food utilization and diarrhea. In chickens, vitamin B$_2$ deficiency causes the typical symptom of inwardly curved toes.

Requirement
Owing to the specific function in protein and fat metabolism, the vitamin B$_2$ requirement is dependent on the protein and energy content of the feed ration. The vitamin B$_2$ requirement of pigs is increased at low ambient temperatures, as in this case more carbohydrates are broken down to produce energy. The requirement is 4 – 12 mg per kg of complete feed. When using pharmaceuticals, the vitamin B$_2$ requirement is markedly higher.

Toxicity
The LD$_{50}$/oral/rat is 10,000 mg/kg.
Primary skin irritation/rabbit: non-irritant.
Primary irritations of the mucous membrane/rabbit: non-irritant.

Dosage recommendations
The dosage recommendations are given per kg feed on the assumption that the animals (pigs/chicken) are fed mainly with complete feed. If, in addition to the basic ration, a supplementary feed is administered (cows/horses, etc.), the recommendations apply per animal and day. The vitamin dosage in the feed is dependent on the following factors:
- Species, breed, and desired use of the animal
- Age of the animal
- Performance of the animal
- Feed composition
- Environmental influences

In addition, an extra supplementation should be administered to increase the body’s defenses, especially for young animals. The dosage recommendations focus on a high performance level of the animals, typically found in Western Europe or North America.
The recommended vitamin dosages are also appropriate in other regions, because the extreme environmental conditions there often constitute stress factors for the animals. Under special circumstances/requirements, it might be advantageous to exceed the given dosage recommendations.

### Pigs

<table>
<thead>
<tr>
<th></th>
<th>per kg complete feed (88% dry matter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piglets, prestarter</td>
<td>6 – 8 mg</td>
</tr>
<tr>
<td>Piglets, starter</td>
<td>5 – 7 mg</td>
</tr>
<tr>
<td>Grower</td>
<td>4 – 6 mg</td>
</tr>
<tr>
<td>Finisher</td>
<td>3 – 5 mg</td>
</tr>
<tr>
<td>Breeding sows</td>
<td>5 – 7 mg</td>
</tr>
<tr>
<td>Breeding boars</td>
<td>5 – 7 mg</td>
</tr>
</tbody>
</table>

### Poultry

<table>
<thead>
<tr>
<th></th>
<th>per kg complete feed (88% dry matter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chickens, starter</td>
<td>8 – 10 mg</td>
</tr>
<tr>
<td>Chickens, pullets</td>
<td>4 – 6 mg</td>
</tr>
<tr>
<td>Laying hens</td>
<td>5 – 8 mg</td>
</tr>
<tr>
<td>Breeding hens</td>
<td>8 – 10 mg</td>
</tr>
<tr>
<td>Broiler</td>
<td>5 – 7 mg</td>
</tr>
<tr>
<td>Turkeys, starter</td>
<td>10 – 14 mg</td>
</tr>
<tr>
<td>Turkeys, grower</td>
<td>6 – 8 mg</td>
</tr>
<tr>
<td>Turkeys, finisher</td>
<td>4 – 6 mg</td>
</tr>
<tr>
<td>Turkeys, breeding animals</td>
<td>8 – 10 mg</td>
</tr>
<tr>
<td>Ducks/geese</td>
<td>6 – 8 mg</td>
</tr>
</tbody>
</table>

### Ruminants and horses

<table>
<thead>
<tr>
<th></th>
<th>per animal per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calves, milk replacers</td>
<td>4 – 6 mg</td>
</tr>
<tr>
<td>Foals</td>
<td>8 – 12 mg</td>
</tr>
<tr>
<td>Saddle horses</td>
<td>6 – 8 mg</td>
</tr>
<tr>
<td>Racing horses and breeding horses</td>
<td>8 – 12 mg</td>
</tr>
</tbody>
</table>

### Pets and fish

<table>
<thead>
<tr>
<th></th>
<th>per kg complete feed (88% dry matter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dogs</td>
<td>4 – 6 mg</td>
</tr>
<tr>
<td>Cats</td>
<td>5 – 8 mg</td>
</tr>
<tr>
<td>Rabbits</td>
<td>3 – 6 mg</td>
</tr>
<tr>
<td>Minks</td>
<td>6 – 10 mg</td>
</tr>
<tr>
<td>Cold water fish</td>
<td>20 – 30 mg</td>
</tr>
<tr>
<td>Warm water fish</td>
<td>10 – 20 mg</td>
</tr>
<tr>
<td>Shrimps</td>
<td>50 – 80 mg</td>
</tr>
</tbody>
</table>
Lutavit® B₂ SG 80

**Active ingredient**
Vitamin B₂ (riboflavin)

**PRD-No.**
30215030

**Articles**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>54690103</td>
<td>25 kg PE bag</td>
</tr>
<tr>
<td>54690156</td>
<td>25 kg PE bag (USA)</td>
</tr>
<tr>
<td>54690209</td>
<td>500 kg big bag, coated, antistatic</td>
</tr>
</tbody>
</table>

**Specification**

Content at least 80%
(method: modified according to Ph. Eur. II)


**Other chemical and physical data**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formulation</td>
<td>granulate</td>
</tr>
<tr>
<td>Particle size</td>
<td>at least 95% &lt; 0.35 mm</td>
</tr>
<tr>
<td>Bulk density</td>
<td>about 0.5 g/cm³</td>
</tr>
<tr>
<td>Water content</td>
<td>not more than 5% (according to Karl Fischer)</td>
</tr>
<tr>
<td>Solubility</td>
<td>dispersible in cold water, but does not give a homogeneous dispersion</td>
</tr>
</tbody>
</table>

**Stability**

Lutavit B₂ is not substantially affected by air, but it is sensitive to alkaline substances, especially in the presence of oxygen. The product should be protected from light and atmospheric moisture. In the unopened original packaging it can be kept for 36 months.

**Application**

Lutavit B SG 80 is suitable for all types of vitamin blends, premixes, mineral, and mixed feeds. The flowability and mixing behavior of the product is excellent and guarantees homogeneous mixing in all types of feed. Lutavit B₂ SG 80 — a spray granulated product — hardly forms any dust and has outstanding flow properties. It is especially suitable for use in fully automatic small component dosage units.

**Dosage recommendations**

Please refer to “Vitamins — Vitamin B₂.”

**Note**

Under normal conditions, Lutavit B₂ is not toxic. A high uptake (inspiration and skin contact), however, must be avoided. Lutavit B₂ can only be ignited with difficulty. If the product burns, however, toxic fumes can develop. When exposed to this product, the provisions of the safety data sheet are to be observed.
Pantothenic acid

Conversion factors

1 mg of calcium d-pantothenate
= 0.92 mg of pantothenic acid

1 mg of pantothenic acid
= 1.087 mg of calcium d-pantothenate

Bioavailability

Due to its water solubility, calcium d-pantothenate is very well absorbed and is active in the metabolism as pantothenic acid. Pantothenic acid and the pantothenates are optically active compounds and occur in D(+) and L(−)-forms. Only the D(+) form can be utilized biologically.

Occurrence

Apart from tapioca, nearly all feeds contain pantothenic acid to a certain extent. Root crops and also some cereal species (barley, maize) are relatively poor sources of this vitamin. High contents of pantothenic acid are found in milk and milk products, fish solubles, milling by-products, good-quality alfalfa meals, beer and feeding yeasts, various oilseed cakes, and in other vegetable protein products.

Physiological importance

As a constituent of coenzyme A, pantothenic acid is involved in many reactions of protein, carbohydrate, and fat metabolism. It has a special function in the synthesis and breakdown of fats, as the transfer of $C_2$ units (activated acetic acid) and the activation of long-chain fatty acids is carried out by coenzyme A.

Activated acetic acid is necessary for the synthesis of phospholipids, cholesterol, and several steroid hormones. The importance of pantothenic acid is also demonstrated by the fact that coenzyme A is found in all types of tissues.

Deficiency symptoms

Pantothenic acid deficiency can lead to varied disorders in animals. The deficiency symptoms are not of the same kind in all animal species. In each case, however, health and performance are adversely affected. The following symptoms can occur:

- Pathological changes of the skin and mucosae: pigment loss and loss of hair and feathers, rough coat, and poor plumage. Brown exudate around the eyes, especially in the pig. Encrustations on the beak and around the eyes in poultry.
- Disorders in the gastrointestinal tract and organ changes: formation of ulcers in the gastrointestinal region, intestinal hemorrhages and diarrhea, changes in the liver (fatty liver syndrome). This leads to lack of appetite, poor feed utilization, and depression of growth as far as losses in weight.
- Hormonal disorders: fertility disorders, incomplete formation of the genitals in young animals, absence of lactation in sows. Decreased sucking reflex and high mortality in the first days of life in piglets. Reduced egg yield in hens and unsatisfactory incubation results in poultry.
- Disorders in the nervous system: cramps and paralysis symptoms, which occur especially in the pig (so-called "goose stepping"). Higher stress sensitivity.
**Recommendations for supply**

As a rule, the native pantothenic acid occurring in the feeds is not present in amounts which cover the requirements. The composition of the total ration, therefore, plays an important role. Pigs and poultry are fundamentally dependent on the supplementation of the ration with pantothenic acid in the case of modern feeding methods and performance demands. In the case of ruminants having a fully developed rumen, according to modern knowledge, addition of pantothenic acid is not necessary if the total ration is ruminant-related. Pantothenic acid is synthesized microbially in these animals in adequate quantities. On the other hand, in calves which are fed on a milk substitute basis, the supply of pantothenic acid from the feeds is not sufficient; suitable pantothenic acid supplements are therefore necessary here.

**Toxicity**

The LD$_{50}$/oral/rat is 5,000 mg/kg. Primary skin irritation/rabbit: non-irritant. Primary irritations of the mucous membrane/rabbit: non-irritant.

**Dosage recommendations**

The dosage recommendations are given per kg feed on the assumption that the animals (pigs/chicken) are fed mainly with complete feed. If, in addition to the basic ration, a supplementary feed is administered (cows/horses, etc.), the recommendations apply per animal and day. The vitamin dosage in the feed is dependent on the following factors:

- Species, breed, and desired use of the animal
- Age of the animal
- Performance of the animal
- Feed composition
- Environmental influences

In addition, an extra supplementation should be administered to increase the body’s defenses, especially for young animals.

The dosage recommendations focus on a high performance level of the animals, typically found in Western Europe or North America.

The recommended vitamin dosages are also appropriate in other regions, because the extreme environmental conditions there often constitute stress factors for the animals. Under special circumstances/requirements, it might be advantageous to exceed the given dosage recommendations.

**Pigs**

per kg complete feed (88% dry matter)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piglets, prestarter</td>
<td>15 – 20</td>
<td></td>
</tr>
<tr>
<td>Piglets, starter</td>
<td>12 – 16</td>
<td></td>
</tr>
<tr>
<td>Grower</td>
<td>10 – 14</td>
<td></td>
</tr>
<tr>
<td>Finisher</td>
<td>8 – 12</td>
<td></td>
</tr>
<tr>
<td>Breeding sows</td>
<td>12 – 16</td>
<td></td>
</tr>
<tr>
<td>Breeding boars</td>
<td>12 – 16</td>
<td></td>
</tr>
</tbody>
</table>

**Poultry**

per kg complete feed (88% dry matter)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chickens, starter</td>
<td>10 – 15</td>
<td></td>
</tr>
<tr>
<td>Chickens, pullets</td>
<td>8 – 10</td>
<td></td>
</tr>
<tr>
<td>Laying hens</td>
<td>8 – 10</td>
<td></td>
</tr>
<tr>
<td>Breeding hens</td>
<td>10 – 15</td>
<td></td>
</tr>
<tr>
<td>Broiler</td>
<td>10 – 12</td>
<td></td>
</tr>
<tr>
<td>Turkeys, starter</td>
<td>15 – 20</td>
<td></td>
</tr>
<tr>
<td>Turkeys, grower</td>
<td>10 – 15</td>
<td></td>
</tr>
<tr>
<td>Turkeys, finisher</td>
<td>8 – 12</td>
<td></td>
</tr>
<tr>
<td>Turkeys, breeding animals</td>
<td>10 – 15</td>
<td></td>
</tr>
<tr>
<td>Ducks/geese</td>
<td>8 – 12</td>
<td></td>
</tr>
<tr>
<td>Ruminants and horses</td>
<td>per animal per day</td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------------</td>
<td></td>
</tr>
<tr>
<td>Calves, milk replacers (per kg feed)</td>
<td>10 – 20 mg</td>
<td></td>
</tr>
<tr>
<td>Foals (per 100 kg live weight per day)</td>
<td>8 – 10 mg</td>
<td></td>
</tr>
<tr>
<td>Saddle horses (per 100 kg live weight per day)</td>
<td>6 – 8 mg</td>
<td></td>
</tr>
<tr>
<td>Racing horses and breeding horses (per 100 kg live weight per day)</td>
<td>10 – 12 mg</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pets and fish</th>
<th>per kg complete feed (88% dry matter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dogs</td>
<td>8 – 10 mg</td>
</tr>
<tr>
<td>Cats</td>
<td>10 – 14 mg</td>
</tr>
<tr>
<td>Rabbits</td>
<td>10 – 14 mg</td>
</tr>
<tr>
<td>Minks</td>
<td>10 – 14 mg</td>
</tr>
<tr>
<td>Cold water fish</td>
<td>40 – 50 mg</td>
</tr>
<tr>
<td>Warm water fish</td>
<td>30 – 40 mg</td>
</tr>
<tr>
<td>Shrimps</td>
<td>100 – 150 mg</td>
</tr>
</tbody>
</table>
### Active ingredient
Calcium d-pantothenate

### PRD-No.
30041184

### Articles
<table>
<thead>
<tr>
<th>Article Code</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>50011144</td>
<td>25 kg PE bag</td>
</tr>
<tr>
<td>54505345</td>
<td>25 kg PE bag (USA)</td>
</tr>
<tr>
<td>50738476</td>
<td>big bag (USA)</td>
</tr>
</tbody>
</table>

### Specification
- **Content**: at least 98% (according to Ph. Eur.) calculated for dry substance


### Other chemical and physical data
<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss on drying</td>
<td>not more than 3%</td>
</tr>
<tr>
<td>Specific rotation</td>
<td>+25.0 ° to +28.0 ° based on dry matter (589 nm, 20 °C, 50 g/l of water)</td>
</tr>
<tr>
<td>Formulation</td>
<td>granulate</td>
</tr>
<tr>
<td>Particle size</td>
<td>97% &lt; 0.5 mm</td>
</tr>
<tr>
<td>Bulk density</td>
<td>about 0.6 g/cm³</td>
</tr>
<tr>
<td>Solubility</td>
<td>readily soluble in water (about 40 g/100 ml)</td>
</tr>
</tbody>
</table>

### Stability
Calcium d-pantothenate is highly stable to the effects of atmospheric oxygen and light. In the unopened original packaging it can be kept for at least 36 months.

### Application
Lutavit Calpan 98% is suitable for all types of vitamin blends, premixes, mineral, and mixed feeds. The flowability and mixing behavior of the product is excellent and guarantees homogeneous mixing in all types of feed.

### Dosage recommendations
Please refer to “Vitamins — Pantothenic acid.”

### Note
Calcium d-pantothenate is a biologically highly active compound. The processing of the powder should therefore be carried out with the customary care in terms of occupational hygiene. The instructions of the safety data sheet are to be observed.
**Choline**

**Occurrence**
Choline occurs in all feeds. Rich sources of choline are animal by-products, dry feed yeasts, and some oilseed meals; poor sources are tapioca and maize. The naturally occurring choline of soya meal is utilized to an extent of 60 – 70%, and that of cereals to a smaller extent.

**Physiological importance**
Choline, which is included in the vitamin B group (vitamin B₄), occurs principally as a methyl-group donor. These so-called “labile methyl groups” (CH₃ groups) are absolutely necessary for the formation of vital bodily substances, for example creatine and adrenaline, and in fat conversion and other metabolic reactions. Moreover, choline has other functions in the metabolism as a building block in which it can be replaced neither by betaine nor by methionine (so-called essential choline requirement).

Choline serves among other things here as a:

- Building block of acetylcholine, which in this case has an important function in the transmission of stimuli in the nervous system (neurotransmitter).
- Building block of lecithin. Lecithin fulfills an important function in fat transport in the metabolism.
- Building block of ceramides, which are present in the brain substance. Interference in the enzymatic synthesis or degradation of these membrane building blocks results in metabolic disorders.

The supply of choline must therefore be ensured by the formation of choline in the animal body and by addition with the feed. Choline is in equilibrium with other vitamins. Its synthesis is promoted by vitamin B₁₂.

**Chemical structure**

\[
\begin{align*}
\text{C}_5\text{H}_{14}\text{ClNO} \\
\text{CH}_3\text{N}^-\text{-CH}_2-\text{CH}_2-\text{OH} \\
\text{CH}_3 \\
\text{Cl}^\ominus
\end{align*}
\]

Molar mass 139.6 g/mol

**Deficiency symptoms**
In the nutrition of **poultry**, a deficiency of choline has a particularly severe effect: depending on the degree, it leads in chicks to perosis (deformity of the legs as a result of displacement of the Achilles tendons), to growth retardation and to fatty degeneration of the liver. In the case of laying hens, reduction in the egg yield, decrease in the egg weight, and thus poorer hatchability are observed. Choline deficiency also appears to play a role in fatty liver formation (fatty liver syndrome).

In **pigs**, the deficiency of choline is manifested in a poorer distribution of fat and a retardation of growth. Malformations of the limbs, nerve degeneration can also be observed and kidney damage. Breeding sows which receive too little choline with the feed are less fertile, give birth to weak piglets, and have less milk.

In **ruminants** having a fully developed rumen function, a deficiency of choline only occurs occasionally because the microorganisms of the rumen can synthesize choline. However, calves have a real requirement, which is often not covered by the natural choline content of the feed. Calves with choline deficiency have a poor appetite, more rapid and strained respiration, and are generally weakened.
Toxicity
The LD$_{50}$/oral/rat is 2,000 mg/kg. Primary skin irritation/rabbit: non-irritant. Primary irritations of the mucous membrane/rabbit: non-irritant.

Dosage recommendations
The dosage recommendations are given per kg feed on the assumption that the animals (pigs/chicken) are fed mainly with complete feed. If, in addition to the basic ration, a supplementary feed is administered (cows/horses, etc.), the recommendations apply per animal and day. The vitamin dosage in the feed is dependent on the following factors:
- Species, breed, and desired use of the animal
- Age of the animal
- Performance of the animal
- Feed composition
- Environmental influences
In addition, an extra supplementation should be administered to increase the body's defenses, especially for young animals. The dosage recommendations focus on a high performance level of the animals, typically found in Western Europe or North America. The recommended vitamin dosages are also appropriate in other regions, because the extreme environmental conditions there often constitute stress factors for the animals. Under special circumstances/requirements, it might be advantageous to exceed the given dosage recommendations.

Conversion factors
x 1.155 = Choline chloride calculated 100%
x 1.536 = Choline chloride solution 75%

Poultry
per kg complete feed (88% dry matter)

<table>
<thead>
<tr>
<th>Species</th>
<th>Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicken, starter</td>
<td>400 – 700 mg</td>
</tr>
<tr>
<td>Chickens, pullets</td>
<td>250 – 400 mg</td>
</tr>
<tr>
<td>Laying hens</td>
<td>300 – 500 mg</td>
</tr>
<tr>
<td>Breeding hens</td>
<td>400 – 600 mg</td>
</tr>
<tr>
<td>Broiler</td>
<td>300 – 600 mg</td>
</tr>
<tr>
<td>Turkeys, starter</td>
<td>800 – 1,200 mg</td>
</tr>
<tr>
<td>Turkeys, grower</td>
<td>600 – 800 mg</td>
</tr>
<tr>
<td>Turkeys, finisher</td>
<td>500 – 700 mg</td>
</tr>
<tr>
<td>Turkeys, breeding animals</td>
<td>500 – 700 mg</td>
</tr>
<tr>
<td>Ducks/geese</td>
<td>400 – 600 mg</td>
</tr>
</tbody>
</table>

Ruminants and horses
per animal per day

<table>
<thead>
<tr>
<th>Species</th>
<th>Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calves, milk replacers</td>
<td>150 – 250 mg</td>
</tr>
<tr>
<td>Foals (per 100 kg live weight per day)</td>
<td>150 – 250 mg</td>
</tr>
<tr>
<td>Saddle horses (per 100 kg live weight per day)</td>
<td>150 – 250 mg</td>
</tr>
<tr>
<td>Racing horses and breeding horses (per 100 kg live weight per day)</td>
<td>300 – 400 mg</td>
</tr>
</tbody>
</table>

Pets and fish
per kg complete feed (88% dry matter)

<table>
<thead>
<tr>
<th>Species</th>
<th>Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dogs</td>
<td>1,000 – 1,200 mg</td>
</tr>
<tr>
<td>Cats</td>
<td>1,200 – 1,400 mg</td>
</tr>
<tr>
<td>Rabbits</td>
<td>600 – 800 mg</td>
</tr>
<tr>
<td>Minks</td>
<td>600 – 800 mg</td>
</tr>
<tr>
<td>Cold water fish</td>
<td>800 – 1,000 mg</td>
</tr>
<tr>
<td>Warm water fish</td>
<td>600 – 800 mg</td>
</tr>
<tr>
<td>Shrimps</td>
<td>400 – 600 mg</td>
</tr>
</tbody>
</table>
Choline Chloride 75%

Active ingredient
Choline chloride

PRD-No.
30041094

Articles
50481584 1100 kg IBC
50036955 bulk

Specification
Content at least 75% choline chloride (argentometrically)
Trimethylamine not more than 0.05%


Other chemical and physical data
Formulation liquid
Density 1.10 g/ml (20 °C)
Water content about 25%
Boiling point at temperatures above 100 °C the water evaporates and the salt crystallizes
Crystallization point -18 °C
Viscosity 21 mPa-s (at 20 °C)
Electrical conductivity 30,000 mS/cm (mS = micro Siemens)

Stability
Choline chloride is stable. The direct addition of choline chloride to the feed mixture as an individual component has proved suitable. Problems in the premix are thus avoided. In the unopened original packaging it can be kept for at least 24 months.

Recommended materials
Depending on the temperature and oxygen content, choline chloride in liquid form behaves corrosively to a varying extent. Only very specific materials are suitable for the storage and processing of Choline Chloride 75%. The statements made in the following tables are based on test results, many years of working experience, and practical applications. The stability data apply exclusively to 75% strength choline chloride.

Materials for storage and use

<table>
<thead>
<tr>
<th>Highly alloyed steel</th>
<th>Plastics</th>
<th>Boilerplate (rubberized)</th>
<th>PTFE (Teflon)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage container</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Pipelines</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Pumps</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Valves</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Nozzles</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Fittings</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Seals</td>
<td>•</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Metallic materials
The corrosiveness of choline chloride increases with the temperature and oxygen content. Water-diluted choline chloride also acts more corrosively than the 75% strength material. For choline chloride liquid metering plants, highly alloyed, austenitic chrome-nickel-molybdenum steel (e.g., X 6 CrNiMoTi 17 12 2, material no.: 1.4571) is recommended.
Recommendations when using highly alloyed steel

<table>
<thead>
<tr>
<th>Materials</th>
<th>Aeration</th>
<th>Resistance</th>
<th>up to a threshold temperature of</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4541</td>
<td>yes</td>
<td>no</td>
<td>-</td>
</tr>
<tr>
<td>1.4541</td>
<td>no</td>
<td>yes</td>
<td>45 °C</td>
</tr>
<tr>
<td>1.4571</td>
<td>yes</td>
<td>yes</td>
<td>45 °C</td>
</tr>
<tr>
<td>1.4571</td>
<td>no</td>
<td>yes</td>
<td>80 °C</td>
</tr>
</tbody>
</table>

Molybdenum-free chrome-nickel steel (e.g., X 6 CrNiTi 18 10, material no.: 1.4541) is not resistant to corrosion, as the oxygen-free choline chloride solution supplied is usually enriched with oxygen from the air on transferring to a tank. Under such conditions, and also on exceeding the threshold temperature, local pit and crack corrosion occurs in the highly alloyed stainless steels. Contaminations (e.g., iron salts or residues from a prior other use of the tank) can also increase the corrosiveness of the choline chloride. In this case, corrosion can also occur at temperatures lower than those mentioned in the table. In these cases and when constructing new plants, glass fiber-reinforced plastics are to be preferred to the metallic materials.

Plastics

Plastics are resistant to pit and crack corrosion in oxygen containing and oxygen-free choline chloride. For many years, plastics have been used successfully for the storage of choline chloride. In particular, glass fiber-reinforced plastics (GSP) can be employed in various material combinations suited to the specific individual case. Palatal with its types A410 and A420 has proved suitable. These are special resins, which were stable to Choline Chloride 75% up to 70 °C in the corrosion test. Recently, tanks appropriate to the spatial conditions can also be installed on site with Palatal.

Dosage recommendations

Please refer to “Vitamins — Choline.”

Note

These instructions replace the leaflet “From research and practice” no. 13, “Advice for the choice of materials when storing and using Choline Chloride solution 75%.” When exposed to the substance, the instructions of the safety data sheet are to be observed. For transport, storage, loading, and unloading of Choline Chloride 75%, the legal water procedures valid in the particular countries are to be observed.
Vitamin E

Occurrence
Vitamin E (tocopherols) is present in animal and vegetable feeds in varying amounts. For animal nutrition, not the total tocopherol content, but the content of active d-α-tocopherol (highest vitamin E activity) is important. Besides the latter only d-β-tocopherol has any significant biological activity. The tocopherol contents are high in young green fodder and wheat seedlings. In cereals, the tocopherol fraction is composed only to a small extent of the valuable α-tocopherol, so that only a low vitamin E activity is to be expected. This applies to a larger extent to growing cereals, as the α-tocopherol content considerably decreases during germination. Root crops and low-fat feeds (by-products from oil production, skimmed milk, whey) contain only a little or no tocopherol at all. For practical reasons, the stable dl-α-tocopheryl acetate* is used in animal nutrition instead of the strongly oxygen-sensitive d-α-tocopherol. It has about 2/3 of the biological activity of d-α-tocopherol (see table).

Vitamin E activity of tocopherols

<table>
<thead>
<tr>
<th>Compound</th>
<th>Activity in I.U.</th>
</tr>
</thead>
<tbody>
<tr>
<td>d-α-tocopherol = 5,7,8-trimethyltocol</td>
<td>1.49</td>
</tr>
<tr>
<td>d-β-tocopherol = 5,8-dimethyltocol</td>
<td>0.33</td>
</tr>
<tr>
<td>d-γ-tocopherol = 7,8-dimethyltocol</td>
<td>0.01</td>
</tr>
<tr>
<td>d-θ-tocopherol = 8-methyltocol</td>
<td>0.01</td>
</tr>
<tr>
<td>dl-α-tocopherol</td>
<td>1.10</td>
</tr>
</tbody>
</table>

* 1 mg dl-α-tocopheryl acetate = 1 I.U. of vitamin E

Physiological importance
On the one hand, vitamin E is necessary for cellular metabolism (cell respiration, nucleic acid metabolism). On the other hand, it acts as an antioxidant, by means of which the autoxidation of unsaturated fatty acids and vitamin A in vivo is suppressed. This is also of importance with respect to the quality of meat, as the action of the vitamin E stored in the depot fat in the meat still persists. Other tasks of vitamin E are: control of carbohydrate and creatine metabolism, muscle metabolism and glycogen balance; regulation of the development and function of the gonads; preparation and protection of pregnancy, regulation of hormone metabolism by means of the anterior pituitary lobe, stimulation of antibody formation, antitoxic action in cellular metabolism.
**Deficiency symptoms**

In calves, lambs, pigs, and poultry, muscular dystrophy is prominent, combined with lightening of the skeletal musculature (myoglobin loss) and degenerative changes in the heart musculature (mulberry heart disease), which can lead to sudden heart failure. In poultry, encephalomalacia occurs as a result of increased permeability of the blood vessels, in particular in the form of hemorrhages and formation of oedema in the cerebellum. Externally, the encephalomalacia is characterized by uncoordinated movements and by abnormal posture of the head. Exudative diathesis in poultry is attributed to increased plasma exudation (formation of oedema) from the blood capillaries. Owing to the plasma loss, the concentration of the blood contents and thus the loading of the heart musculature is increased. In the rat, vitamin E deficiency reduces fertility (absorption sterility).

**Recommendations for supply**

The vitamin E requirement of the animals is influenced by the following factors:

- Composition of the feed, content of sulfur-containing amino acids, nutrient concentration, and performance level. In particular, the amount and quality of added fats and the content of unsaturated fatty acids influence the vitamin E requirement decisively. The additional amounts of vitamin E required specifically for the antioxidative action are from 2 to 3 mg per g of unsaturated fatty acids in the feed, depending on the animal species. Owing to the multiplicity of factors involved, various values may be stated for the requirements, depending on the aim. Amounts of vitamin E over and above the nutritional requirements improve the storage life of meat and meat products.

---

**Example of the calculation of the vitamin E supply of piglets and fattening pigs:**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Required vitamin E content in the feed (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>According to NRC* (National Research Council, 1998)</td>
<td></td>
</tr>
<tr>
<td>11 – 15</td>
<td></td>
</tr>
<tr>
<td>With 3% soybean oil in the feed, additionally 36 mg of vitamin E (about 18 g unsaturated fatty acids FS x 2 mg vitamin E)</td>
<td>47 – 51</td>
</tr>
<tr>
<td>Increase in immune resistance and defense against infections</td>
<td>150 – 200</td>
</tr>
<tr>
<td>Reduction of stress-related mortality</td>
<td>200 – 250</td>
</tr>
<tr>
<td>Increase in storage stability of the fat in meat and meat products</td>
<td>100 – 150</td>
</tr>
</tbody>
</table>

* NRC data contain no safety supplements

In the case of dairy cows, vitamin E doses of 1,000 mg per animal and per day may reduce the incidence of mastitis and the somatic cell counts in the milk. Moreover, a rancid oxidation taste of the milk can be prevented (off flavor). Particular attention should be paid to the vitamin E supplements since organic damage due to vitamin E deficiency is irreversible and cannot be eliminated by subsequent increased dosages.
Toxicity
Vitamin E has a toxic effect only at very high dosages. Thus in chicks, for example, it can be assumed that a daily absorption of 1,000 mg of vitamin E per kg of body weight is without negative effects.

Dosage recommendations
The dosage recommendations are given per kg feed on the assumption that the animals (pigs/chicken) are fed mainly with complete feed. If, in addition to the basic ration, a supplementary feed is administered (cows/horses, etc.), the recommendations apply per animal and day. The vitamin dosage in the feed is dependent on the following factors:
• Species, breed, and desired use of the animal
• Age of the animal
• Performance of the animal
• Feed composition
• Environmental influences

In addition an extra supplementation should be administered to increase the body’s defenses, especially for young animals.

The dosage recommendations focus on a high performance level of the animals, typically found in Western Europe or North America. The recommended vitamin dosages are also appropriate in other regions, because the extreme environmental conditions there often constitute stress factors for the animals. Under special circumstances/requirements, it might be advantageous to exceed the given dosage recommendations.

Pigs
per kg complete feed (88% dry matter)

<table>
<thead>
<tr>
<th>Category</th>
<th>Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piglets, prestarter¹</td>
<td>100 – 150 mg</td>
</tr>
<tr>
<td>Piglets, starter</td>
<td>80 – 120 mg</td>
</tr>
<tr>
<td>Grower</td>
<td>60 – 80 mg</td>
</tr>
<tr>
<td>Finisher¹</td>
<td>40 – 60 mg</td>
</tr>
<tr>
<td>Breeding sows</td>
<td>60 – 80 mg</td>
</tr>
<tr>
<td>Breeding boars</td>
<td>140 – 160 mg</td>
</tr>
</tbody>
</table>

¹ up to 250 mg to increase immunity and improve the meat quality

Poultry
per kg complete feed (88% dry matter)

<table>
<thead>
<tr>
<th>Category</th>
<th>Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chickens, starter¹</td>
<td>40 – 60 mg</td>
</tr>
<tr>
<td>Chickens, pullets</td>
<td>20 – 30 mg</td>
</tr>
<tr>
<td>Laying hens</td>
<td>20 – 30 mg</td>
</tr>
<tr>
<td>Breeding hens</td>
<td>40 – 60 mg</td>
</tr>
<tr>
<td>Broiler¹</td>
<td>30 – 50 mg</td>
</tr>
<tr>
<td>Turkeys, starter¹</td>
<td>40 – 60 mg</td>
</tr>
<tr>
<td>Turkeys, grower</td>
<td>30 – 50 mg</td>
</tr>
<tr>
<td>Turkeys, finisher¹</td>
<td>30 – 40 mg</td>
</tr>
<tr>
<td>Turkeys, breeding animals</td>
<td>40 – 60 mg</td>
</tr>
<tr>
<td>Ducks/geese</td>
<td>40 – 60 mg</td>
</tr>
</tbody>
</table>

¹ up to 200 mg to increase immunity and improve meat quality
### Ruminants and horses
**per animal per day**

<table>
<thead>
<tr>
<th>Animal Type</th>
<th>Recommended Dose (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calves, milk replacers&lt;sup&gt;1)&lt;/sup&gt; (per kg feed)</td>
<td>80 – 120 mg</td>
</tr>
<tr>
<td>Cows, breeding</td>
<td>100 – 150 mg</td>
</tr>
<tr>
<td>Beef bulls&lt;sup&gt;2)&lt;/sup&gt;</td>
<td>200 – 300 mg</td>
</tr>
<tr>
<td>Dairy cows&lt;sup&gt;3)&lt;/sup&gt;</td>
<td>500 – 1000 mg</td>
</tr>
<tr>
<td>Sheep/goats</td>
<td>50 – 80 mg</td>
</tr>
<tr>
<td>Foals (per 100 kg live weight per day)</td>
<td>100 – 120 mg</td>
</tr>
<tr>
<td>Saddle horses (per 100 kg live weight per day)</td>
<td>80 – 100 mg</td>
</tr>
<tr>
<td>Racing horses and breeding horses (per 100 kg live weight per day)</td>
<td>200 – 300 mg</td>
</tr>
</tbody>
</table>

<sup>1)</sup> up to 200 mg to increase immunity first 14 days following the colostrum phase

<sup>2)</sup> to improve meat quality from the 100<sup>th</sup> day prior to slaughtering

<sup>3)</sup> to improve the udder condition during the dry period within the first 10 lactation weeks

### Pets and fish
**per kg complete feed (88% dry matter)**

<table>
<thead>
<tr>
<th>Animal Type</th>
<th>Recommended Dose (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dogs</td>
<td>80 – 120 mg</td>
</tr>
<tr>
<td>Cats</td>
<td>100 – 150 mg</td>
</tr>
<tr>
<td>Rabbits</td>
<td>30 – 50 mg</td>
</tr>
<tr>
<td>Minks</td>
<td>80 – 120 mg</td>
</tr>
<tr>
<td>Cold water fish&lt;sup&gt;1)&lt;/sup&gt;</td>
<td>200 – 300 mg</td>
</tr>
<tr>
<td>Warm water fish&lt;sup&gt;1)&lt;/sup&gt;</td>
<td>150 – 200 mg</td>
</tr>
<tr>
<td>Shrimps&lt;sup&gt;1)&lt;/sup&gt;</td>
<td>180 – 250 mg</td>
</tr>
</tbody>
</table>

<sup>1)</sup> high content in polyunsaturated fatty acids (PUFA's) requires additional doses
Lutavit® E 50 S

**Active ingredient**
Vitamin E acetate (dl-α-tocopheryl acetate)

**PRD-No.**
30040904

**Articles**
- 50048779 25 kg bag in box (Europe)
- 50054821 25 kg bag in box (Oversea)

**Specification**
| Content | at least 50% vitamin E acetate (GC, according to USP method) |


**Other chemical and physical data**
- Loss on drying: not more than 3%
- Formulation: powder
- Particle size: at least 97% < 0.6 mm
- Bulk density: about 0.35 g/cm³
- Composition: fine dispersion in a matrix of milk constituents and gelatine
- Solubility: dispersible in cold water
- Residue on ignition: at most 3% (at 600 °C)

**Stability**
In mixtures, vitamin E losses can occur depending on the composition (e.g. higher trace elements content) and the production and storage conditions (pelleting, action of heat). These active substance losses are particularly important in the presence of strong vitamin stress factors (moisture, choline chloride, trace elements) and in alkaline medium (high contents of magnesium oxide). In critical mixtures, Lutavit E 50 S should be employed to improve the vitamin E stability. The vitamin stability of this coated product is somewhat better under stress conditions than that of vitamin E adsorbates. In the unopened original packaging it can be kept for at least 24 months.

**Application**
Lutavit E 50 S is used for the vitaminization of all types of feed. It is very readily miscible and, because of its large particle number per unit of weight, highly suitable for premixtures, mineral feeds, and for mixed feed. Lutavit E 50 S is very easily dispersible in cold water.

The milky emulsion which is formed is stable. The mixing behavior of the powder in premixes and feeds is excellent. Because of its high particle number and good dispersibility in water, Lutavit E 50 S is particularly suitable for:
1. Feed mixtures with high contents of choline chloride, trace elements, and alkaline substances,
2. Milk replacers for piglets, calves, and other animals,
3. Water-dispersible multivitamin mixtures which are administered directly via the drinking water.
Dosage recommendations
Please refer to “Vitamins — Vitamin E.”

Note
Vitamin E exists in a biologically highly active form. The processing of the powder should therefore be carried out with the customary care in terms of occupational hygiene following the instructions in the safety data sheet.
Lutavit® E 50

Active ingredient
Vitamin E acetate (dl-α-tocopheryl acetate)

PRD-No.
30040915

Articles
50075923  25 kg plastic bag
50043993  500 kg big plastic bag

Specification
Content  at least 50% vitamin E acetate (GC, according to USP method)


Other chemical and physical data
Loss on drying  not more than 5%
Formulation  powder
Particle size  at least 96% < 0.35 mm
Bulk density  about 0.45 – 0.60 g/cm³
Composition  adsorbate based on colloidal silica
Solubility  insoluble in water; on addition of water the oily vitamin E acetate is set free on the surface
Residue on ignition  45 – 46% (at 600 °C)

Stability
In mixtures, vitamin E losses can occur depending on the composition (e.g., higher trace elements content) and the production and storage conditions (pelleting, action of heat). These active substance losses are particularly important in the presence of strong vitamin stress factors (moisture, choline chloride, trace elements) and in alkaline medium (high contents of magnesium oxide). In critical mixtures, Lutavit E 50 S should be employed to improve the vitamin E stability. The vitamin stability of this coated product is somewhat better under stress conditions than that of vitamin E adsorbates. The product has a storage life of 24 months in the unopened original packaging.

Application
Lutavit E 50 is used for the vitaminization of all types of feed. It is very readily miscible and, because of its large particle number per unit of weight, highly suitable for premixtures, mineral feeds, and for mixed feed.

Lutavit E 50 S can be used for this area of application as well. The milky emulsion which is formed is stable. The mixing behavior of the powder in premixes and feeds is excellent. Because of its high particle number and good dispersibility in water, Lutavit E 50 S is particularly suitable for:
1. Feed mixtures with high contents of choline chloride, trace elements, and alkaline substances,
2. Milk replacers for piglets, calves, and other animals,
3. Water-dispersible multivitamin mixtures which are administered directly via the drinking water.
Dosage recommendations
Please refer to “Vitamins — Vitamin E.”

Note
Vitamin E exists in a biologically highly active form. The processing of the powder should therefore be carried out with the customary care in terms of occupational hygiene following the instructions in the safety data sheet.
**Vitamin E-Acetate**

**Oily Feed**

**Active ingredient**
Vitamin E acetate (dl-α-tocopheryl acetate)

**PRD-No.**
30041056

**Articles**
- 55434330  25 kg plastic bucket
- 54729852  190 kg steel drum

**Specification**
Content at least 92% (GC, according to USP method)


**Other chemical and physical data**

**Formulation**
liquid

**Solubility**
soluble in hydrocarbons, alcohols, fats and oils; insoluble in water.

**Stability**
The product should be stored cool and protected from light. In the unopened original packaging it can be kept for at least 24 months.

**C₃₁H₅₂O₃**  Molar mass 472.8 g/mol

**Use**
For the preparation of liquid vitamin E preparations for oral use. In aqueous formulations, the use of solubilizers, for example Cremophor® EL or Cremophor RH 40, is necessary.

The figure below shows the ratio of vitamin E acetate to Cremophor EL necessary in the final solution:

A sterilization of the final preparation is necessary for parenteral use.

**Dosage recommendations**
Please refer to “Vitamins — Vitamin E.”
**Active ingredient**
Vitamin E acetate (dl-α-tocopheryl acetate)

**PRD-No.**
30041054

**Articles**
- 55434595  5 kg plastic can
- 55434171  25 kg plastic bucket
- 57425300 190 kg steel drum

**Specification**
Content  at least 96% – 102% (according to USP, FCC, Ph. Eur.)


**Other chemical and physical data**
- Heavy metals  ≤ 10 ppm
- Relative density d$_{20}^20$  0.952 – 0.966
- Acid number  ≤ 2
- Refractive index n$_{D}^{20}$  1.494 – 1.498
- Acidity (USP, FCC)  complies
- Specific extinction E$_{1}^{1}$
  - (in absolute ethanol)  42 – 45 (284 nm)  7 – 9 (254 nm)
- Formulation  liquid
- Solubility  soluble in hydrocarbons, alcohols, fats and oils; insoluble in water.

If not stated otherwise, the analytical methods are to be taken from the Ph. Eur. The product complies with the appropriate monograph of the Ph. Eur., USP, and FCC, and it can be supplied in accordance with the requirements of the JP.

**Stability**
In contrast to vitamin E alcohol, vitamin E acetate is very stable to heat and oxygen. It is unstable to alkalis (hydrolysis) and oxidants. Up to 25 °C, the product has a storage life of 36 months in the unopened original packaging. The instructions in the safety data sheet should be observed.

**Use**
For the preparation of liquid vitamin E preparations for oral and parenteral use. In aqueous formulations, the use of solubilizers, for example Cremophor® EL or Cremophor RH 40, is necessary. The figure below shows the ratio of vitamin E acetate to Cremophor EL necessary in the final solution:

A sterilization of the final preparation is necessary for parenteral use.

**Dosage recommendations**
Please refer to “Vitamins — Vitamin E.”
Carotenoids
<table>
<thead>
<tr>
<th>Carotenoids</th>
<th>47</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astaxanthin</td>
<td>54</td>
</tr>
<tr>
<td>Lucantin Pink</td>
<td>55</td>
</tr>
<tr>
<td>Lucantin Pink CWD</td>
<td>56</td>
</tr>
<tr>
<td><strong>β-Carotene</strong></td>
<td>57</td>
</tr>
<tr>
<td>Lucarotin 10% Feed</td>
<td>58</td>
</tr>
<tr>
<td>Lucarotin 10% Feed Special</td>
<td>59</td>
</tr>
<tr>
<td>Canthaxanthin</td>
<td>60</td>
</tr>
<tr>
<td>Lucantin Red</td>
<td>61</td>
</tr>
<tr>
<td>Lucantin Red CWD</td>
<td>63</td>
</tr>
<tr>
<td><strong>Citranaxanthin</strong></td>
<td>64</td>
</tr>
<tr>
<td>Lucantin CX forte</td>
<td>65</td>
</tr>
<tr>
<td><strong>C-30 ester</strong></td>
<td>66</td>
</tr>
<tr>
<td>Lucantin Yellow</td>
<td>67</td>
</tr>
</tbody>
</table>
Carotenoids

Carotenoids occur in practically all plants and animals, but particularly in organisms that are exposed to the sun. Straub (1987) described 563 different carotenoids, not counting their various cis and trans isomers. A few of the main carotenoids and polyenes found in foodstuffs and feeds are:

- α- and β-Carotene
- Lutein/Zeaxanthin
- β-Apo-8′-carotenoids
- β-Cryptoxanthin
- Astaxanthin
- Canthaxanthin
- Citranaxanthin
- Lycopene
- Neoxanthin
- Phytoene and phytofluene
- Violaxanthin

Most carotenoids absorb light selectively. They are xanthophylls (Greek: Xanthos = yellow, Phyllon = leaf) that are usually yellow in color and are responsible for the yellow coloration of leaves in autumn. The main xanthophylls involved here are lutein and zeaxanthin. Apart from the xanthophylls, there is also the group of carotenoids that includes the best known of all, beta-carotene. The distribution of carotenoids in plant and animal tissue differs widely. The naturally occurring carotenoids are completely insoluble in water and are often associated with lipids, to which they impart their color, e.g., milk fat, egg yolk, red palm oil. In fish muscle and shrimps however, carotenoid pigments are protein-bound. Some of the carotenoids absorbed are not metabolized in the intestinal mucosa; they are incorporated in the chylomicrons, in which they pass unchanged via the lymph into the blood.

Carotenoids with provitamin A activity such as beta-carotene and the two β-apo-8′-carotenoids, β-apo-8′-carotenal, and β-apo-8′-carotenoic acid ethyl ester can be converted in the mucosa to retinal, according to the vitamin A requirement of the organism, and subsequently reduced to retinol (= vitamin A alcohol).

The biological activity of the carotenoids can be subdivided into functions, effects, and associations, according to Bendich and Olson (1989).

Functions
- Conversion into vitamin A (detected for α-, β- and γ-carotene, citranaxanthin, astaxanthin, and canthaxanthin in fish, cryptoxanthin, echinenone, zeaxanthin, and various β-apocarotenals)
- Color signalling in reproductive displays, and camouflage in some animals
- Protection of fish eggs from light-induced damage

Effects
- Antioxidant effect, particularly at low partial pressures of oxygen
- Inhibition of mutagenicity
- Increase in immune response
- Reduction of light-induced neoplasias
- Resistance to hypoxia in crustaceans

Associations in humans and animals
- A low plasma level of beta-carotene is associated with an increased risk of various precancerous diseases and various forms of cancer.
- A low plasma level of beta-carotene is associated with an increased risk of cardiovascular disease.
- A high plasma level of lycopene is supposed to reduce the risk of prostate cancer.

Carotenoids are widely used in animal nutrition. For their coloring properties, they are incorporated into feeds in order to pigment egg yolks, broiler skin, fish and shrimp tissues. BASF’s products are also applied wherever carotenoids are seen to have health-boosting and fertility enhancing roles. The fertility of cattle, swine, and horses can be improved through feeding β-carotene. Astaxanthin and canthaxanthin have been demonstrated to have health and growth improving potential in larval fish and in salmonid fingerlings. Lucantin® and Lucarotin® are BASF’s registered trademarks.
**Dosage recommendations**

1) Poultry

**Broiler skin pigmentation**
Depending on the content of naturally yellow-coloring carotenoids in the feed, a golden yellow skin pigmentation is achieved by a supplement of 100 – 300 g of Lucantin Yellow per metric ton of feed. Depending on the intended coloration and the prevailing market conditions, broiler skin pigmentation can be further intensified by a supplement of up to 50 g of Lucantin Red.

**Egg yolk pigmentation**

**Yellow pigmentation**
As shown in the accompanying tables, the selected dosage of Lucantin Yellow in laying hen feed depends on the Ovocolor scale value achieved without Lucantin, the analyzed or calculated xanthophyll content in the feed, and the color score being targeted. Use of Lucantin Yellow on its own is only economically efficient for achieving up to Ovocolor scale value 7 – 8.

On administration of a xanthophyll-free ration containing a supplement of 25 g of Lucantin Yellow per metric ton of feed, an egg yolk pigmentation can be achieved, which corresponds to an average Ovocolor scale (BASF, 2001) value of 7.

An average Ovocolor score of 7 means that 50% of egg yolks will be at score 7 or less, as is typical with a normal distribution. In order for nearly all eggs to attain an Ovocolor score of 7, the supplement of Lucantin Yellow should be raised to 30 g Lucantin Yellow per metric ton of feed.

Natural variations in the xanthophyll content of feed raw-materials can also be compensated for in this way.

**Red pigmentation**
The required dosage of Lucantin Red or Lucantin CX forte for laying hen feed has to be adapted to the xanthophyll content of the ration and to the intended Ovocolor scale value. Reliable egg yolk pigmentation extending beyond Ovocolor scale 7 is achieved by the use of Lucantin Red and/or Lucantin CX forte.

At the higher end of the Ovocolor range (14 – 15), where the background feed-xanthophyll content is less than 10 ppm, an additional use of Lucantin Yellow is advisable to avoid the intensive red coloration, less popular with consumers.

Using the recommendations set out in the accompanying tables should ensure that, on average, egg yolks attain the intended color targets. Under certain circumstances, where secondary factors may affect pigment efficiency (see Tab. 1), the dosage recommendations for Lucantin Red or Lucantin CX forte may be increased by 5 g per metric ton.

Lucantin Red and Lucantin CX forte can be used interchangeably when the correct exchange ratio is observed. Lucantin Red is 1.5 times more effective than Lucantin CX forte at imparting color (see Fig. 1). This means that 1.5 times more Lucantin CX forte is required in order to generate the same yolk color as Lucantin Red.
If the combined use of Lucantin CX forte and Lucantin Red is preferred, the action ratio of 1.5:1 should be included in the calculation of the required quantities to be applied.

Example:

Xanthophyll content in the feed: 5 g/t
Intended color scale value: 13

This results in the following use recommendations according to Tables 1 and 2:

- Lucantin Yellow: 20 g/t of feed
- Lucantin CX forte: 75 g/t of feed

Instead of using Lucantin Yellow and Lucantin CX forte, an alternative combination, for example the following, is suitable:

- Lucantin Yellow: 20 g/t of feed
- Lucantin CX forte: 30 g/t of feed
- Lucantin Red: 30 g/t of feed

The following factors affect egg yolk pigmentation:

- Improvement of the pigmentation is achieved by addition of linoleic acid-containing oil, such as from soybeans, to the feed.
- Large doses of vitamin E support the absorption of carotenoids and act in vivo as a physiological antioxidant.
- Antioxidants protect the fat and the xanthophylls in the feed from oxidation.
- A higher peroxide content in the feed adversely affects the stability of the carotenoids in vivo and in vitro.
- The pigmentation effect is adversely affected by increased feed calcium content. The calcium content should therefore not be set higher than absolutely necessary.
- Mycotoxins in the feed can reduce the serum content of carotenoids and thus adversely affect the pigmentation of the egg yolks.
- Doses of vitamin A of more than 15,000 I.U./kg can lead to an adverse effect on egg yolk pigmentation, since in such cases, carotenoid absorption can be impaired (absorption competition).
- The feed intake of the laying hens may be reduced as a result of increased energy contents in the feed or as a result of stress factors (e.g., higher house temperatures), so that the amount of carotenoids absorbed is insufficient for the intended yolk pigmentation.
- Diseases such as salmonellosis, Newcastle disease, coccidiosis, or infestation with other endoparasites damage the mucosa of the digestive tract and reduce the absorption of carotenoids. The absorption of fat-soluble carotenoids is also reduced as a result of insufficient bile acid secretion, and thus adversely affects the pigmentation action.
<table>
<thead>
<tr>
<th>Contents of natural yellow-coloring carotenoids (ppm)</th>
<th>Supplement of: Y = Lucantin Yellow R = Lucantin Red</th>
<th>Supplements of Lucantin dry powder in g/t of feed for an intended value of the color scale of:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>0 – 2</td>
<td>Y</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>2 – 4</td>
<td>Y</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>4 – 6</td>
<td>Y</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>6 – 8</td>
<td>Y</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>8 – 10</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>10 – 12</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>12 – 16</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>16 +</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R</td>
<td></td>
</tr>
</tbody>
</table>
Tab. 2:  
**Lucantin CX forte and Lucantin Yellow dosage recommendations for layer feeds**  
*(based on BASF Ovocolor scale, 2001)*

<table>
<thead>
<tr>
<th>Contents of natural yellow-coloring carotenoids (ppm)</th>
<th>Supplement of:</th>
<th>Supplements of Lucantin dry powder in g/t of feed for an intended value of the color scale of:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Y = Lucantin Yellow</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>CX = Lucantin CX forte</td>
<td></td>
</tr>
<tr>
<td>0 – 2</td>
<td>Y</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>CX</td>
<td>-</td>
</tr>
<tr>
<td>2 – 4</td>
<td>Y</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>CX</td>
<td>-</td>
</tr>
<tr>
<td>4 – 6</td>
<td>Y</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>CX</td>
<td>-</td>
</tr>
<tr>
<td>6 – 8</td>
<td>Y</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>CX</td>
<td>-</td>
</tr>
<tr>
<td>8 – 10</td>
<td>Y</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>CX</td>
<td>-</td>
</tr>
<tr>
<td>10 – 12</td>
<td>Y</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>CX</td>
<td>-</td>
</tr>
<tr>
<td>12 – 16</td>
<td>Y</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>CX</td>
<td>-</td>
</tr>
<tr>
<td>16 +</td>
<td>Y</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>CX</td>
<td>-</td>
</tr>
</tbody>
</table>
Dosage recommendations
2) Fish and shrimps

Salmonid fish are capable of depositing astaxanthin and canthaxanthin in their muscle, skin, and gonads. The extent of pigmentation depends mainly upon dosage, duration of feeding, feed intake, and feed conversion rate, although it is clear that health, genetics, and environmental effects also have a great impact. Even fish from the same parents may vary greatly in their attained pigmentation. However, the guidelines within this section are designed to enable the majority of a given population to attain what is considered as a good/marketable color level. Because the relationship of pigment to attained flesh color varies between species and also between individuals of the same species, dosages have been suggested that should yield colors conforming to internationally recognized flesh quality standards.

It should also be noted that suggested dosages assume that no pigment is lost through the feed production process. This will be the case when Lucantin Pink CWD and Lucantin Red CWD are applied using post-pelleting liquid application systems. When products are added to a formulation preextrusion, losses of carotenoids are related to the harshness of the feed process conditions. Both astaxanthin formulations, CWD and Dry Powder can be used via preextrusion.

**Atlantic salmon (Salmo salar)**

It is generally recognized that astaxanthin or canthaxanthin should be applied in the seawater growth phase of the Atlantic salmon. Pigmentation at 70 – 80 mg/kg feed (700 – 800 g Lucantin Pink or Red per metric ton. Within the EU, canthaxanthin in permitted at a maximum of 25 mg/kg) can be commenced from when transferred smolt reach 70 – 100 g in weight and feed levels are maintained until harvest. When pre-harvest checks on flesh pigmentation are carried out, feed pigment levels may be reduced to 40 – 50 mg/kg when fish attain a flesh pigment level of 8 – 9 mg/kg.

When no checks are carried out, it is unwise to drop feed pigment levels, and levels of at least 70 mg/kg should be retained. Having set a flesh “minimum target pigment level” of 8 mg/kg, both raw and smoked salmon should conform to European premium quality standards.

**Rainbow trout (Oncorhynchus mykiss)**

Astaxanthin should be included at a level of 50 – 60 mg/kg (500 – 600 g Lucantin Pink/metric ton) in rainbow trout from 50 g body weight until harvest. For markets where higher color levels are intended, Lucantin Pink should be added at 800 – 900 g per metric ton of feed.

For large sea-grown trout, feed doses of 50 mg/kg should result in a good flesh color at harvest.

**Salmonid Broodstock**

Because of the proven benefits of astaxanthin on egg survival and performance of juveniles, it is recommended that 800 g Lucantin Pink per metric ton are applied in broodstock rations.

**Application of carotenoids in other salmonids, non-salmonid fish, and in crustacea**

Inclusion of at least 50 mg astaxanthin per kg feed, from 100 g bodyweight until harvest should result in good pigmentation in coho salmon, chinook salmon, red seabream, red tilapia, and snapper.

In shrimp, 50 mg/kg astaxanthin in the 12 weeks running to harvest should impart sufficient color for most markets. There is evidence that higher doses (200 mg/kg) confer health benefits. It should also be noted that 50 mg/kg beta carotene fed during the entire growing period result in sufficient color.
Lucantin Pink dosage recommendations for fish and shrimps
— should result in good/superior level coloration in marketed/processed product

<table>
<thead>
<tr>
<th>Species</th>
<th>Feed dose (mg/kg)</th>
<th>Feeding period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlantic salmon</td>
<td>70 – 80</td>
<td>Seawater phase, 70 g – harvest</td>
</tr>
<tr>
<td>Rainbow trout</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In Freshwater</td>
<td>50 – 60</td>
<td>50 g body weight (bw) – harvest</td>
</tr>
<tr>
<td>Seawater grown</td>
<td>50</td>
<td>100 g bw to harvest</td>
</tr>
<tr>
<td>Coho salmon</td>
<td>50 – 70</td>
<td>Entire seawater phase</td>
</tr>
<tr>
<td>Chinook salmon</td>
<td>50 – 70</td>
<td>Entire seawater phase</td>
</tr>
<tr>
<td>Red seabream</td>
<td>50</td>
<td>100 g – harvest</td>
</tr>
<tr>
<td>Red tilapia</td>
<td>50</td>
<td>100 g – harvest</td>
</tr>
<tr>
<td>Red snapper</td>
<td>50</td>
<td>100 g – harvest</td>
</tr>
<tr>
<td>Shrimp</td>
<td>50 – 200</td>
<td>12 weeks pre-harvest</td>
</tr>
</tbody>
</table>

For health benefits throughout the culture of shrimp, continuous feeding of pigment is necessary.

Lucarotin dosage recommendations for others

<table>
<thead>
<tr>
<th>Animal species</th>
<th>β-Carotene dosage mg/animal/day</th>
<th>Start</th>
<th>End</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy cow</td>
<td>200</td>
<td>3 weeks before calving</td>
<td>on discovery of new pregnancy</td>
</tr>
<tr>
<td>Breeding sow</td>
<td>400 200</td>
<td>1 week before weaning after mating</td>
<td>up to mating on discovery of new pregnancy</td>
</tr>
<tr>
<td>Breeding mare</td>
<td>500</td>
<td>4 weeks before foaling</td>
<td>10 weeks after foaling</td>
</tr>
<tr>
<td>Breeding rabbits</td>
<td>10 – 20 mg/kg of compound feed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shrimps</td>
<td>50 mg/kg feed for the entire growing period</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Astaxanthin

Occurrence
Astaxanthin is found in abundance in nature, particularly in marine species. It occurs in tissue, ovaries, skin, and organs of various fish species and crustaceans. Astaxanthin is responsible for the orange to red pigmentation of animal tissues such as the flesh of various fish species. In living shrimp and lobsters, astaxanthin appears as a grey to blue color within the crustacean’s exoskeleton. After boiling, astaxanthin is released from the bound form to reveal the typical pink color. Astaxanthin also naturally occurs in skin, feathers, and ovaries of various bird species. The substance can also be found in algae and fungal species.

Role in animal feed
Crustacea and fish are reliant on carotenoid intake from the food chain since they cannot synthesize astaxanthin de novo. In the wild, astaxanthin is produced by plants, bacteria, and fungi, and from these organisms transferred up the food chain and stored in organisms that have the ability to do so. In culture situations where fish and crustacea are not able to obtain enough “wild pigment” to satisfactorily pigment their tissues, astaxanthin preparations can be incorporated into the formulated feed.

Astaxanthin has been shown to provide growth and health benefits in shrimp (Chien and Jeng, 1992) and in larval and juvenile fish. In salmonid reproduction and larval development, astaxanthin has been seen to be essential to the survival of larvae through the fry stage, with levels of no less than 0.11 µg astaxanthin per egg necessary to prevent the appearance of M74 syndrome in Baltic salmon (Pettersson and Lignell, 1999).

As a potential source of vitamin A, astaxanthin is involved in immune functioning. Vitamin A and retinoid metabolites are known to influence the immune response by any one of a number of proposed mechanisms. Astaxanthin’s cancer suppressive role (Gradelet et al., 1998) may also be explained in relation to vitamin A bio conversion. However, a further explanation of the tumor-preventive effect is due to the antioxidant properties of the astaxanthin molecule.

Biological activity
Astaxanthin has a vitamin A activity in combination with antioxidative immune stimulating properties and increases the reproduction rate in fish.

Areas of application
Feed supplement which intensifies the pigmentation of fish and crustaceans.

Note
Astaxanthin has no provitamin A activity.
Lucantin® Pink

Active ingredient
Astaxanthin dry powder 10%
3,3′-dihydroxy-4,4′-dioxo-β-carotene

PRD-No.
30053187 stabilized with ethoxyquin

Articles
50383377 5 kg bag in box
55619086 25 kg bag in box

Specification
Content at least 10% (spectrophotometrically, calculated using $E_1^1 = 1910$ at 476 nm in acetone/water (9:1))


Other chemical and physical data
Loss on drying at most 5%
Formulation powder
Particle size at least 95% < 0.63 mm
Bulk density about 0.48 g/cm³
Composition spray formulation based on gelatine, mono- and poly-saccharides
Solubility swells slowly in cold water more rapidly in warm water (40 °C) and finally disintegrates with the formation of a dispersion

Stability
The product should be stored cool (below 20 °C) and dry in unopened original packaging. Carefully close the packaging after partial amounts have been removed. In unopened original packaging, the product can be kept for 18 months.

Dosage recommendations
Please refer to “Carotenoids.”

Note
The active substance astaxanthin occurs in Lucantin Pink in a biologically highly active form. The processing of this product should therefore be carried out with the customary care in terms of occupational hygiene following the instructions of the safety data sheet.
Lucantin® Pink CWD

**Active ingredient**
Astandanthin CWD* powder 10%
3,3’-dihydroxy-4,4'-dioxo-β-carotene

**PRD-No.**
30076413

**Articles**

<table>
<thead>
<tr>
<th>Article No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>51027961</td>
<td>20 kg bag in box</td>
</tr>
<tr>
<td>57043356</td>
<td>250 kg plastic big bag</td>
</tr>
</tbody>
</table>

**Specification**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>at least 10% (spectrophotometrically, calculated using $E_1^1 = 1910$ at 476 nm in acetone/water (9:1))</td>
</tr>
</tbody>
</table>


**Other chemical and physical data**

<table>
<thead>
<tr>
<th>Property</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss on drying</td>
<td>at most 6%</td>
</tr>
<tr>
<td>Formulation</td>
<td>powder</td>
</tr>
<tr>
<td>Particle size</td>
<td>at least 95% &lt; 0.35 mm</td>
</tr>
<tr>
<td>Bulk density</td>
<td>about 0.4 – 0.6 g/cm³</td>
</tr>
<tr>
<td>Composition</td>
<td>spray formulation based on plant-protein, mono- and polysaccharides</td>
</tr>
<tr>
<td>Solubility</td>
<td>disperses in cold water to form a fine dispersion comprising nano-sized particles of the active ingredient (astaxanthin)</td>
</tr>
</tbody>
</table>

**Application**

Cold water dispersible formulation for the use in pre- and post-extrusion applications.

**Stability**

The product should be stored cool (below 20 °C) and dry in unopened original packaging. Carefully close the packaging after partial amounts have been removed. In unopened original packaging, the product can be kept for 12 months.

**Dosage recommendations**

Please refer to “Carotenoids.”

**Note**

The active substance astaxanthin occurs in Lucantin Pink CWD in a biologically highly active form. The processing of this product should therefore be carried out with the customary care in terms of occupational hygiene following the instructions of the safety data sheet.

* CWD = Cold-water-dispersible
Occurrence
β-Carotene occurs in nature, in particular in green plants. In addition to the varying amounts in individual plant feedstuffs, climate harvesting, degree of wilting, type of preservation (drying, ensiling), and storage time affect the content.

Role in animal feed
Investigations in recent years show that β-carotene has a positive effect on the fertility process of male and female cattle. Comparable investigations also exist for other animal species such as breeding mares, sows, and rabbits. It was also possible to observe an increase in the powers of resistance against infectious rearing diseases in young animals. The utilization of β-carotene is dependent on the animal species and on the carotene and vitamin A supply status. In ruminants, with a vitamin A supply approximately covering the requirement, a conversion rate of β-carotene to vitamin A of 6:1 (1.8 µg of β-carotene provides 0.3 µg of vitamin A alcohol = 1 I.U. of vitamin A) can be assumed.

Deficiency symptoms
A deficiency of β-carotene occurs during the keeping of animals indoors and on feeding β-carotene-low feeds. Depending on the degree and duration of the deficit, the following deficiency symptoms can occur:
- Silent oestrus
- Retarded ovulation
- Lack of fertility, for example, return to oestrus
- Embryonic death, early abortion
- Increased susceptibility to rearing and infectious diseases

Requirements
In general, the supply of β-carotene when grazing or in fresh green fodder is adequate. During winter feeding, the daily requirement of the breeding cattle (calf reproduction phase) of 400 – 600 mg of β-carotene per breeding animal (depending on breed, age, performance stage) can be met only when feeding good quality grass silage. Other conservates (e.g., hay, maize, beet tops silage) require supplementation of β-carotene at a level of at least 50% of the daily requirement. Regular covering of the requirement is necessary as β-carotene is hardly stored in the body — in contrast to vitamin A.

Areas of application
Feed supplement which can be used to ensure/enhance animal fertility.

Note
β-Carotene has a provitamin A activity which is at max. 2:1 for poultry and rats. For other species the exchange rate is lower. Maximum possible exchange rate is also depending on the vitamin A content of the ration.
## Lucarotin® 10% Feed

### Active ingredient

β-Carotene dry powder 10%

### PRD-No.

30041168 stabilized with ethoxyquin

### Article

55619351 25 kg bag in box

### Specification

<table>
<thead>
<tr>
<th>Content</th>
<th>at least 10% (spectrophotometrically, calculated using $E_1 = 2230$ at 450 nm in acetone/water (9:1))</th>
</tr>
</thead>
</table>


### Other chemical and physical data

<table>
<thead>
<tr>
<th>Loss on drying</th>
<th>at most 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formulation</td>
<td>powder</td>
</tr>
<tr>
<td>Particle size</td>
<td>at least 95% &lt; 0.63 mm</td>
</tr>
<tr>
<td>Bulk density</td>
<td>about 0.6 g/cm³</td>
</tr>
<tr>
<td>Composition</td>
<td>spray formulation based on gelatine, mono- and polysaccharides</td>
</tr>
<tr>
<td>Solubility</td>
<td>dissolves slowly in cold water, more rapidly in warm water (40 °C) and finally disintegrates with the formation of a dispersion</td>
</tr>
</tbody>
</table>

### Stability

The product should be stored cool (below 20 °C) and dry in unopened original packaging. Carefully close the packaging after partial amounts have been removed. In unopened original packaging, the product can be kept for 18 months.

### Dosage recommendations

Please refer to “Carotenoids.”

### Note

The active substance β-carotene is present in Lucarotin 10% Feed in a biologically highly active form. The processing of this product should therefore be carried out with the customary care in terms of occupational hygiene following the instructions in the safety data sheet.
Lucarotin® 10% Feed Special

Active ingredient
β-Carotene dry powder 10%

PRD-No.
30059535 stabilized with mixed toco-
pherol (without ethoxyquin)

Article
50058587 25 kg bag in box

Specification
Content at least 10% (spectrophotometrically, calculated using E₁ = 2230 at 450 nm in acetone/water (9:1))


Other chemical and physical data
Loss on drying at most 5%
Formulation powder
Particle size at least 95% < 0.63 mm
Bulk density about 0.6 g/cm³
Composition spray formulation based on gelatine, mono- and poly-
saccharides
Solubility dissolves slowly in cold water, more rapidly in warm water (40 ºC) and finally disinte-
grates with the formation of a dispersion

Stability
The product should be stored cool (below 20 ºC) and dry in unopened original packaging. Carefully close the packaging after partial amounts have been removed. In unopened original packaging, the product can be kept for 18 months.

Dosage recommendations
Please refer to “Carotenoids.”

Note
The active substance β-carotene is present in Lucarotin 10% Feed Special in a biologically highly active form. The processing of this product should therefore be carried out with the customary care in terms of occupational hygiene following the instructions in the safety data sheet.
Canthaxanthin

Occurrence
Canthaxanthin is naturally occurring in birds (feathers), fish, crustacea, insects, fungi (e.g., Cantharellus cinnabarinus), algae, and in many other organisms.

Role in animal feed
Naturally occurring in birds (feathers), fish, crustacea, fungi, algae, and in many other organisms, canthaxanthin is widely applied as a feed additive delivering red pigmentation.
In poultry pigmentation, canthaxanthin is used to impart a red color to egg yolks and to broiler skin. Used in conjunction with yellow pigments, canthaxanthin increases yolk color intensity to meet market demands for golden-orange yolks. In the pigmentation of salmonid fish, canthaxanthin is supplied in the feed in order to impart a desirable coloration to flesh. Addition of this pigment to grow-out salmonid feeds ensures that flesh products attain the color according to consumer expectations. Besides its vitamin A activity, canthaxanthin is a well known free-radical scavenger.

Areas of application
Feed supplement which intensifies the pigmentation of egg yolk, broiler skin, fish, and crustaceans.

Note
Canthaxanthin has no provitamin A activity.
Lucantin® Red

**Active ingredient**
Canthaxanthin dry powder 10%
4,4’-dioxo-β-carotene

**PRD-No.**
30041146 stabilized with ethoxyquin

**Articles**
- 50027048 5 kg bag in box
- 55618980 25 kg bag in box

**Specification**
Content at least 10% (spectrophotometrically, calculated using $E_1^{1%} = 1970$ at 472 nm in acetone/water (9:1))

For further information see separate document:

**Other chemical and physical data**
- Loss on drying at most 5%
- Formulation powder
- Particle size at least 95% < 0.63 mm
- Bulk density about 0.6 g/cm³
- Composition spray formulation based on gelatine, mono- and poly- saccharides
- Solubility swells slowly in cold water more rapidly in warm water (40 °C) and finally disintegrates with the formation of a dispersion

**Stability**
The product should be stored cool (below 20 °C) and dry in unopened original packaging. Carefully close the packaging after partial amounts have been removed. In unopened original packaging, the product can be kept for 18 months.

**Dosage recommendations**
Please refer to “Carotenoids.”

**Note**
The active substance canthaxanthin occurs in Lucantin Red in a biologically highly active form. The processing of this product should therefore be carried out with the customary care in terms of occupational hygiene following the instructions of the safety data sheet.
**Lucantin® Red CWD**

**Active ingredient**
Canthaxanthin CWD* powder 10% 4,4'-dioxo-β-carotene

**PRD-No.**
30061309

**Article**
50040143 20 kg box, corrugated cardboard

**Specification**
<table>
<thead>
<tr>
<th>Content</th>
<th>at least 10% (spectrophotometrically, calculated using (E_1^1 = 1970) at 472 nm in acetone/water (9:1))</th>
</tr>
</thead>
</table>


**Other chemical and physical data**
<table>
<thead>
<tr>
<th>Loss on drying</th>
<th>at most 6%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formulation</td>
<td>powder</td>
</tr>
<tr>
<td>Particle size</td>
<td>at least 95% &lt; 0.35 mm</td>
</tr>
<tr>
<td>Bulk density</td>
<td>about 0.4 – 0.6 g/cm³</td>
</tr>
<tr>
<td>Composition</td>
<td>spray formulation based on plant-protein, mono- and polysaccharides</td>
</tr>
<tr>
<td>Solubility</td>
<td>disperses in cold water to form a fine dispersion comprising nano-sized particles of the active ingredient (Canthaxanthin)</td>
</tr>
</tbody>
</table>

**Application**
Cold water dispersible formulation for post-extrusion and post-pelleting applications.

**Stability**
The product should be stored cool (below 20 °C) and dry in unopened original packaging. Carefully close the packaging after partial amounts have been removed. In unopened original packaging, the product can be kept for 12 months.

**Dosage recommendations**
Please refer to “Carotenoids.”

**Note**
The active substance canthaxanthin occurs in Lucantin Red CWD in a biologically highly active form. The processing of this product should therefore be carried out with the customary care in terms of occupational hygiene following the instructions of the safety data sheet.

---

* CWD = Cold-water-dispersible
Citranaxanthin

**Occurrence**
Citranaxanthin naturally occurs in the peel of citrus fruits.

**Role in animal feed**
This red carotenoid is used exclusively in poultry rations in order to impart redness to egg yolks. A close relative of the yellow pigment C-30 ester, citranaxanthin is efficiently assimilated and deposited in yolks, where it contributes to the consumer appeal of eggs and egg products. Used in conjunction with yellow pigments, citranaxanthin increases yolk color intensity to meet market demands for golden-orange yolks. Citranaxanthin has been applied in this field for approximately 30 years and is second only to canthaxanthin for its coloring properties.

**Areas of application**
Feed supplement which intensifies the pigmentation of egg yolk. In comparison with canthaxanthin, a constant action ratio of 1.5:1 is achieved over the entire range.

**Note**
Citranaxanthin has a vitamin A activity which is up to 300 I.U./mg of citranaxanthin, depending on the vitamin A content of the ration.

\[
\text{C}_{33}\text{H}_{44}\text{O} \text{ Molar mass 456.7 g/mol}
\]
Lucantin® CX forte

Active ingredient
Citranaxanthin dry powder 10%
5’, 6’-dihydro-5’-apo-18’-nor-β-carotene-6’-one

PRD-No.
30041155 stabilized with ethoxyquin

Article
55619298 25 kg bag in box

Specification
Content at least 10% (spectrophotometrically, calculated using $E_1^1 = 2680$ at 472 nm in cyclohexane/acetone)


Other chemical and physical data
Loss on drying at most 5%
Formulation powder
Particle size at least 95% < 0.63 mm
Bulk density about 0.6 g/cm³
Composition micronized active substance, formulated on the basis of gelatine, mono- and poly-saccharides
Solubility swells slowly in cold water; more rapidly in warm water (40 °C) and finally disintegrates with the formation of a dispersion

Stability
The product should be stored cool (below 20 °C) and dry in unopened original packaging. Carefully close the packaging after partial amounts have been removed. In unopened original packaging, the product can be kept for 18 months.

Dosage recommendations
Please refer to “Carotenoids.”

Note
The active substance citranaxanthin is present in Lucantin CX forte in a biologically highly active form. The processing of this product should therefore be carried out with the customary care in terms of occupational hygiene following the instructions in the safety data sheet.
C-30 ester
β-apo-8'-carotenoic acid ethyl ester

Occurrence
C-30 ester occurs in nature as a metabolic product of apocarotinal, which can be extracted from grass, lucerne, green vegetables, and citrus fruits.

Role in animal feed
Pigmentation of egg-yolks and broiler skin is due to the yellow pigments consumed in the feed. These pigments may be found in common feed-stuffs, although the low bioavailability of these sources and their variability in content means that practical application is difficult or, at best, unreliable.

C-30 ester (or apocarotene) is applied exclusively in the poultry sector in order to impart a golden-yellow color to egg yolks and skin. Found in animal tissues after metabolic transformation of the plant pigment apocarotinal (e.g., in citrus fruits, lucerne, grass, alfalfa), C-30 ester is the most efficacious yellow pigment available to poultry producers. In comparison to xanthophylls from plants, C-30 ester provides three times more coloring potential in yolks and 1.5 times better coloration when applied in poultry skin pigmentation applications. C-30 ester is metabolically active as a vitamin A precursor.

Areas of application
Feed supplement which intensifies the pigmentation of egg yolk and broiler skin.

Note
C-30 ester has a vitamin A activity which can be at most 420 I.U./mg, depending on the vitamin A content.
**Lucantin® Yellow**

**Active ingredient**
C-30 ester dry powder 10%  
β-apo-8’-carotenoic acid ethyl ester

**PRD-No.**
30041147 stabilized with ethoxyquin

**Articles**
- 50073640  5 kg film, aluminium laminate
- 55619192  25 kg box, corrugated cardboard

**Specification**
Content at least 10% (spectrophotometrically, calculated using $E_1^1 = 2450$ at 449 nm in cyclohexane/acetone)


**Other chemical and physical data**
- Loss on drying at most 5%
- Formulation powder
- Particle size at least 95% < 0.63 mm
- Bulk density about 0.6 g/cm³
- Composition spray formulation based on gelatine, mono- and poly-saccharides
- Solubility swells slowly in cold water more rapidly in warm water (40 °C) and finally disintegrates with the formation of a dispersion

**Stability**
The product should be stored cool (below 20 °C) and dry in unopened original packaging. Carefully close the packaging after partial amounts have been removed. In unopened original packaging, the product can be kept for 18 months.

**Dosage recommendations**
Please refer to “Carotenoids.”

**Note**
The active substance β-apo-8’-carotenoic acid ethyl ester is present in Lucantin Yellow in a biologically highly active form. The processing of this product should therefore be carried out with the customary care in terms of occupational hygiene following the instructions in the safety data sheet.
Enzymes
<table>
<thead>
<tr>
<th>Enzymes</th>
<th>71</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phytase Natuphos</td>
<td>72</td>
</tr>
<tr>
<td>Natuphos 5000</td>
<td>79</td>
</tr>
<tr>
<td>Natuphos 5000 G</td>
<td>80</td>
</tr>
<tr>
<td>Natuphos 5000 G (EU)</td>
<td>81</td>
</tr>
<tr>
<td>Natuphos 5000 L</td>
<td>82</td>
</tr>
<tr>
<td>Natuphos 10000 G</td>
<td>83</td>
</tr>
<tr>
<td>Natuphos 10000 G (EU)</td>
<td>84</td>
</tr>
<tr>
<td>Natuphos 10000 L</td>
<td>85</td>
</tr>
<tr>
<td>Natuphos 10000 L (EU)</td>
<td>86</td>
</tr>
<tr>
<td>Natuphos Combi TS L</td>
<td>87</td>
</tr>
<tr>
<td>NSP-hydrolyzing enzymes Natugrain</td>
<td>89</td>
</tr>
<tr>
<td>Natugrain Wheat TS</td>
<td>92</td>
</tr>
<tr>
<td>Natugrain Wheat TS L</td>
<td>93</td>
</tr>
<tr>
<td>Natugrain TS</td>
<td>94</td>
</tr>
<tr>
<td>Natugrain TS L</td>
<td>95</td>
</tr>
</tbody>
</table>
Enzymes

Use of enzymes in animal nutrition
Only recently have enzymes been used in animal nutrition, predominantly for monogastric animals, such as pigs and poultry. When administered in the feed, enzymes generally catalyze chemical reactions in the gastrointestinal tract, which lead to degradation of the feed ingredients. The name of an enzyme generally consists of the name of the substrate that is cleaved under the influence of the enzyme, to which the ending “-ase” has been added.

Enzymes and enzyme complexes obtained by fermentation are primarily used for the following purposes:

• Increase the availability/convertibility of feed ingredients (e.g., phytase for cleaving phytate and make phytate-bound phosphorus available).
• Degrade or destroy antinutritive substances (e.g., degradation of arabinoxylans in wheat by the use of β-xylanase).

Since enzymes are complex protein compounds with lower hydrothermal stability than other additives, mild methods are used preferentially during processing of mixed feeds and mineral feeds.

When processing the feed at high temperature, the use of a liquid enzyme product should be considered. The liquid enzyme product should then be sprayed on to the cooled, sieved pellets, using an appropriate application system. In the animal, enzymes are primarily responsible for better conversion of minerals (e.g., by using phytase) or nutrients (e.g., by using NSP-hydrolyzing enzymes). This, in turn, generally results in a reduction of the nutrients excreted in the manure. This improvement in nutrient utilization, with the associated reduction in environmental burden, embraces the concept of “responsible farming,” in accordance with recent increases in public eco-awareness.
Phytase
Natuphos®

Occurrence of phytase
Phytase occurs in many vegetable feeds, e.g., soy, corn, wheat, rye, and barley. Various microorganisms (fungi, yeasts, bacteria), such as the rumen microbes in ruminants, are also capable of producing phytases. Extremely low phytate-cleaving enzyme activities are also detectable in the gastric and intestinal mucous membranes.

Importance of phytase for animal nutrition
In the seeds of various vegetable feeds (cereals, oil seeds, etc.), approximately two thirds of the phosphorus present is in the form of phytate phosphorus. This compound is considered to be the main form in which phosphorus is stored in seeds. In addition to phosphorus, other bivalent cations, such as calcium, magnesium, iron, and zinc, plus proteins or amino acids, are also attached to phytate. Figure 1 shows a possible structure of phytate and the nutrients attached to it. Monogastric animals, such as poultry and pigs, are able to utilize phytate phosphorus only to a small extent or not at all because little or no “naturally occurring” phytase enzyme is present in their digestive tracts.

Depending on the vegetable feed and other factors, the digestibility of phosphorus in pigs varies between 18% (e.g., corn) and 40% (e.g., wheat, soy). The major part of this phosphorus fraction is thus excreted unused in the feces.

Fig. 1: Possible interactions of phytic acid with protein, minerals and starch.

Natuphos
With the additional use of Natuphos, the digestion and utilization of the total phosphorus contained in vegetable feeds can be substantially increased. Consequently, more phosphorus is available for absorption in the small intestine of monogastric animals. Thus, less mineral phosphorus must be added to the feed to cover the animal’s phosphorus requirement. The usual level of supplements of inorganic phosphorus added to the feed can be reduced substantially without adversely affecting the output or skeletal mineralization of the animals.

In pigs and poultry, the use of Natuphos thus reduces the phosphorus excretion with the manure by about 30%, both directly via the higher utilization of the vegetable phosphorus and indirectly via the consequent decrease in the level of inorganic phosphorus supplements. The release of phosphorus into soils and through leaching into surface water (eutrophication) is therefore significantly reduced by the use of Natuphos.
Natuphos also improves the digestibility of calcium, magnesium, and trace elements. An increasing number of studies have shown that Natuphos not only improves the digestibility of crude protein and amino acids but also increases the energy value of the feed. Concurrent to the reduction in mineral phosphorus supplement, quantities of calcium, protein, or synthetic amino acids can also be decreased.

**Biological action of Natuphos**

The optimum pH for phytate cleavage by vegetable phytase is approximately 5. In contrast, Natuphos phytase has a broad pH optimum that ranges from a pH of 2 to one of 6.5. Natuphos can thus cleave substantial quantities of phytic acid even in the acidic part of the stomach (fundus) as well as in the small intestine.

**Effects in poultry**

A large number of dose-response trials with broilers and laying hens have shown that the addition of Natuphos has a positive influence on performance, as well as on the utilization of phosphorus and calcium. Figure 2 illustrates an experiment with broilers in which either the phosphorus content was increased from 4.5 g/kg to 7.5 g/kg by addition of inorganic phosphorus, or the basal diet of 4.5 gP/kg was supplemented with Natuphos at 5 levels (250, 500, 750, 1,000, and 1,500 FTU/kg). The use of mineral phosphorus resulted in available phosphorus levels of below 50%. The use of Natuphos increased phosphorus availability in the basal diet up to 64% (Fig. 2).

In addition to the fact that phosphorus from phytate is poorly digested by monogastric animals, phytate is also able to bind cations, proteins, and amino acids, which also makes it more difficult for the animal to digest these nutrients. This is an additional aspect of the antinutritional properties of phytate. In experiments with broilers the influence of Natuphos on the digestibility of nitrogen and the individual amino acids was tested. Supplementing a wheat/sorghum/soy diet with 400 FTU Natuphos/kg increased the ileal digestibility of nitrogen and several amino acids by more than 2% (Fig. 3).

---

**Fig. 2: Effect of supplementation of Natuphos and inorganic phosphorus on the P-availability in broilers (Simons et al., 1990).**

![Figure 2](image-url)
Fig. 3: Influence of Natuphos on the digestibility of amino acids (Ravindran et al., 1997).

Differences in the efficiency of Natuphos are rarely seen, since most diets contain similar levels of phytate. In the case of significantly higher levels of phytate in the diet (e.g., when using rice bran), the efficiency may be increased.

Effects in pigs

Positive effects on the utilization of phosphorus, calcium, trace elements, and protein can also be shown for piglets and fattening pigs. In an experiment with piglets, the basal diet (4.2 g tP, 2.3 g phytin P) was supplemented with either 125, 250, 500, and 1,000 FTU Natuphos, or with 0.4, 0.8, and 1.2 g P from MCP. P-retention was two and a half times higher after supplementing with 1,000 FTU Natuphos. This was greater than the retention achieved using a supplement of 1.2 g P from MCP (Fig. 4).

In a further trial, a pig corn/soy diet was supplemented with 280, 500, 750 FTU Natuphos per kg feed during post weaning, growing, and fattening. ADG and FCR stayed at the same level when total phosphorus (tP) was lowered by reduction of DCP, but the Natuphos level was increased (Fig. 5). In addition, it was clearly shown that the inclusion of Natuphos in the diet lowers P and Zn excretion (Fig. 6), and thus, not only has a positive impact on the environment, but also allows reduction of the level of these elements in the feed formula accordingly.

Natuphos in practical applications

On the basis of large numbers of experiments, Natuphos can now be incorporated in linear optimization as a feed ingredient. Thus, it is possible to save the quantities of nutrients (P, Ca, amino acids, energy), which Natuphos liberates from the phytate complex. If broiler feed is supplemented with 500 FTU/kg, it is possible, e.g., to reduce DCP supplementation by 6.4 kg/metric ton of feed. Apart from the ecological benefits, the use of Natuphos provides significant economical advantages in the preparation of mixed feeds. This data is available in the following section “Dosage recommendations and matrix values.”
Fig. 5: *Effect of Natuphos on pig performance (Gaudré et al 2006).*

<table>
<thead>
<tr>
<th></th>
<th>tP (g/kg)</th>
<th>DCP added (kg/t)</th>
<th>Ca</th>
<th>Natuphos (FTU/kg feed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>7.2</td>
<td>21</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>6.1</td>
<td>14.5</td>
<td>9</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>5.8</td>
<td>12.8</td>
<td>8.8</td>
<td>750</td>
</tr>
<tr>
<td>P2</td>
<td>5.7</td>
<td>12.9</td>
<td>7.3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>4.8</td>
<td>8</td>
<td>6.7</td>
<td>280</td>
</tr>
<tr>
<td></td>
<td>4.5</td>
<td>6.3</td>
<td>6.3</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>4.2</td>
<td>4.5</td>
<td>6</td>
<td>750</td>
</tr>
<tr>
<td>P3</td>
<td>4.9</td>
<td>9</td>
<td>5.8</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>4.1</td>
<td>5.3</td>
<td>280</td>
</tr>
<tr>
<td></td>
<td>3.7</td>
<td>2.4</td>
<td>4.8</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>3.4</td>
<td>0.7</td>
<td>4.5</td>
<td>750</td>
</tr>
</tbody>
</table>

Fig. 6: *Effect of Natuphos on P and Zn excretion in pigs from 12 to 110 kg body weight (Gaudré et al. 2006).*
Dosage recommendations and matrix values

It is recommended to include the matrix values as indicated in Tab. 1a/b/c/d up to the following levels in linear programming. The efficacy of Natuphos is documented by an extended number of scientific experiments. The following equivalences have been proven:

**Pigs:**

- 1,000 FTU = 1.20 g dig. P = 1.50 g P (from MCP) = 1.73 g P (from DCP)
- 500 FTU = 0.80 g dig. P = 1.00 g P (from MCP) = 1.15 g P (from DCP)

**Broilers, turkeys, ducks:**

- 1,000 FTU = 1.04 g dig. P = 1.30 g P (from MCP) = 1.50 g P (from DCP)
- 500 FTU = 0.80 g dig. P = 1.00 g P (from MCP) = 1.15 g P (from DCP)

**Laying hens:**

- 600 FTU = 1.04 g dig. P = 1.30 g P (from MCP) = 1.50 g P (from DCP)
- 300 FTU = 0.80 g dig. P = 1.00 g P (from MCP) = 1.15 g P (from DCP)

500 FTU/kg = 100 g Natuphos 5000 per metric ton of feed/ 50 g Natuphos 10000 per metric ton of feed

1,000 FTU/kg = 200 g Natuphos 5000 per metric ton of feed/100 g Natuphos 10000 per metric ton of feed

Tab. 1a: Standard matrix values for least-cost formulation of pig and poultry feed for all Natuphos types containing 5,000 FTU/g
**Tab. 1b: Standard matrix values for least-cost formulation of pig and poultry feed for all Natuphos types containing 10,000 FTU/g**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Pigs</th>
<th>Broilers, turkeys, and ducks</th>
<th>Laying hens</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Up to 500 FTU/kg of feed one kg of Natuphos 10,000 is equivalent to</td>
<td>Up to 500 FTU/kg of feed one kg of Natuphos 10,000 is equivalent to</td>
<td>Up to 300 FTU/kg of feed one kg of Natuphos 10,000 is equivalent to</td>
</tr>
<tr>
<td>Total phosphorus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>From DCP (P 70% digestible)</td>
<td>23,000 g</td>
<td>23,000 g</td>
<td>38,332 g</td>
</tr>
<tr>
<td>From MCP (P 80% digestible)</td>
<td>20,000 g</td>
<td>20,000 g</td>
<td>33,334 g</td>
</tr>
<tr>
<td>Calcium</td>
<td>20,000 g</td>
<td>20,000 g</td>
<td>33,334 g</td>
</tr>
<tr>
<td>Lysine*</td>
<td>1,600 g</td>
<td>2,400 g</td>
<td>2,400 g</td>
</tr>
<tr>
<td>Methionine*</td>
<td>500 g</td>
<td>200 g</td>
<td>200 g</td>
</tr>
<tr>
<td>Cysteine*</td>
<td>600 g</td>
<td>600 g</td>
<td>600 g</td>
</tr>
<tr>
<td>Threonine*</td>
<td>1,000 g</td>
<td>2,600 g</td>
<td>2,600 g</td>
</tr>
<tr>
<td>Tryptophane*</td>
<td>600 g</td>
<td>600 g</td>
<td>600 g</td>
</tr>
<tr>
<td>Isoleucine*</td>
<td>1,000 g</td>
<td>2,400 g</td>
<td>2,400 g</td>
</tr>
<tr>
<td>Crude protein*</td>
<td>40,000 g</td>
<td>45,000 g</td>
<td>45,000 g</td>
</tr>
<tr>
<td>ME (metabolizable energy)</td>
<td>800 MJ/190,000 kcal</td>
<td>4,430 MJ/1,060,000 kcal</td>
<td>4,430 MJ/1,060,000 kcal</td>
</tr>
</tbody>
</table>

* Apparent ileal digestibility
Tab. 1c: The extended matrix values for least-cost formulation of pig and poultry feed for all Natuphos types containing 5,000 FTU/g

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Pigs</th>
<th>Broilers, turkeys, and ducks</th>
<th>Laying hens</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>For a dosage above 500 FTU/kg of feed one kg of Natuphos 5,000 is equivalent to</td>
<td>For a dosage above 500 FTU/kg of feed one kg of Natuphos 5,000 is equivalent to</td>
<td>For a dosage above 300 FTU/kg of feed one kg of Natuphos 5,000 is equivalent to</td>
</tr>
<tr>
<td>Total phosphorus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>From DCP (P 70% digestible)</td>
<td>5,750 g</td>
<td>3,450 g</td>
<td>5,750 g</td>
</tr>
<tr>
<td>From MCP (P 80% digestible)</td>
<td>5,000 g</td>
<td>3,000 g</td>
<td>5,000 g</td>
</tr>
<tr>
<td>Calcium</td>
<td>5,000 g</td>
<td>3,000 g</td>
<td>5,000 g</td>
</tr>
<tr>
<td>Lysine*</td>
<td>400 g</td>
<td>360 g</td>
<td>360 g</td>
</tr>
<tr>
<td>Methionine*</td>
<td>125 g</td>
<td>30 g</td>
<td>30 g</td>
</tr>
<tr>
<td>Cysteine*</td>
<td>150 g</td>
<td>90 g</td>
<td>90 g</td>
</tr>
<tr>
<td>Threonine*</td>
<td>250 g</td>
<td>390 g</td>
<td>390 g</td>
</tr>
<tr>
<td>Tryptophane*</td>
<td>150 g</td>
<td>90 g</td>
<td>90 g</td>
</tr>
<tr>
<td>Isoleucine*</td>
<td>250 g</td>
<td>360 g</td>
<td>360 g</td>
</tr>
<tr>
<td>Crude protein*</td>
<td>10,000 g</td>
<td>6,750 g</td>
<td>6,750 g</td>
</tr>
<tr>
<td>ME (metabolizable energy)</td>
<td>200 MJ/47,250 kcal**</td>
<td>665 MJ/159,000 kcal</td>
<td>665 MJ/159,000 kcal</td>
</tr>
</tbody>
</table>

Tab. 1d: The extended matrix values for least-cost formulation of pig and poultry feed for all Natuphos types containing 10,000 FTU/g

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Pigs</th>
<th>Broilers, turkeys, and ducks</th>
<th>Laying hens</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>For a dosage above 500 FTU/kg of feed one kg of Natuphos 10,000 is equivalent to</td>
<td>For a dosage above 500 FTU/kg of feed one kg of Natuphos 10,000 is equivalent to</td>
<td>For a dosage above 300 FTU/kg of feed one kg of Natuphos 10,000 is equivalent to</td>
</tr>
<tr>
<td>Total phosphorus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>From DCP (P 70% digestible)</td>
<td>11,500 g</td>
<td>6,900 g</td>
<td>11,500 g</td>
</tr>
<tr>
<td>From MCP (P 80% digestible)</td>
<td>10,000 g</td>
<td>6,000 g</td>
<td>10,000 g</td>
</tr>
<tr>
<td>Calcium</td>
<td>10,000 g</td>
<td>6,000 g</td>
<td>10,000 g</td>
</tr>
<tr>
<td>Lysine*</td>
<td>800 g</td>
<td>720 g</td>
<td>720 g</td>
</tr>
<tr>
<td>Methionine*</td>
<td>250 g</td>
<td>60 g</td>
<td>60 g</td>
</tr>
<tr>
<td>Cysteine*</td>
<td>300 g</td>
<td>180 g</td>
<td>180 g</td>
</tr>
<tr>
<td>Threonine*</td>
<td>500 g</td>
<td>780 g</td>
<td>780 g</td>
</tr>
<tr>
<td>Tryptophane*</td>
<td>300 g</td>
<td>180 g</td>
<td>180 g</td>
</tr>
<tr>
<td>Isoleucine*</td>
<td>500 g</td>
<td>720 g</td>
<td>720 g</td>
</tr>
<tr>
<td>Crude protein*</td>
<td>20,000 g</td>
<td>13,500 g</td>
<td>135,000 g</td>
</tr>
<tr>
<td>ME (metabolizable energy)</td>
<td>400 MJ/95,000 kcal**</td>
<td>1,330 MJ/318,000 kcal</td>
<td>159,000 MJ/318,000 kcal</td>
</tr>
</tbody>
</table>

* Apparent ileal digestibility
** Based on crude protein, calculated using the formula of the German Society for Nutritional Physiology (1987)
Natuphos® 5000

Active ingredient
Myo-inositol-hexakisphosphate β-phosphohydrolase (EC 3.1.3.8), produced by Aspergillus niger

PRD-No.
30041116

Articles
52481119 20 kg cardboard box
52481596 350 kg big bag

Specification
Content at least 5,000 FTU/g (Phytase activity)


Application
The use of Natuphos 5000 is recommended for non-pelleted compound feed and at pelleting temperatures below 75 °C.

Definition of activity
One unit of phytase activity (FTU) is defined as the amount of enzyme which liberates 1 micromole of inorganic phosphorus per minute from a solution of 0.0051 mol/l sodium phytate at pH 5.5 and 37 °C.

Dosage recommendation
Please refer to “Enzymes — Phytase Natuphos.”

Other chemical and physical data
Formulation powder
Bulk density approx 0.35 g/cm³

This product has excellent flow properties and is free of dust.

Stability
Under correct storage conditions (below room temperature, 20 °C, dry), the declared content in closed original packaging is guaranteed for 12 months after date of manufacturing.
Natuphos® 5000 G

Active ingredient
Myo-inositol-hexakisphosphate
β-phosphohydrolase (EC 3.1.3.8), produced by
Aspergillus niger

PRD-No.
30060577

Articles
50092561 20 kg cardboard box

Specification
Content at least 5,000 FTU/g
(Phytase activity)

Application
The use of Natuphos 5000 G is recommended for
pelleted feed, especially if pelleting temperature
is below 85 °C and for use in premix.

Definition of activity
One unit of phytase activity (FTU) is defined as the
amount of enzyme which liberates 1 micromole of
inorganic phosphorus per minute from a solution
of 0.0051 mol/l sodium phytate at pH 5.5 and
37 °C.

Dosage recommendation
Please refer to “Enzymes — Phytase Natuphos.”

Other chemical and physical data
Formulation granulate
Bulk density approx. 0.70 g/cm³

This product has excellent flow properties and is
free of dust.

Stability
Under correct storage conditions (below room
temperature, 20 °C, dry), the declared content
in closed original packaging is guaranteed for
15 months after date of manufacturing.
Natuphos® 5000 G (EU)

**Active ingredient**
Myo-inositol-hexakisphosphate β-phosphohydrolase (EC 3.1.3.8), produced by Aspergillus niger

**PRD-No.**
30077741

**Articles**
<table>
<thead>
<tr>
<th>Article</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>52481702</td>
<td>20 kg paper bag</td>
</tr>
<tr>
<td>52481755</td>
<td>350 kg big bag</td>
</tr>
</tbody>
</table>

**Specification**
Content at least 5,000 FTU/g (Phytase activity)


**Other chemical and physical data**
Formulation granulate
Bulk density approx. 0.70 g/cm³

This product has excellent flow properties and is free of dust.

**Stability**
Under correct storage conditions (below room temperature, 20 °C, dry), the declared content in closed original packaging is guaranteed for 15 months after date of manufacturing.

**Application**
The use of Natuphos 5000 G (EU) is recommended for pelleted feed, especially if pelleting temperature is below 85 °C and for use in premix.

**Definition of activity**
One unit of phytase activity (FTU) is defined as the amount of enzyme which liberates 1 micromole of inorganic phosphorus per minute from a solution of 0.0051 mol/l sodium phytate at pH 5.5 and 37 °C.

**Dosage recommendation**
Please refer to “Enzymes — Phytase Natuphos.”
Natuphos® 5000 L

Active ingredient
Myo-inositol-hexakisphosphate
β-phosphohydrolase (EC 3.1.3.8), produced by Aspergillus niger

PRD-No.
30041121

Articles
- 52481861  125 kg PE drum
- 52482232 1000 kg IBC

Specification
Content at least 5,000 FTU/g (Phytase activity)


Other chemical and physical data
Formulation liquid
Density approx. 1.15 – 1.25 g/cm³ (range 0 – 20 °C)
Viscosity approx. 30 mPa·s (at 0 °C)
approx. 12 mPa·s (at 20 °C)
approx. 10 mPa·s (at 25 °C)
Solubility infinitely miscible with water

Stability
Under correct storage conditions (below room temperature, 20 °C, dry), the declared content in closed original packaging is guaranteed for 12 months after date of manufacturing.

Application
The use of Natuphos 5000 L is recommended for pelleted feed, especially if pelleting temperature rises above 85 °C. Product must be sprayed on cooled and sieved pellets, using an appropriate application system.

Definition of activity
One unit of phytase activity (FTU) is defined as the amount of enzyme which liberates 1 micromole of inorganic phosphorus per minute from a solution of 0.0051 mol/l sodium phytate at pH 5.5 and 37 °C.

Dosage recommendation
Please refer to “Enzymes — Phytase Natuphos.”
Natuphos® 10000 G

Active ingredient
Myo-inositol-hexakisphosphate β-phosphohydrolase (EC 3.1.3.8), produced by Aspergillus niger

PRD-No.
30069924

Articles
50510363  20 kg cardboard box
55584583  350 kg big bag

Specification
Content at least 10,000 FTU/g
(Phytase activity)


Application
The use of Natuphos 10000 G is recommended for pelleted feed, especially if pelleting temperature is below 85 °C and for use in premix.

Definition of activity
One unit of phytase activity (FTU) is defined as the amount of enzyme which liberates 1 micromole of inorganic phosphorus per minute from a solution of 0.0051 mol/l sodium phytate at pH 5.5 and 37 °C.

Dosage recommendation
Please refer to “Enzymes — Phytase Natuphos.”

Other chemical and physical data
Formulation granulate
Bulk density 0.75 g/cm³

This product has excellent flow properties and is free of dust.

Stability
Under correct storage conditions (below room temperature, 20 °C, dry), the declared content in closed original packaging is guaranteed for 15 months after date of manufacturing.
Natuphos® 10000 G (EU)

Active ingredient
Myo-inositol-hexakisphosphate β-phosphohydrolase (EC 3.1.3.8), produced by Aspergillus niger

PRD-No.
30337528

Articles
<table>
<thead>
<tr>
<th>Article Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>53232129</td>
<td>20 kg paper bag</td>
</tr>
<tr>
<td>56780265</td>
<td>350 kg big bag</td>
</tr>
</tbody>
</table>

Specification

| Content | at least 10,000 FTU/g (Phytase activity) |


Other chemical and physical data

<table>
<thead>
<tr>
<th>Formulation</th>
<th>granulate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk density</td>
<td>0.75 g/cm³</td>
</tr>
</tbody>
</table>

This product has excellent flow properties and is free of dust.

Stability
Under correct storage conditions (below room temperature, 20 °C, dry), the declared content in closed original packaging is guaranteed for 15 months after date of manufacturing.

Application
The use of Natuphos 10000 G (EU) is recommended for pelleted feed, especially if pelleting temperature is below 85 °C and for use in premix.

Definition of activity
One unit of phytase activity (FTU) is defined as the amount of enzyme which liberates 1 micromole of inorganic phosphorus per minute from a solution of 0.0051 mol/l sodium phytate at pH 5.5 and 37 °C.

Dosage recommendation
Please refer to “Enzymes — Phytase Natuphos.”
Natuphos® 10000 L

**Active ingredient**
Myo-inositol-hexakisphosphate
β-phosphohydrolase (EC 3.1.3.8), produced by *Aspergillus niger*

**PRD-No.**
30172646

**Articles**
- 51161416  125 kg PE drum
- 51709595  500 kg IBC

**Specification**

| Content | at least 10,000 FTU/g (Phytase activity) |


**Other chemical and physical data**

| Formulation | liquid |
| Density | 1.18 – 1.23 g/cm³ (range 0 – 20 °C) |
| Viscosity | approx. 80 mPa·s (at 0 °C)
approx. 25 mPa·s (at 20 °C)
approx. 20 mPa·s (at 25 °C) |
| Solubility | infinitely miscible with water |

**Stability**
Under correct storage conditions (below room temperature, 20 °C, dry), the declared content in closed original packaging is guaranteed for 12 months after date of manufacturing.

**Application**
The use of Natuphos 10000 L is recommended for pelleted feed, especially if pelleting temperature rises above 85 °C. Product must be sprayed on cooled and sieved pellets, using an appropriate application system.

**Definition of activity**
One unit of phytase activity (FTU) is defined as the amount of enzyme which liberates 1 micromole of inorganic phosphorus per minute from a solution of 0.0051 mol/l sodium phytate at pH 5.5 and 37 °C.

**Dosage recommendation**
Please refer to “Enzymes — Phytase Natuphos.”
Natuphos® 10000 L (EU)

Active ingredient
Myo-inositol-hexakisphosphate \(\beta\)-phosphohydrolase (EC 3.1.3.8), produced by Aspergillus niger

PRD-No.
30337547

Articles
<table>
<thead>
<tr>
<th>Article Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>56785724</td>
<td>125 kg PE drum</td>
</tr>
<tr>
<td>56785830</td>
<td>500 kg IBC</td>
</tr>
</tbody>
</table>

Specification
Content at least 10,000 FTU/g (Phytase activity)


Other chemical and physical data
Formulation liquid
Density 1.18 – 1.23 g/cm\(^3\) (range 0 – 20 °C)
Viscosity approx. 80 mPa·s (at 0 °C)
approx. 25 mPa·s (at 20 °C)
approx. 20 mPa·s (at 25 °C)
Solubility infinitely miscible with water

Stability
Under correct storage conditions (below room temperature, 20 °C, dry), the declared content in closed original packaging is guaranteed for 12 months after date of manufacturing.

Application
The use of Natuphos 10000 L (EU) is recommended for pelleted feed, especially if pelleting temperature rises above 85 °C. Product must be sprayed on cooled and sieved pellets, using an appropriate application system.

Definition of activity
One unit of phytase activity (FTU) is defined as the amount of enzyme which liberates 1 micromole of inorganic phosphorus per minute from a solution of 0.0051 mol/l sodium phytate at pH 5.5 and 37 °C.

Dosage recommendation
Please refer to “Enzymes — Phytase Natuphos.”
Active ingredients
Myo-inositol-hexakisphosphate
β-phosphohydrolase (EC 3.1.3.8), produced by Aspergillus niger
Endo-1,4-β-xylanase (EC 3.2.1.8), produced by Aspergillus niger

PRD-No.
30363075

Articles
50910516 1000 kg IBC

Specification
Content
- Phytase at least 5,000 FTU/g
- Xylanase at least 5,600 TXU/g


Other chemical and physical data
Formulation liquid
Density 1.16 – 1.20 g/cm³ (range 0 – 20 °C)
Viscosity approx. 44 mPa·s (at 0 °C)
approx. 16 mPa·s (at 20 °C)
approx. 13 mPa·s (at 25 °C)
Solubility infinitely miscible with water

Stability
Under correct storage conditions (below room temperature, 20 °C, dry), the declared content in closed original packaging is guaranteed for 12 months after date of manufacturing.

Application
The use of Natuphos Combi TS L is recommended for pelleted feed, especially if pelleting temperature rises above 85 °C. Product must be sprayed on cooled and sieved pellets, using an appropriate application system. Natuphos Combi TS L has been developed especially for cereal containing poultry diets. Due to the fact that both the phytase and the xylanase are mixed in the same product, only a liquid dosing system is required to dose two enzyme activities. Natuphos Combi TS L is also well suited for feed producers that are using cereals in their diets during only certain parts of the year. Natuphos Combi TS L can thus replace liquid phytase, using the same dosing equipment, as the dosage of Natuphos 5000 L and Natuphos Combi TS L is identical.

Definition of activity
One unit of phytase activity (FTU) is defined as the amount of enzyme which liberates 1 micromole of inorganic phosphorus per minute from a solution of 0.0051 mol/l sodium phytate at pH 5.5 and 37 °C. One thermostable endo-xylanase unit (TXU) is defined as the amount of enzyme which liberates 5 micromole reducing sugars, measured as xylose equivalents per minute from a buffer solution containing 1 g arabinoxylan per 100 ml at pH 3.5 and 40 °C.

Dosage recommendation
Please refer to “Enzymes — Phytase Natuphos” and “Enzymes — NSP-hydrolyzing enzymes Natugrain.”
Non-starch-polysaccharides
Non-starch-polysaccharides (NSPs) are cell-wall components, which are sometimes referred to as “dietary fiber”; they are part of all cereal feed ingredients. The content of NSP in different cereals varies greatly depending on type of cereal and the environment in which the cereal has grown. The NSP content ranges in cereals are shown in the following table (Tab. 1). The main group of NSPs in cereals is often, as a group, referred to as pentosans, and in cereals, a major part of the pentosans is (arabino-) xylan. Nevertheless, especially in rye and barley containing diets β-glucans also might have a significant negative impact on nutrient digestibility.

Tab. 1: Content of pentosans and β-glucans in different cereals

<table>
<thead>
<tr>
<th>Cereal</th>
<th>Pentosans</th>
<th>β-Glucans</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total (g/kg)</td>
<td>Soluble in water (g/kg)</td>
</tr>
<tr>
<td>Rye</td>
<td>58 – 122</td>
<td>19 – 27</td>
</tr>
<tr>
<td>Triticale</td>
<td>46 – 86</td>
<td>6 – 11</td>
</tr>
<tr>
<td>Wheat</td>
<td>54 – 83</td>
<td>8 – 14</td>
</tr>
<tr>
<td>Oat</td>
<td>37 – 80</td>
<td>8</td>
</tr>
<tr>
<td>Barley</td>
<td>31 – 77</td>
<td>5 – 10</td>
</tr>
<tr>
<td>Corn</td>
<td>43 – 68</td>
<td>4 – 6</td>
</tr>
</tbody>
</table>


NSPs are the indigestible substances of vegetable cell walls. Typically, they trap nutrients, thus making them unavailable for endogenous enzymes. They also increase the viscosity of the intestinal contents as a result of their physical and chemical properties. Higher viscosity of the digesta reduces the mixing of undigested nutrients and endogenous enzymes in the gastro-intestinal tract. This in turn reduces the efficacy of endogenous enzymes and definitely has a negative impact on nutrient digestibility. Higher viscosity also decreases the passage rate of the digesta, which is favorable for bacterial growth and can have negative effects on the health of the bird and its digestion process. Large quantities of NSPs in poultry feeds can also cause increased water intake and excretion of wet, sticky feces.

Benefit of use
The use of NSP-hydrolyzing enzymes in poultry diets provides a number of advantages:

- Improved feed conversion and faster weight gain are achieved due to increased nutrient utilization of feed (e.g., amino acid, Kluth et al. 2006/8, Fig. 1a).
- Reduced viscosity of intestinal contents and the improved condition of feces have a positive effect on litter quality and the hygienic conditions in the production unit (Fig. 1b).
- Lowered water consumption.
- In laying hens, the quantity of dirty eggs decreases.
- The use of enzymes balances out variations in the nutritional value between different types of cereals used.
- The producer of compound feed has more flexibility in the linear optimization of poultry feed rations since there is the option of feeding larger quantities of cereals.
Recommendation for **Natugrain Wheat TS/Natugrain Wheat TS L** in broiler is 280 TXU (minimum dosage) to 560 TXU (standard dosage) per kg of compound feed. This means 50 to 100 g Natugrain Wheat TS/Natugrain Wheat TS L per metric ton of compound feed. For turkeys and layers, a dosage rate of 560 FTU/kg of compound feed (100 g per metric ton) has been found to be the most effective dosage for an optimal use. The economical optimal dosage rate for your diet, however, varies depending on the wheat, corn, and — probably — rye content of the diet, and is influenced by the costs and quality (anti nutrition substances) of the raw material used. As a general guide line for wheat-based diets, the following dosage levels can be recommended:

<table>
<thead>
<tr>
<th>Wheat in the diet</th>
<th>Dosage (TXU/kg feed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 40%</td>
<td>280</td>
</tr>
<tr>
<td>40 – 50%</td>
<td>420</td>
</tr>
<tr>
<td>Over 50%</td>
<td>560</td>
</tr>
</tbody>
</table>
Dosage recommendations

Natugrain TS / Natugrain TS L is recommended for diets containing large quantities of non-starch-polysaccharides (NSP). This is usually the case when more than 30% of wheat, rye, barley, and/or triticale in used, but also improves the value of pure corn/soy diets.

The following is recommended per kg of complete feeding stuff:

**Piglet:**
\[
560 \text{ – } 840 \text{ TXU/250 – 375 TGU} \\
= 100 \text{ – } 150 \text{ g Natugrain TS/Natugrain TS L per metric ton of feed}
\]

**Broiler:**
\[
280 \text{ – } 840 \text{ TXU/125 – 375 TGU} \\
= 50 \text{ – } 150 \text{ g Natugrain TS/Natugrain TS L per metric ton of feed}
\]

**Layer:**
\[
560 \text{ – } 840 \text{ TXU/250 – 375 TGU} \\
= 100 \text{ – } 150 \text{ g Natugrain TS/Natugrain TS L per metric ton of feed}
\]

**Turkey:**
\[
560 \text{ – } 840 \text{ TXU/250 – 375 TGU} \\
= 100 \text{ – } 150 \text{ g Natugrain TS/Natugrain TS L per metric ton of feed}
\]

**Duck:**
\[
280 \text{ – } 840 \text{ TXU/125 – 375 TGU} \\
= 50 \text{ – } 150 \text{ g Natugrain TS/Natugrain TS L per metric ton of feed}
\]

The economically optimal dosage rate for your diet, however, varies depending on the wheat, rye, barley, triticale, and corn content of the diet, and is influenced by the costs and quality (anti-nutritive substances) of the raw materials used. As a general guideline, the following dosage levels can be recommended:

<table>
<thead>
<tr>
<th>Wheat/rye/barley/triticale in the diet</th>
<th>Dosage (TXU/TGU per kg feed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 40% (broiler/duck)</td>
<td>280/125</td>
</tr>
<tr>
<td>Up to 40% (piglet/layer/turkey)</td>
<td>560/250</td>
</tr>
<tr>
<td>40 – 60%</td>
<td>560/250</td>
</tr>
<tr>
<td>More than 60%</td>
<td>≥ 560/250</td>
</tr>
</tbody>
</table>
Natugrain® Wheat TS

**Active ingredient**
Endo-1,4-β-xylanase (EC 3.2.1.8), produced by *Aspergillus niger*

**PRD-No.**
30269735

**Articles**
- 52569309 20 kg cardboard box
- 52569415 350 kg big bag

**Specification**

<table>
<thead>
<tr>
<th>Content</th>
<th>at least 5,600 TXU*/g</th>
</tr>
</thead>
</table>

* TXU = Thermostable endo-xylanase unit


**Other chemical and physical data**

<table>
<thead>
<tr>
<th>Formulation</th>
<th>powder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk density</td>
<td>approx 0.35 g/cm³</td>
</tr>
</tbody>
</table>

This product has excellent flow properties and is free of dust.

**Stability**
Under correct storage conditions (below room temperature, 20 °C, dry), the declared content in closed original packaging is guaranteed for 12 months after date of manufacturing.

**Application**
Natugrain Wheat TS has been developed especially for poultry feed mixtures containing a high content of wheat and wheat by-products, such as wheat bran, to achieve improved bird performance through high biological effectiveness. Improvements can also be expected in rye containing diets. The use of Natugrain Wheat TS is recommended for non-pelleted compound feed, pelleted compound feed up to temperatures at 85 °C, and for use in premix. Certain losses of activity due to choline chloride or trace elements might occur in exceptional cases.

**Definition of activity**
One thermostable endo-xylanase unit (TXU) is defined as the amount of enzyme which liberates 5 micromole reducing sugars, measured as xylase equivalents per minute from a buffer solution containing 1 g arabinomylan per 100 ml at pH 3.5 and 40 °C.

**Dosage recommendation**
Please refer to “Enzymes — NSP-hydrolyzing enzymes Natugrain.”
Natugrain® Wheat TS L

Active ingredient
Endo-1,4-β-xylanase (EC 3.2.1.8), produced by Aspergillus niger

PRD-No.
30270056

Articles
<table>
<thead>
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<th>Article No.</th>
<th>Description</th>
<th>Quantity</th>
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<tr>
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</tr>
<tr>
<td>52290582</td>
<td>1000 kg IBC</td>
<td></td>
</tr>
</tbody>
</table>

Specification
Content at least 5,600 TXU*/g

* TXU = Thermostable endo-xylanase unit


Other chemical and physical data

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>approx 1.16 – 1.2 g/ml (range 0 – 20 °C)</td>
</tr>
<tr>
<td>Viscosity</td>
<td>21.7 mPa·s (0 °C)</td>
</tr>
<tr>
<td></td>
<td>9.4 mPa·s (15 °C)</td>
</tr>
<tr>
<td></td>
<td>8.4 mPa·s (20 °C)</td>
</tr>
<tr>
<td></td>
<td>6.5 mPa·s (25 °C)</td>
</tr>
</tbody>
</table>

Stability
Under correct storage conditions (below room temperature, 20 °C, dry), the declared content in closed original packaging is guaranteed for 12 months after date of manufacturing.

Application
Natugrain Wheat TS L has been developed especially for poultry feed mixtures containing a high content of wheat and wheat by-products, such as wheat bran, to achieve improved bird performance through high biological effectiveness. Improvements can also be expected in rye containing diets. The use of Natugrain Wheat TS L is recommended for pelleted compound feed manufactured at temperatures of 85 °C and more. Product must be sprayed on cooled and sieved pellets, using an appropriate application system.

Definition of activity
One thermostable endo-xylanase unit (TXU) is defined as the amount of enzyme which liberates 5 micromole reducing sugars, measured as xylase equivalents per minute from a buffer solution containing 1 g arabinoxylan per 100 ml at pH 3.5 and 40 °C.

Dosage recommendation
Please refer to “Enzymes — NSP-hydrolyzing enzymes Natugrain.”
Natugrain® TS

Active ingredients
Endo-1,4-β-xylanase (EC 3.2.1.8), produced by Aspergillus niger
Endo-1,4-β-glucanase (EC 3.2.1.4), produced by Aspergillus niger

PRD-No.
30285907

Articles
53688722  20 kg cardboard box
53688775  350 kg big bag

Specification
Content  at least 5,600 TXU*/g
         at least 2,500 TGU*/g
* TXU = Thermostable endo-xylanase unit
* TGU = Thermostable endo-glucanase unit


Other chemical and physical data
Formulation  powder
Bulk density  approx. 0.35 g/cm³

This product has excellent flow properties and is free of dust.

Stability
Under correct storage conditions (below room temperature, 20 °C, dry), the declared content in closed original packaging is guaranteed for 12 months after date of manufacturing.

Application
Natugrain TS has been developed especially for feed mixtures containing a high content of wheat, rye, and barley, to achieve improved bird and pig performance through high biological effectiveness.

The use of Natugrain TS is recommended for non-pelleted compound feed, pelleted compound feed up to temperatures at 85 °C, and for use in premix. Certain losses of activity due to choline chloride or trace elements might occur in exceptional cases.

Definition of activity
One thermostable endo-xylanase unit (TXU) is defined as the amount of enzyme which liberates 5 micromole reducing sugars, measured as xylanase equivalents per minute from a buffer solution containing 1 g arabinoxylan per 100 ml at pH 3.5 and 40 °C.
One thermostable endo-glucanase unit (TGU) is defined as the amount of enzyme which liberates 1 micromole reducing sugars, measured as glucose equivalents per minute from a buffer solution containing 0.714 g beta-glucan per 100 ml at pH 3.5 and 40 °C.

Dosage recommendation
Please refer to “Enzymes — NSP-hydrolyzing enzymes Natugrain.”
**Natugrain® TS L**

**Active ingredients**
Endo-1,4-β-xylanase (EC 3.2.1.8), produced by *Aspergillus niger*
Endo-1,4-β-glucanase (EC 3.2.1.4), produced by *Aspergillus niger*

**PRD-No.**
30285884

**Article**
53686496 1000 kg IBC

**Specification**
Content
- at least 5,600 TXU*/g
- at least 2,500 TGU*/g

* TXU = Thermostable endo-xylanase unit
* TGU = Thermostable endo-glucanase unit


**Other chemical and physical data**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formulation</td>
<td>liquid</td>
</tr>
<tr>
<td>Density</td>
<td>approx 1.13 – 1.17 g/ml (range 0 – 20 °C)</td>
</tr>
<tr>
<td>Viscosity</td>
<td>22.3 mPa·s (0 °C)</td>
</tr>
<tr>
<td></td>
<td>10.6 mPa·s (15 °C)</td>
</tr>
<tr>
<td></td>
<td>8.6 mPa·s (20 °C)</td>
</tr>
<tr>
<td></td>
<td>7.1 mPa·s (25 °C)</td>
</tr>
</tbody>
</table>

**Stability**
Under correct storage conditions (below room temperature, 20 °C, dry), the declared content in closed original packaging is guaranteed for 12 months after date of manufacturing.

**Application**
Natugrain TS L has been developed especially for feed mixtures containing a high content of wheat, rye, barley, and corn, to achieve improved bird and pig performance through high biological effectiveness.
The use of Natugrain TS L is recommended for pellet compound feed manufactured of temperatures of 85 °C and more. Product must be sprayed on cooled and sieved pellet, using an appropriate application system.

**Definition of activity**
One thermostable endo-xylanase unit (TXU) is defined as the amount of enzyme which liberates 5 micromole reducing sugars, measured as xylase equivalents per minute from a buffer solution containing 1 g arabinoxylan per 100 ml at pH 3.5 and 40 °C.
One thermostable endo-glucanase unit (TGU) is defined as the amount of enzyme which liberates 1 micromole reducing sugars, measured as glucose equivalents per minute from a buffer solution containing 0.714 g beta-glucan per 100 ml at pH 3.5 and 40 °C.

**Dosage recommendation**
Please refer to “Enzymes — NSP-hydrolyzing enzymes Natugrain.”
Organic acids
<table>
<thead>
<tr>
<th>Product Type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic acids</td>
<td>99</td>
</tr>
<tr>
<td>Formic acid</td>
<td>100</td>
</tr>
<tr>
<td>Amasil 99</td>
<td>102</td>
</tr>
<tr>
<td>Amasil 85</td>
<td>103</td>
</tr>
<tr>
<td>Amasil NA</td>
<td>104</td>
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<tr>
<td>Propionic acid</td>
<td>105</td>
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<tr>
<td>Luprosil</td>
<td>108</td>
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<tr>
<td>Lupro-Grain</td>
<td>109</td>
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<tr>
<td>Luprosil NC</td>
<td>110</td>
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<td>Acid mixtures</td>
<td>111</td>
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<tr>
<td>Lupro-Cid</td>
<td>113</td>
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<tr>
<td>Lupro-Mix</td>
<td>114</td>
</tr>
<tr>
<td>Lupro-Cid NA</td>
<td>115</td>
</tr>
<tr>
<td>Lupro-Mix NC</td>
<td>116</td>
</tr>
</tbody>
</table>
Organic acids

The name organic acids is used for all acids whose structures are based on a carbon framework. They are also referred to as “carboxylic acids.” The carboxylic acids include formic acid (derived from methane) and propionic acid (derived from propane). These acids occur naturally and are completely metabolizable. Their energy content can therefore be included in the estimated energy content of a compound feed. This energy content is not negligible, especially with high propionic acid contents.

Propionic and formic acids are used in animal nutrition in particular for preserving and ensiling feedstuffs. In addition, in some situations, there may be certain nutritive effects. The acids act by intervening specifically in the metabolism of the microorganisms involved in spoilage. In addition, the reduction in the pH creates an environment, which is unfavorable for microorganisms.

These feed additives thus also have a beneficial effect on digestion of nutrients in non-ruminants as a result of their prevention of diarrhea, especially in young stock.

Propionic acid is particularly appropriate for preserving compound feed and raw components based on its pronounced anti-mold effect. Formic acid is a stronger acid and has a very good inhibition effect on bacteria and yeasts. Both acids can be used very effectively for controlling salmonellae in raw ingredients or in compound feed. Furthermore, mixtures of propionic and formic acid show additive effects, i.e., an appropriate combination of propionic and formic acids will provide the optimal solution to specific applications in feed preservation.

Our organic acid portfolio comprises a full range of pure formic and propionic acids and different mixtures of them. For all acid products, a non-corrosive (irritant) alternative product is available.

Packaging/shelf-life
Organic acids should be stored in well ventilated areas. In the case of leakage, neutralize products which have leaked with lime or soda. For organic acids and their mixtures, the respective legal storage requirements are to be observed.
Formic acid and its derivatives play an important part in transferring C1 units in intermediary metabolism. After intake of formic acid, a small proportion is excreted unchanged with the urine. The remaining much larger part of the formic acid enters into intermediary metabolism. Formic acid is readily absorbed by the body. Absorption through the skin and mucous membranes is also possible. Traces of formic acid are generated during fermentation in the rumen.

**Effect on microorganisms**
The effect of formic acid, in particular on bacteria, derives from its action in lowering the pH and from a bactericidal effect of the formate anion. Formate has a protein denaturing action. Lactic acid bacteria and molds are relatively resistant to formic acid.

**Applications**
1. **In vivo acidification:**
   Use of formic acid in young stock results in a reduction of the gut pH. This primarily reduces the number of coliform organisms in the feed and thus decreases the stock’s microbial intake via feed. The pH reduction facilitates the acidification of the feed in the pig’s stomach. The anion of the acid has a bactericidal and bacteriostatic effect in the digestive tract, resulting in a reduction in nutrient losses due to reduced risk of digestive disorders and diarrhea.
2. **Acidification of milk and dairy products:**
   Formic acid is appropriate for acidifying milk replacers, milk, skim milk, and whey. This makes it possible to stabilize these products for longer periods.
3. **As silage additive:**
   Formic acid is especially appropriate for ensiling of materials which are difficult to ensile, in particular wet and protein-rich crops. The rapid reduction in the pH inhibits the growth of bacteria producing butyric acid and ammonia, and promotes the growth of lactobacilli.

Lactic acid causes the low pH required for storage. The silage stabilized in this manner acquires the typical lactic acid odor and is very well accepted by the animals.

**Non-corrosive alternative to formic acid**
Amasil® NA is a buffered formic acid and specifically developed for agricultural use. The product is non-caustic and labeled as irritant although its formic acid content is very similar to pure formic acid (Amasil 85).

**Recommended materials**
Amasil is corrosive. Only corrosion-resistant materials must be used for storage and transport. Suitable materials are:
- Austenitic chromium/nickel/molybdenum steels, such as materials nos.: 1.4439, 1.4539, 1.4435, 1.4404
- Up to 40 °C, the austenitic chromium/nickel/molybdenum steel, material no.: 1.4571
- Nickel-based alloys, such as NiMo 16Cr16Ti, material no.: 2.4610
- Teflon C (PTFE)

Resistant to 60 °C – polyethylene
Resistant to 40 °C – polypropylene
Resistant to 20 °C – stainless steel (V2A) – PVC

Unsuitable materials are:
- Non-ferrous metals
- Galvanized steels
- Unalloyed steels

Where different metallic materials are present in combination, there may also be electrochemical corrosion on other parts of the system.
Precautionary measures when handling
Amasil causes burns. The vapors irritate the eyes and respiratory tract. Contact with eyes and skin must be strictly avoided because formic acid is absorbed through the skin and may cause serious damage to skin and bones. Vapors and mists must not be inhaled. The LD_{50} of formic acid on oral administration is 1.1 g/kg of bodyweight for mice and about 1.2 g/kg for rats.

When handling the product, acid-resistant gloves and tightly-fitting goggles must be worn. If appropriate, breathing equipment that is independent of the ambient air should be worn. If the product comes in contact with the skin or gets into the eyes, immediate thorough rinsing with copious amounts of fresh water is required. Contaminated items of clothing must be immediately removed, and a physician or eye specialist should be consulted without delay. The instructions in the safety data sheet must be observed.

Note
To comply with Appendix 6 of the Hazardous Substance Regulations, the substance must be labeled with the hazard symbol C. This hazard symbol must appear on storage tanks, pumps, pipelines, and nozzles. Further details are to be found in the safety data sheet. The water-protection regulations applying in the country of use must be observed during transport, storage, as well as loading and unloading of formic acid.

Dosage recommendations
1. When formic acid is used to optimize gastrointestinal acidity, thus aiding digestive processes, addition of the following quantities of Amasil 85 or Amasil NA to the feed (in kg/t) has proven appropriate.

<table>
<thead>
<tr>
<th></th>
<th>Amasil 85 (in kg/t)</th>
<th>Amasil NA (in kg/t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piglets</td>
<td>5 – 8</td>
<td>6 – 10</td>
</tr>
<tr>
<td>Fattening pigs</td>
<td>3 – 5</td>
<td>4 – 6</td>
</tr>
<tr>
<td>Breeding sows</td>
<td>4 – 6</td>
<td>5 – 9</td>
</tr>
<tr>
<td>Broilers</td>
<td>2 – 3</td>
<td>3 – 4</td>
</tr>
<tr>
<td>Turkeys</td>
<td>3 – 5</td>
<td>4 – 6</td>
</tr>
</tbody>
</table>

2. To acidify dairy products in milk replacers and liquid dairy products, 0.1 – 0.3% Amasil 85 (0.15 – 0.35% Amasil NA), corresponding to 1 – 3% of a 10% solution in water, should be mixed in to obtain the required acidification.

3. For ensiling, depending on the dry matter content of the forage, 0.15 – 0.7% (1.5 – 7 kg/t) Amasil 85 (0.3 – 0.45% Amasil NA) is required to reduce the pH rapidly as required and to achieve optimal ensiling with good anaerobic stability. Acid-resistant equipment must be used for the application.
Amasil® 99

Active ingredient
Formic acid

PRD-No.
30041107

Article
50078124 bulk

Specification
Content of active substance at least 99%


Other chemical and physical data
Water content not more than 1%

Formulation liquid

Density 1,220 kg/m³ (20 °C)

Flashpoint 48 °C

Ignition temperature 480 °C

Boiling point 101 °C

Freezing point 8 °C

Vapor pressure 42 mbar (20 °C)

Viscosity 1.8 mPa·s (20 °C)

Electrical conductivity 164 µS/cm

Solubility infinitely miscible with water

HCOOH Molar mass 46.02 g/mol

Estimated energy
Dairy cow MJ NEL 5.2 per kg
Pigs MJ ME 6.8 per kg
Poultry MJ ME 6.8 per kg
Beef cattle MJ ME 6.5 per kg

Stability
24 months if the product is stored correctly.

Dosage recommendation
Please refer to “Organic acids — Formic acid.”
Amasil® 85

Active ingredient
Formic acid

PRD-No.
30041102

Articles
50076852  bulk
50034148  1200 kg Combi IBC

Specification
Content of active substance  at least 85%


Other chemical and physical data
Water content  not more than 15%
Formulation  liquid
Density  1,190 kg/m³ (20 °C)
Flashpoint  65 °C
Ignition temperature  500 °C
Boiling point  approx. 107 °C
Freezing point  approx. -13.5 °C
Vapor pressure  28 mbar (20 °C)
Viscosity  1.44 mPa·s (20 °C)
Electrical conductivity  2,255 µS/cm
Solubility  infinitely miscible with water

HCOOH  Molar mass 46.02 g/mol

Estimated energy
Dairy cow MJ NEL  4.8 per kg
Pigs MJ ME  5.6 per kg
Poultry MJ ME  5.6 per kg
Beef cattle MJ ME  6.0 per kg

Stability
36 months if the product is stored correctly.

Dosage recommendation
Please refer to “Organic acids — Formic acid.”
Amasil® NA

Active ingredients
Mixture of formic acid and sodium formate

PRD-No.
30286605

Articles
<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>53755025</td>
<td>bulk</td>
</tr>
<tr>
<td>56068369</td>
<td>1000 kg IBC</td>
</tr>
</tbody>
</table>

Specification
Content of active substance
- 61% Formic acid
- 20.5% Sodium formate


Other chemical and physical data
Water content 18 ± 2%
Formulation liquid
Density 1,301 kg/m³ (20 °C)
Flash point > 106 °C
Electrical conductivity 49,000 µS/cm
Freezing point < -25 °C
Vapor pressure 12.3 hPa (20 °C) 
65.4 hPa (50 °C)
Viscosity 9.3 mPa·s (20 °C)
Solubility in water fully miscible
Classification irritant

Estimated energy
<table>
<thead>
<tr>
<th>Source</th>
<th>MJ NEL (kg)</th>
<th>MJ ME (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy cow</td>
<td>3.6</td>
<td>4.2</td>
</tr>
<tr>
<td>Pigs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poultry</td>
<td>4.2</td>
<td>4.5</td>
</tr>
<tr>
<td>Beef cattle</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Stability
36 months if the product is stored correctly.

Applications
Amasil NA is a partly buffered formic acid. Therefore, the product is only irritant, easier to handle, and has a reduced odor compared to pure formic acid.

Based on the very high content of formic acid and sodium formate, Amasil NA is an excellent preservative to inhibit bacteria and yeasts in feedstuffs. Thus Amasil NA is recommended to improve feed hygiene by reducing microorganisms like Salmonella, E. coli, or Campylobacter in pig and poultry feed and single feed components (dosage 6 – 12 kg/t feed). Amasil NA can also be used as feed acidifier (dosage 6 – 12 kg/t feed).

A special application field is silage treatment. Amasil NA reduces pH and improves silage fermentation under wet and difficult conditions (low dry matter, high protein content of grass silages). Recommended dosage for silage treatment is 3.0 – 4.5 l/t silage.

Up to 60 °C, recommended materials for storage are austenitic chromium/nickel and chromium/nickel/molybdenum steels, materials nos.: 1.4541 and 1.4571.

Dosage recommendation
Please refer to “Organic acids — Formic acid.”
Propionic acid

**Occurrence**
Propionic acid is a natural metabolic product. For example, in dairy cows approximately 1.5 l of propionic acid is produced every day by the ruminal microorganisms. This represents an important source of energy for the animals. However, propionic acid is also formed in metabolism of other animals. Thus, non-ruminants can also utilize propionic acid very rapidly. In addition, propionic acid is found in small concentrations in dairy products as well as in urine and sweat.

**Biological effects of propionic acid**
Propionic acid has a pronounced antimicrobial action. It acts on mold, yeasts, and bacteria. The preservative effect of propionic acid derives from intervention in the carbohydrate metabolism and DNA synthesis of the microorganisms. The undissociated acid is effective for this. Since the pK of propionic acid is relatively high, at 4.9, it is particularly effective in the pH ranges which are typical of feedstuffs, i.e., pH value 5.5 – 6.5. However, there is also a good preservative effect when the pH of the feedstuffs is higher.

**Applications**
1. Preservation
   Propionic acid and its salts are very appropriate for preserving compound feeds and raw materials. The quantities used for this purpose depend on a large number of factors, which can be employed to assess the use of a preservative. These include the moisture content and microbe content of the material to be preserved, the length of storage, and the storage conditions (day/night temperature differences, relative humidity).

   **Advantages of preservation with propionic acid**
   - The effects from addition of adequate amounts of propionic acid are the following:
     - Prevention of nutrient losses
     - Prevention of mycotoxin formation
     - Less stress on the stock due to large numbers of microbes and thus prevention of microbial diarrhea
     - Improved palatability of the feed
     - Improved flowability of the treated feed

2. Ensiling
   The addition of propionic acid to silage results in a long-term improvement in the aerobic stability of the silage. Moreover, the addition of propionic acid can prevent secondary fermentation and surface losses. This also applies to treatment of the cut surfaces.

   **Reduction in storage losses:**
   The addition of propionic acid can minimize enzymatic activities in the stored feedstuffs and reduce insect infestation. Consequently, losses are virtually excluded.

   **Effect of propionic acid on feed quality**
   The addition of propionic acid has no negative effect on the active substances present in the feed mix. Similarly, propionic acid has no adverse effect on the pelleting properties of compound feeds.
Acceptance of propionic acid

Propionic acid can be regarded as physiologically innocuous. In ruminants, propionic acid is an end product of ruminal fermentation, is absorbed in large quantities, and subsequently undergoes intermediary metabolism. Propionic acid is also a physiological compound in non-ruminants, occurring in the metabolic breakdown of odd-numbered fatty acids, of cholesterol, and of amino-acids such as valine and isoleucine. Non-ruminants are also able to metabolize very large quantities of propionic acid.

Propionic acid can be included in the calculation of feed compositions as an energy-rich substance.

Recommended materials

Propionic acid is corrosive. Only corrosion-resistant materials must be used for storage and transport.

Suitable materials are:
- Up to 40 °C, the austenitic chromium/nickel and chromium/nickel/molybdenum steels, materials nos.: 1.4541 and 1.4571
- Austenitic chromium/nickel/molybdenum steels, such as materials nos.: 1.4439, 1.4539, 1.4435, 1.4404
- Nickel-based alloys, such as NiMo 16Cr16Ti, material no.: 2.4610
- Teflon C (PTFE) high-density polyethylene
- Polypropylene
- Polyethylene

The following materials are resistant to Luprosil® NC up to 40 °C:
- PVC
- Polyethylene
- Polypropylene

Unsuitable materials are
- Non-ferrous metals
- Hot-galvanized steels
- Cast iron
- Unalloyed steels

Where different metallic materials are present in combination, there may also be electrochemical corrosion on other parts of the system.

Precautionary measures when handling

Contact of Luprosil with the skin and inhalation of Luprosil containing vapors must be avoided. Goggles and gloves must be worn when handling Luprosil.

If Luprosil comes in contact with the skin or gets into the eyes immediate thorough rinsing with copious amounts of fresh water is required. Contaminated items of clothing should be immediately removed, and a physician or eye specialist should be consulted without delay.

The instructions in the safety data sheet must be observed.

Feedstuffs which have been treated with propionic acid in concentrations of 5 – 6% have been tolerated without problems by cattle, sheep, and pigs. The oral toxicity of propionic acid (LD₅₀) in rats was found to be 3,500 mg per kg body weight. Thus, toxicity is extremely low.

Propionic acid has been officially tested and licensed as preservative in feedstuffs in many countries. In the U.S., propionic acid is on the GRAS (Generally Recognized As Safe) list of the FDA without any restrictions.
Application methods
The precondition for effectiveness of Luprosil, Lupro-Grain®, Luprosil NC, and other acid products is a maximally homogeneous dispersion.

The following methods are appropriate:
- Spraying the compounded feed with subsequent mixing
- Spraying into the main mixer (through 2 or 3 nozzles where possible)
- Preparation of premixes (e.g., combined with molasses or fat) which are then added to the feed

If metering is accurate and the acid is not sprayed directly onto the metallic components, the mixer can be made of a corroding material provided that the concentration of Luprosil in the feed is less than 0.5%.

Note
The water-protection regulations applying in the country of use must be observed during transport, storage, as well as in loading and unloading of propionic acid.

Feedstuff preservation with propionic acid
A moisture content of 12.5% in temperate climatic zones, and above 11% in hot zones, makes feedstuffs unstable for storage. This is caused by the reproduction of microorganisms (molds, bacteria, yeasts), which are always present in feedstuffs.

Because of its antimicrobial effect, propionic acid is appropriate for preserving both compound feeds as well as ground and unground individual ingredients (e.g., cereals). The precondition for efficient preservation is uniform distribution in the material to be preserved. This does not cause any problems when appropriate metering devices are used for liquid products and when the acid is added during the mixing of powdered products. Propionic acid prevents the feedstuffs from becoming moldy, reduces their microbial content, and thus prevents heating up, lumping, and losses of nutrients. The inhibition of fungal growth also efficiently prevents mycotoxin formation. The quantities of propionic acid and other propionic acid products, which should be used for adequate preservation are listed in the following table.

Dosage recommendations for preserving compound feed

<table>
<thead>
<tr>
<th>Moisture content of the feed (%)</th>
<th>Minimum amounts (kg/t)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Product Lupro-Grain, Luprosil NC</td>
</tr>
<tr>
<td>&lt; 12</td>
<td>0.50 1.00 0.75 1.50</td>
</tr>
<tr>
<td>12</td>
<td>0.75 1.50 1.25 2.50</td>
</tr>
<tr>
<td>13</td>
<td>1.00 2.00 1.75 3.50</td>
</tr>
<tr>
<td>14</td>
<td>1.25 2.50 2.25 4.50</td>
</tr>
<tr>
<td>15</td>
<td>1.50 3.00 2.75 5.50</td>
</tr>
<tr>
<td>16</td>
<td>1.75 3.50 3.25 6.50</td>
</tr>
<tr>
<td>17</td>
<td>* 4.00 * 7.50</td>
</tr>
<tr>
<td>18</td>
<td>* 4.50 * 8.50</td>
</tr>
</tbody>
</table>

1 Short storage period (< 4 weeks), small temperature differences between day and night, low relative humidity (< 60%), low initial microbial content
2 Longer storage period (< 3 months), large temperature differences between day and night, high relative humidity (> 60%), higher initial microbial content
* Conditions unfavorable because of high water content.
Luprosil®

**Active ingredient**
Propionic acid

**PRD-No.**
30041113

**Articles**
- 50078760 bulk
- 50034360 950 kg Combi IBC

**Specification**
Content of active substance  at least 99.5% (acidometric)


**Other chemical and physical data**
- **Water content** not more than 0.5%
- **Formulation** liquid
- **Density** 990 – 998 kg/m³ (20 °C)
- **Flashpoint** 50 °C
- **Ignition temperature** 485 °C
- **Boiling range** approx. 141 °C
- **Crystallization point** approx. -20 °C
- **Vapor pressure** 5 mbar (20 °C)
- **Viscosity** 1 mPa·s (20 °C)
- **Electrical conductivity** < 0.02 µS/cm
- **Solubility** infinitely miscible with water

**Estimated energy**
- Dairy cow MJ NEL 14.6 per kg
- Pigs MJ ME 20.7 per kg
- Poultry MJ ME 20.7 per kg
- Beef cattle MJ ME 18.2 per kg

**Stability**
36 months if the product is stored correctly.

**Dosage recommendation**
Please refer to “Organic acids — Propionic acid.”
**Active ingredients**
Propionic acid, ammonium propionate

**PRD-No.**
30062123

**Articles**
| 50020215 | bulk |
| 50656908 | 1000 kg Combi IBC |

**Specification**

| Content of active substance | 73% propionic acid | 21% ammonium propionate | 4% 1,2-Propandiol |


**Estimated energy**

| Dairy cow MJ NEL | 14.1 per kg |
| Pigs MJ ME | 20.0 per kg |
| Poultry MJ ME | 20.0 per kg |
| Beef cattle MJ ME | 17.6 per kg |

**Stability**
36 months if the product is stored correctly.

**Dosage recommendation**
Please refer to “Organic acids — Propionic acid.”

**Caution:** Corrosiveness increases considerably when diluted with water!

**Other chemical and physical data**

| Composition of product | 90% propionic acid | 4% ammonia | 4% 1,2-Propandiol |

| Water content | max. 2% |
| Formulation | liquid |
| Density | 1,031 kg/m³ (20 °C) |
| Boiling range | 143 – 211 °C |
| Crystallization point | -29.5 °C |
| Flashpoint | 62.5 °C |
| Ignition temperature | non-flammable up to 110 °C |
| Vapor pressure | 2 mbar (20 °C) |
| Viscosity | 13.7 mPa·s (20 °C) |
| Electrical conductivity | 1,100 µS/cm |
| Solubility | entirely soluble in water |
Luprosil® NC

Active ingredient
Ammonium propionate

PRD-No.
30053183

Article
50094981 1000 kg Combi IBC

Specification
Content of active substance
- 12% propionic acid
- 51% ammonium propionate
- 11.5% 1,2-Propandiol


Other chemical and physical data
Composition of product
- 53.5% propionic acid
- 9.5% ammonia
- 11.5% 1,2-Propandiol

Water content
approx. 25.5%

Formulation
liquid

Density
1,070 kg/m³ (20 °C)

Boiling range
110 °C

Crystallization point
approx. -30 °C

Flashpoint
110 °C

Ignition Temperature
470 °C

Vapor pressure
12 mbar (20 °C)

Electrical conductivity
19 µS/cm

Viscosity
25 mPa·s (20 °C)
39 mPa·s (10 °C)

Solubility
terily soluble in water

Estimated energy
- Dairy cow MJ NEL 9.7 per kg
- Pigs MJ ME 13.8 per kg
- Poultry MJ ME 13.8 per kg
- Beef cattle MJ ME 12.1 per kg

Stability
36 months if the product is stored correctly.

Dosage recommendation
Please refer to “Organic acids — Propionic acid.”
BASF’s acid mixtures combine the advantages of formic acid and propionic acid optimally for every application. The chemical compositions of these mixtures of formic and propionic acids are shown in the following table:

<table>
<thead>
<tr>
<th>Product</th>
<th>Propionic acid</th>
<th>Formic acid (85%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lupro-Mix®</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Lupro-Cid®</td>
<td>25</td>
<td>75</td>
</tr>
<tr>
<td>Lupro-Mix NC</td>
<td>38</td>
<td>47</td>
</tr>
<tr>
<td>Lupro-Cid NA</td>
<td>18</td>
<td>63</td>
</tr>
</tbody>
</table>

**Applications**
1. Lupro-Cid/Lupro-Cid NA, Lupro-Mix/Lupro-Mix NC for acidification and preservation: Formic as well as propionic acid are well known for their antimicrobial and antifungal efficacy. The combination of the two ingredients, which results in excellent additional effects, is realized in the products Lupro-Cid, Lupro-Cid NA, Lupro-Mix, and Lupro-Mix NC. Optimizing the hygienic status of the feed protects the animals from alimentary uptake of mold, bacteria, and yeasts. Thus, the microflora in the intestinal tract is stabilized, resulting in a reduction of nutrient losses and improving gut health. The lowered feed pH supports the acidification of the crop and/or gut environment. Particularly in young animals, this contributes to diarrhea prophylaxis.

2. Lupro-Cid for controlling salmonella, producing fish silage, and acidifying: Salmonella can be efficiently controlled with formic and propionic acid. Lupro-Cid is a mixture of these two ingredients. Addition of Lupro-Cid/Lupro-Cid NA makes it possible to remove salmonella contamination completely from feedstuffs and, furthermore, to effectively prevent recontamination of salmonella-free feedstuffs.

Regular treatment of compound feed with Lupro-Cid/Lupro-Cid NA significantly promotes, for example, the reduction of salmonella contamination of broilers at slaughter.

**Recommended materials**
Acid mixtures are corrosive. Only corrosive-resistant materials must be used for storage and transport. The materials appropriate for this are described in the section on formic acid.

**Precautionary measures during handling**
Acid-resistant gloves and tightly fitting goggles must be worn when handling acid mixtures. The same precautionary measures apply as for handling formic acid.

**Dosage recommendations**
1. Recommended dosages of Lupro-Cid, Lupro-Cid NA, Lupro-Mix/Lupro-Mix NC for acidification and preservation:

<table>
<thead>
<tr>
<th></th>
<th>Lupro-Cid, Lupro-Mix*</th>
<th>Lupro-Mix NC, Lupro-Cid NA*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piglets</td>
<td>6 – 8</td>
<td>8 – 10</td>
</tr>
<tr>
<td>Fattening pigs</td>
<td>4 – 6</td>
<td>5 – 8</td>
</tr>
<tr>
<td>Breeding sows</td>
<td>5 – 6</td>
<td>7 – 8</td>
</tr>
<tr>
<td>Broilers</td>
<td>2 – 4</td>
<td>3 – 5</td>
</tr>
<tr>
<td>Turkeys</td>
<td>4 – 6</td>
<td>5 – 8</td>
</tr>
</tbody>
</table>

* in kg/t
2. Lupro-Cid for controlling salmonella, producing fish silage, and acidifying. Depending on the degree of contamination and moisture content, 0.6 – 2% Lupro-Cid is recommended for eliminating salmonella contamination from feedstuffs. Recontamination of salmonella-free feedstuffs can be prevented in the long-term by using about 0.3 – 0.6% Lupro-Cid. Moreover, regular treatment of compound feed with 0.5 – 1% Lupro-Cid reduces the salmonella contamination of ready-to-cook broilers.

In the production of fish silage, 2.5 – 4.5% Lupro-Cid is necessary for complete liquefaction and preservation. Fish silage must be stored in acid-resistant tanks.

For acidifying milk, dairy products, and milk replacers, 0.1 – 0.4% Lupro-Cid is necessary in order to achieve the required large pH reduction.

**Lupro-Mix NC used as silage additive**

1. Treatment of complete bales:
The quantity of Lupro-Mix NC used for treatment of the entire bales/silo depends on the dry matter content of the material to be ensiled. The following quantities of Lupro-Mix NC are recommended for optimal ensiling:

<table>
<thead>
<tr>
<th>Dry matter content of the forage</th>
<th>Lupro-Mix NC (kg/t forage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 25%</td>
<td>4 kg</td>
</tr>
<tr>
<td>25 – 35%</td>
<td>3 kg</td>
</tr>
<tr>
<td>Above 35%</td>
<td>4 kg</td>
</tr>
</tbody>
</table>

2. Surface treatment
For surface treatment of silage, 1 l of Lupro-Mix NC is diluted with 4 l of water. To treat a layer with a thickness of 40 cm, the following quantities should be used, depending on the dry matter content of the material to be ensiled:

<table>
<thead>
<tr>
<th>Dry matter content of the forage</th>
<th>Lupro-Mix NC (l/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 25%</td>
<td>2.4 l</td>
</tr>
<tr>
<td>25 – 35%</td>
<td>2.8 l</td>
</tr>
<tr>
<td>Above 35%</td>
<td>3.2 l</td>
</tr>
</tbody>
</table>

The dilution of 1 l of Lupro-Mix NC with 4 l of water results in the following quantities of the dilution depending on the dry matter content:

<table>
<thead>
<tr>
<th>Dry matter content of the forage</th>
<th>Lupro-Mix NC (l/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 25%</td>
<td>12 l</td>
</tr>
<tr>
<td>25 – 35%</td>
<td>14 l</td>
</tr>
<tr>
<td>Above 35%</td>
<td>16 l</td>
</tr>
</tbody>
</table>
**Active ingredients**
Mixture of propionic and formic acid

**PRD-No.**
30041101

**Articles**
- 50078283: bulk
- 50034042: 1000 kg Combi IBC

**Specification**

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>25%</th>
<th>75%</th>
</tr>
</thead>
<tbody>
<tr>
<td>propionic acid</td>
<td></td>
<td>formic acid</td>
</tr>
<tr>
<td>formic acid (85% pure)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Content of active substance</th>
<th>25%</th>
<th>63.75%</th>
</tr>
</thead>
<tbody>
<tr>
<td>propionic acid</td>
<td></td>
<td>formic acid</td>
</tr>
</tbody>
</table>


**Other chemical and physical data**

- Water content: 11.25%
- Density: 1,150 kg/m³ (20 °C)
- Formulation: liquid
- Boiling range: 107 – 117 °C
- Melting point: -18.2 °C
- Vapor pressure: 24 mbar
- Flashpoint: 55 °C
- Electrical conductivity: 880 µS/cm
- Viscosity: 1.86 mPa·s (20 °C)
- Solubility: infinitely miscible with water

**Estimated energy**

<table>
<thead>
<tr>
<th></th>
<th>Dairy cow MJ NEL</th>
<th>Pigs MJ ME</th>
<th>Poultry MJ ME</th>
<th>Beef cattle MJ ME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated energy</td>
<td>7.2 per kg</td>
<td>9.4 per kg</td>
<td>9.4 per kg</td>
<td>9.1 per kg</td>
</tr>
</tbody>
</table>

**Stability**
36 months if the product is stored correctly.

**Dosage recommendation**
Please refer to “Organic acids — Acid mixtures.”
Lupro-Mix®

Active ingredients
Mixture of propionic and formic acid

PRD-No.
30041100

Article
50078230 bulk

Specification
Content of active substance
50% propionic acid
50% formic acid (85% pure)


Other chemical and physical data
Water content 7.5%
Density 1,088 kg/m³ (20 °C)
Formulation liquid
Boiling range 109 – 142 °C
Melting point -40.5 °C
Vapor pressure 24 mbar (20 °C)
Flashpoint 47 °C
Electrical conductivity 175 µS/cm
Viscosity 2.00 mPa·s (20 °C)
Solubility infinitely miscible with water

Estimated energy
Dairy cow MJ NEL 9.7 per kg
Pigs MJ ME 13.1 per kg
Poultry MJ ME 13.1 per kg
Beef cattle MJ ME 12.1 per kg

Stability
36 months if the product is stored correctly.

Dosage recommendation
Please refer to “Organic acids — Acid mixtures.”
Lupro-Cid® NA

Active ingredients
Mixture of formic acid, sodium formate, and propionic acid

PRD-No.
30287386

Articles
53843535 bulk
56068316 1000 kg Combi IBC

Specification
Ingredients 54% ± 1% Formic acid
18% ± 1% Propionic acid
8% ± 1% Sodium

Content of active substance 39% Formic acid
23% Sodium formate
18% Propionic acid


Other chemical and physical data
Water content 20 ± 2%
Formulation liquid
Density 1,256 kg/m³ (20 °C)
Flash point 71 °C
Electrical conductivity 32,000 µS/cm
Freezing point < -26 °C
Vapor pressure 11.5 hPa (20 °C)
63.1 hPa (50 °C)
Viscosity 13.3 mPa·s (20 °C)
Solubility in water fully miscible
Classification strongly irritant

Estimated energy
Dairy cow MJ NEL 5.2 per kg
Pigs MJ ME 6.8 per kg
Poultry MJ ME 6.8 per kg
Beef cattle MJ ME 6.5 per kg

Stability
36 months if the product is stored correctly.

Applications
Lupro-Cid NA is a partly buffered formic and propionic acid. Therefore, the product is easier to handle and with a reduced odor compared to pure acids. Based on the very high content of formic acid and propionic acid, Lupro-Cid NA is an excellent preservative to inhibit bacteria and yeasts in feedstuffs. Thus Lupro-Cid NA is recommended to improve feed hygiene by reducing microorganisms like Salmonella, E.coli, or Campylobacter in pig and poultry feed and single feed components (dosage 6 – 12 kg/t feed). Lupro-Cid NA can also be used as feed acidifier (dosage 6 – 12 kg/t feed).

A special application field is treatment of silage round bales. Recommended dosage for silage treatment is 4 – 6 l/t silage (fresh matter). Based on the combination of the two active ingredients, Lupro-Cid NA is improving silage fermentation by reducing the pH as well as aerobic stability of highly wilted silage. Safety goggles and gloves need to be used. Body protection must be chosen depending on activity and possible exposure.

Recommended materials
Up to 60 °C, recommended materials for storage are austenitic chromium/nickel and chromium/nickel/molybdenum steels, materials nos.: 1.4541 and 1.4571.

Dosage recommendation
Please refer to “Organic acids — Acid mixtures.”
Lupro-Mix® NC

Active ingredients
Propionic acid, formic acid, ammonium

PRD-No.
30041098

Articles
50080403  bulk
50034307  1000 kg Combi IBC

Specification
Content of active substance
- 34% propionic acid
- 5% ammonium propionate
- 15% formic acid
- 26% ammonium formate


Other chemical and physical data
Composition of product
- 38% propionic acid
- 34% formic acid
- 8% ammonia

Water content
20 ± 2%

Density
1,119 kg/m³ (20 °C)

Formulation
liquid

Boiling range
102 – 222 °C

Melting point
-30 °C

Solidification temperature
-42.8 °C

Vapor pressure
- 15 mbar (24 °C)
- 70 mbar (50 °C)
- 700 mbar (103 °C)

Flashpoint
non-flammable

Ignition temperature
495 °C

Electricity conductivity
48,000 μS/cm

Viscosity
- 15.78 mPa·s (10 °C)
- 8.83 mPa·s (20 °C)
- 6.484 mPa·s (30 °C)

Solubility
completely miscible with water

Estimated energy
- Dairy cow MJ NEL 7.1 per kg
- Pigs MJ ME 9.8 per kg
- Poultry MJ ME 9.8 per kg
- Beef cattle MJ ME 8.9 per kg

Stability
24 months if the product is stored correctly.

Applications
Lupro-Mix NC was especially developed for ensiling corn, corn cob mix, crushed grain, and forage. The combination of active substances is balanced and has a pH value of 4, which is optimal for silage.

Lupro-Mix NC promotes lactic acid fermentation and suppresses the formation of butyric acid. In addition, the aerobic stability of the silage is considerably improved. Moreover, there is a reliable preventive effect on secondary fermentation.

Lupro-Mix NC is accordingly very suitable for treating grass and maize silage both throughout and only on the surface.

Recommended materials
Please refer to “Organic acids — Acid mixtures.”
Precautionary measures when handling
Lupro-Mix NC is an eye irritant. Vapors and mists must not be inhaled.
When handling the product, acid-resistant gloves, e.g., made of PVC, and tightly-fitting goggles must be worn. If the product comes in contact with the skin or gets into the eyes, immediate thorough rinsing with copious amounts of fresh water is required.
Contaminated items of clothing must be immediately removed, and a physician or eye specialist should be consulted without delay. The instructions in the safety data sheet must be observed.

Dosage recommendation
Please refer to “Organic acids — Acid mixtures.”
Omega-6 fatty acids
<table>
<thead>
<tr>
<th>Omega-6 fatty acids</th>
<th>121</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lutrell Pure</td>
<td>123</td>
</tr>
<tr>
<td>Lutalin</td>
<td>124</td>
</tr>
</tbody>
</table>
Omega-6 fatty acids

Occurrence
Fatty acids are components of fat. They are mostly bound or attached to other molecules, such as in triglycerides or phospholipids. When they are not attached to other molecules, they are known as “free” fatty acids. Fatty acids are linear hydrocarbon chains with a methyl (CH₃-, also called the ω-end) and a carboxyl (-COOH) end. Fatty acids vary in their number of carbon atoms and double bonds and are classified as follows:

- Saturated fatty acids (SFAs, no double bonds)
- Monounsaturated fatty acids (MUFAs, one double bond)
- Polyunsaturated fatty acids (PUFAs, two or more double bonds)
- Omega-6 PUFAs
- Omega-3 PUFAs

Omega-6 PUFAs (also known as ω-6 PUFAs, n-6 PUFAs) have the first double bond at carbon number 6 counting from the methyl end. The major omega-6 PUFAs in the diet are:

- Linoleic acid (LA)
- γ-Linolenic acid (GLA)
- Arachidonic acid (AA)

Both saturated and monounsaturated fatty acids can be synthesized by the animal body. Linoleic acid (LA) — and α-linolenic acid (ALA) — however, are essential nutrients and must be obtained from a dietary source to avoid deficiency.

One very specific omega-6 fatty acid is the trans-10, cis-12 isomer of conjugated linoleic acid (CLA). Many CLA isomers arise from the biohydrogenation of polyunsaturated fatty acids in the forstomachs of ruminant animals. CLAs are present in highest amounts in milk fat and tallow. cis-9, trans-11 CLA is the most abundant naturally occurring CLA isomer, and thus it is called rumenic acid.

Desaturation of trans-11 C18:1 or vaccenic acid in animal tissues is the main source of cis-9, trans-11 CLA in milk fat and tallow. Trans-10, cis-12 CLA is formed only in the rumen and it is also present in small amounts in ruminant fat. Diets low in roughage enhance ruminal formation of trans-10, cis-12 CLA, and eventually lead to a milk fat depression. CLAs are absorbed as free fatty acids and subsequently incorporated into different lipids in the body. Highest enrichment of CLAs occurs in triglycerides. cis-9, trans-11 CLA and trans-10, cis-12 CLA can be produced in a methyl ester form, which has the same bioavailability as the free fatty acid form.

Physiological effects
Polyunsaturated fatty acids are structural components of bio membranes. Omega-6 and omega-3 PUFAs are important structural components of the phospholipids, cell membranes of the tissues, which have multiple physiological functions. The composition of the phospholipids influences cell membrane characteristics, such as fluidity and permeability to other molecules. They are essential for various membrane functions, such as activity of membrane-bound enzymes and receptors and signal transduction. Here are some examples:

- Skin: Omega-6 PUFAs are integral components of skin lipids.
- Brain: The developing brain accumulates large amounts of PUFAs both pre- and postnatally.
- Endocrine substances: PUFAs are precursors of eicosanoids.
Omega-6 fatty acids in the form of the trans-10, cis-12 isomer of CLA has further specific effects on the fat metabolism in animals. Scientific literature describes them as follows:
1. A dose-dependent reduction in milk fat concentration for the lactating dairy cow.
2. Reduction of back fat, increase of marbling, improvement of feed conversion.
3. Weight management for dogs.

Please contact us for further scientific information.

**Recommendations for dietary supplementation**

Omega-6 fatty acids are active ingredients in Lutalin and Lutrell pure.

**Dairy cows:** We recommend to feed 50 g Lutrell® Pure from day 20 before calving until day 60 to 100 after calving. This flexibility is possible in order to fit into the feeding regiments of the individual herd.

**Fattening pigs:** We recommend to feed Lutalin® with 0.5% in the diet over the last 4 weeks of the fattening period.

**Dogs:** We recommend to include Lutalin at 0.5% in the diet.
**Active ingredient**
Omega-6 fatty acid methyl ester (feed grade)

**PRD-No.**
30272045

**Article**
52375965 25 kg bag

**Specification**
Content  Omega-6 fatty acid (C18:2) 10 ± 1% (GC, area %)


**Other chemical and physical data**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formulation</td>
<td>granulate</td>
</tr>
<tr>
<td>Water content</td>
<td>at most 0.5% (acc. to Karl Fischer)</td>
</tr>
<tr>
<td>Bulk density</td>
<td>about 800 g/l</td>
</tr>
<tr>
<td>Particle size</td>
<td>at least 85% &gt; 250 µm</td>
</tr>
<tr>
<td></td>
<td>at least 85% &lt; 850 µm</td>
</tr>
<tr>
<td>Solubility</td>
<td>not soluble in water</td>
</tr>
<tr>
<td>Carrier</td>
<td>colloidal silica plus gypsum</td>
</tr>
<tr>
<td>Calcium</td>
<td>0.6%</td>
</tr>
<tr>
<td>Coating</td>
<td>hydrogenated vegetable fats</td>
</tr>
</tbody>
</table>

**Stability**
The esterification of the omega-6 fatty acids and the fat coating guarantee a very good stability. This treatment makes the product insoluble in water and resistant to ruminal fermentation processes. The product has a shelf-life of 12 months in the unopened original packaging under room temperature. Do not store above 25 °C. Some caking caused by the fat coating could occur if stored above 25 °C or if stored under weight pressure (stack factor 1). Reseal packaging properly after use.

**Areas of application**
Lutrell is a rumen-protected formulation of omega-6 fatty acids. It is suitable for all types of vitamin blends, premixes, mineral, and mixed feeds.

**Note**
Omega-6 fatty acids are biologically active compounds. The processing of the granulate should therefore be carried out with the customary care in terms of occupational hygiene. When exposed to this product, the provisions of the safety data sheet are to be observed.
Active ingredient
Omega-6 fatty acid methyl ester

PRD-No.
30321904

Article
55423094 175 kg steel drum

Specification
| Content | Omega-6 fatty acid (C18:2) min. 28% (GC, area) |

Other chemical and physical data
| Water content | at most 0.5% |
| Methanol content | at most 0.015% |
| Formulation | liquid |
| Acid value | max. 15 mg KOH/kg |
| Peroxide value | about 5 meq/kg |
| Bulk density | about 0.85 g/cm³ |
| Solubility | soluble in hydrocarbons, chloro-hydrocarbons, ethers, fats and oils. The solvents should not contain peroxides. Insoluble in water. |

Stability
The product has a shelf-life of 18 months in the unopened original packaging. Store at room temperature in airtight drums under nitrogen headspace. Do not store at temperatures above 40 °C. Some precipitation may occur below 20 °C. Lutalin has a melting point of approximately 5 °C. If product does not flow, gently heat up product above 30 °C and agitate before use. Reseal packaging properly after use.

Note
After skin contact, wash with soap and water. If swallowed, drink water or milk to overcome unpleasant acid taste. For further instructions see data safety sheet.
<table>
<thead>
<tr>
<th>1,2-Propandiol</th>
<th>127</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2-Propandiol USP</td>
<td>128</td>
</tr>
</tbody>
</table>
Because of its characteristic properties, the number of end uses of 1,2-propandiol (propylene glycol) in animal nutrition is growing steadily beyond more preservative applications.

1,2-Propandiol was released for use as an energy-rich animal feed within the EU territory in 1999 and is now mainly applied in feed for ruminants, and particularly dairy cattle. In the first 100 days of their lactation period, dairy cattle frequently suffer from extreme energy deficiency due to a lack of glyconeogenesis substrate. Acting as a glycoplast, 1,2-propandiol in this instance forms the preliminary stage of glucose formation, eliminating or at least reducing the level of metabolic energy deficiency and, by the same token, positively influencing the animal’s performance, health, and even fertility.

1,2-Propandiol may also serve to boost the energy content of pig and poultry feed, and it may also be used as a dog-food preservative. Moreover, the product properties of 1,2-propandiol make it suitable for use as a technical additive in other applications, e.g., as a dust bonding or anti-foaming agent, or as an anti-freeze for drinking-water pipes.

**Use and dosage recommendations**

<table>
<thead>
<tr>
<th>Use in livestock</th>
<th>Dosage recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase of the blood sugar level in cows (ketosis prevention)</td>
<td>at least 150 g per animal per day</td>
</tr>
<tr>
<td>Energy input to feed for all animal species</td>
<td>2 – 4%</td>
</tr>
<tr>
<td>Preservation of dog food with moisture contents of 20 – 30%; moisture retention in dog food</td>
<td>3 – 5%</td>
</tr>
<tr>
<td>Dust binder for mineral feed and other too fine, mealy feeds, such as, tapioca meal</td>
<td>about 1%</td>
</tr>
<tr>
<td>Anti-foaming agent for molasses; reduction of the viscosity of molasses</td>
<td>2 – 5%</td>
</tr>
<tr>
<td>Anti-freeze for drinking water pipes in livestock homes with simultaneous energy supplementation. Freezing protection in moist mink feed</td>
<td>2%</td>
</tr>
</tbody>
</table>
1,2-Propandiol USP

**Active ingredient**
1,2-Propandiol (propylene glycol)

**PRD-No.**
30035115

**Articles**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>53403687</td>
<td>1000 kg bulk container</td>
</tr>
<tr>
<td>50001254</td>
<td>bulk</td>
</tr>
</tbody>
</table>

**Specification**

Content of active substance | at least 99% on anhydrous substance


**Other chemical and physical data**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water according to Karl Fischer</td>
<td>max. 0.2%</td>
</tr>
<tr>
<td>Formulation</td>
<td>liquid</td>
</tr>
<tr>
<td>Boiling range</td>
<td>186 – 189 °C</td>
</tr>
<tr>
<td>Ignition point</td>
<td>410 °C</td>
</tr>
<tr>
<td>Flash point</td>
<td>103 °C</td>
</tr>
<tr>
<td>Crystallization point</td>
<td>-60 °C (glass transition point)</td>
</tr>
<tr>
<td>Solubility</td>
<td>miscible with water and alcohols in any proportion, insoluble in oils and fats</td>
</tr>
<tr>
<td>Stability</td>
<td>12 months</td>
</tr>
</tbody>
</table>

**Physiological importance**

Great differences in carbohydrates digestion result from the differing construction of the digestive systems of non-ruminants and ruminants.

In the non-ruminant animal, the carbohydrates are enzymatically broken down and absorbed as monosaccharides. In ruminants, the degradation of a large part of the carbohydrates (besides starch and sugar, also cellulose, pectins, fructans, hemicelluloses) is carried out by the rumen microflora. The end products of this microbial activity are the volatile fatty acids, in particular acetic acid and propionic acid, which the ruminants can absorb directly from the rumen. While the non-ruminants cover their energy requirements primarily from the carbohydrates absorbed by the intestinal tract, this can only take place in the ruminant in very small amounts owing to the microbial degradation of these in the rumen. It obtains its energy primarily dependent on the composition of the feed ration and on the nutrient composition.

**Mode of action**

1,2-Propandiol is very rapidly absorbed from the rumen. As a result, the losses which can be caused by the bacterial activity in the rumen are negligibly small. Another advantage lies in the avoidance of overacidification of the rumen (acidosis), which would be expected with the use of alternative energy sources such as, for example, easily available carbohydrates. Administered 1,2-propandiol is thus available to a large extent to the intermediate metabolism as a glucoplastic substance. It can be used here both for the synthesis of blood glucose and for direct production of energy via the citric acid cycle and respiratory chain. It is ideally suitable to compensate possible energy deficits in ruminant nutrition, and can thus be employed against ketosis/acetonemia.
1,2-Propandiol has the following energy content (data per kg):

<table>
<thead>
<tr>
<th></th>
<th>Dairy cattle</th>
<th>Beef cattle</th>
<th>Pig, poultry</th>
<th>Beef cattle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>13.6 MJ NEL</td>
<td>1767.0 starch units</td>
<td>23.9 MJ ME</td>
<td>20.4 MJ ME</td>
</tr>
</tbody>
</table>

**Use**

1,2-Propandiol is sprayed into the feed like other liquid components. The addition expediently takes place using a liquid metering unit. Since 1,2-propandiol is not corrosive, it can be stored in any type of tank, if appropriate also as a mixture with other liquids containing water.

**Dosage recommendation**

Please refer to “1,2-Propandiol.”

**Note**

The processing of 1,2-propandiol should be carried out with the customary care in terms of occupational hygiene following the instructions of the safety data sheet.
Nutrition Ingredients

BASF's Nutrition Ingredients business unit is a leading supplier of nutritional ingredients and feed additives. The product portfolio for animal nutrition includes vitamins, carotenoids, enzymes, organic acids, omega-6s, and other feed additives. BASF offers products of outstanding quality produced with modern, state-of-the-art technologies. BASF also combines technical services and scientific expertise to meet the highest demands and to deliver the best value to the industry. Premium formulations are a key strength that has made BASF a leader in the industry. Further information is available at www.nutrition.basf.com