DSM Product Forms

Quality feed additives for more sustainable farming



ANIMAL NUTRITION AND HEALTH

- ESSENTIAL PRODUCTS
- PERFORMANCE SOLUTIONS + BIOMIN®
- PRECISION SERVICES

DSM
BRIGHT SCIENCE. BRIGHTER LIVING.

Adding value to feed with high-quality and sustainable ingredients

To meet the highest quality standards, nutritional and legal requirements for animal feed production, premix producers and feed manufacturers need to handle additives safely and with great precision. **Only the best available ingredients from a reliable and experienced supplier manufactured with the lowest environmental footprint are good enough for our customers.**

Micronutrients are rarely added as pure substances to the feed because they are often sensitive towards oxygen, light or temperature (Figure 1). They are not suited to the rigors of the feed manufacturing processes, and moreover, their handling properties are poor. For example, vitamin A or E are oily liquids, while liquid enzymes are viscous compounds.

Figure 1. *External factors influencing stability of non-formulated feed additives*

Additive	Temperature	Oxygen	Humidity	Light
Vitamin A				
Vitamin D_3				
25 hydroxy cholecalciferol				
Vitamin E				
Vitamin K_3				
Vitamin B_1				
Vitamin B_2				
Vitamin B_6				
Vitamin B_{12}				
Pantothenic acid				
Nicotinates				
Biotin				
Folic acid				
Vitamin C				
Carotenoids				
Enzymes				
Probiotics				
Phytogenics				
Organic acids				

Marked effect | Moderate effect | No effect



Vitamin B_6



Vitamin D



Vitamin E

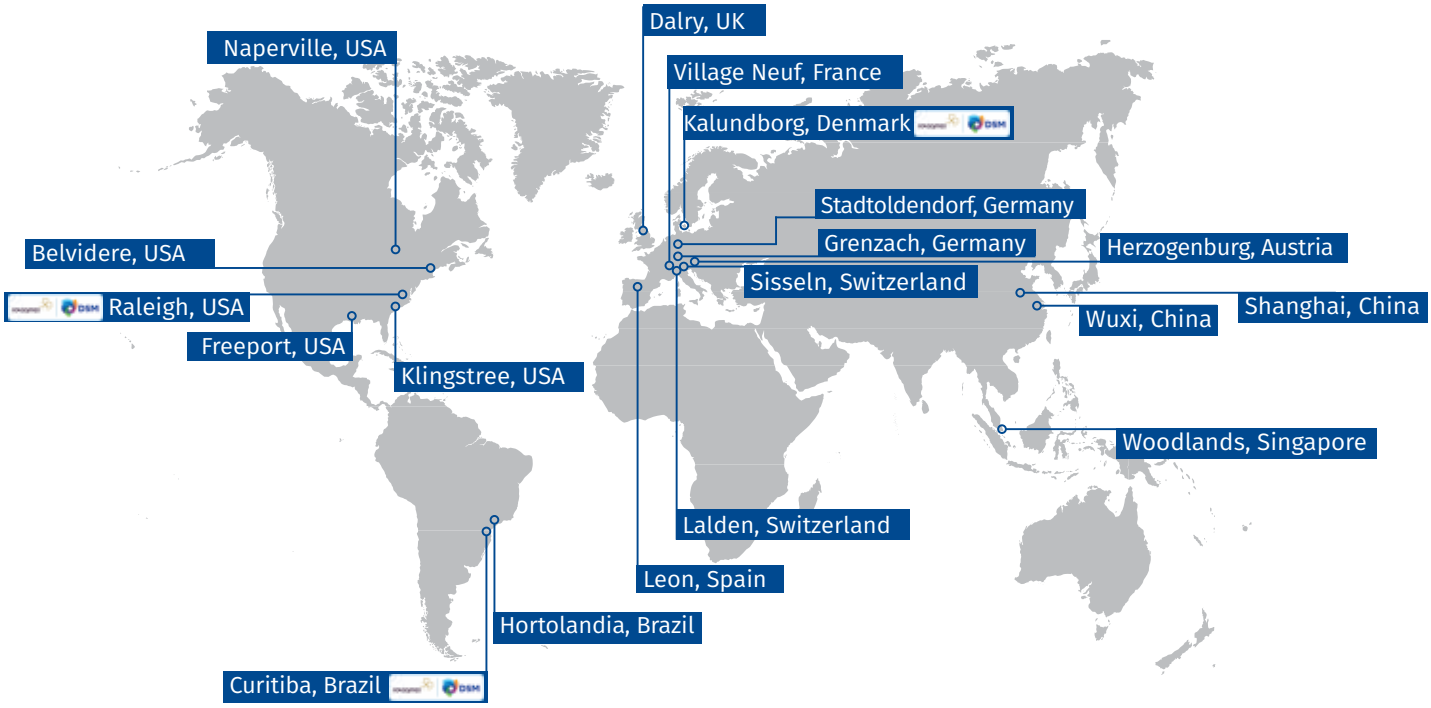
DSM feed additives are the result of many decades of research and development by dedicated specialists. **They consistently add value to premixes and feeds through an outstanding combination of excellent mixing and handling characteristics, chemical and physical stability and high animal bioavailability. All for more sustainable farming.**

Our products are micro-ingredients whose functionality is specific and whose impact can be enormous. It is therefore imperative to manufacture, package, store and ship them in accordance with the highest quality standards. Whether provided as straight products in bulk or as premixes tailored to individual customer needs, our products always meet the most stringent quality requirements.

We work to a unique global quality standard. This is rooted in the official regulations that give us our license to operate and is supplemented by our own internal quality systems.
Full backward integration allows us to ensure quality, safety, and traceability at every step of the supply chain.

DSM, the largest global producer of vitamins, carotenoids and other micronutrients and premix for the feed, food and pharma industries, operates close to 20 micronutrient manufacturing and formulation sites mostly across Europe, America and China (Figure 2).
These sites produce most DSM's nutritional ingredients, which are sold either as straight products or as blends.

Figure 2. *DSM feed additives production sites*



Why do we formulate nutritional ingredients?

Pure active substances of feed micro-nutrients may look very attractive but most times impossible to be used by animals unless they are properly formulated as feed additives and added into premix, feed or drinking water before the animal gets access to them: the right amount of each nutrient, day after day.

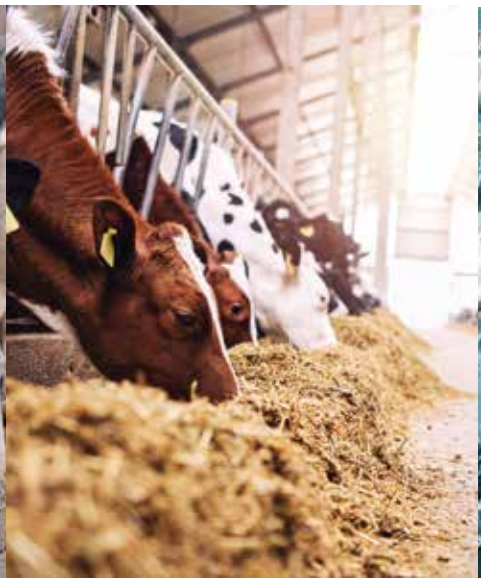
It is about mixing grams or milligrams in one ton of feed with animals eating few grams feed per day, certainly not an easy task!

How to do it? Following the product formulation fundamentals where the high **safety and quality of both the active substance and raw materials,** combined with **appropriate formulation technology,** result in product forms consistently delivering an optimal combination of desirable characteristics and tested in their final application.

For maximum efficacy DSM feed additives are formulated for:

- **low dust and best handling:** safe for workers
- **good flowability:** more efficient dosing operations and less product losses
- **best homogeneity** in premix and feed
- **superior stability in premix and feed:** right daily intake of nutrients by animals
- **high bioavailability**: allowing an efficient absorption and best biological use by the animal
- manufactured with the **lowest environmental footprint** for more sustainable farming






Our goal? Achieve the **best balance between Handling, Mixability, Stability and Bioavailability** depending on the specific application challenges that each nutrient may face (Figure 3).

Figure 3. *DSM Product Formulation Fundamentals*





Handling

Product forms must be safe for workers and the environment, easy to work with when handled in premix and feed plants **and allow for efficient manufacturing operations** which prevents additional costs like more frequent cleaning of the equipment or longer dosing time and mixing processes.

That's why good flowability and low dustiness are key features when developing best product forms.

Low dust

Dusty additives may endanger the safety of operators and lead to cross contamination in premix and feed plants. **Cross contamination** may finally lead to undesired presence of additives in some feed products creating **hazards to human health, contribute to environmental pollution and represent a loss of product** in premix or feed mills and increasing costs (Figure 4).

Figure 4. *Impact of dusty products:*



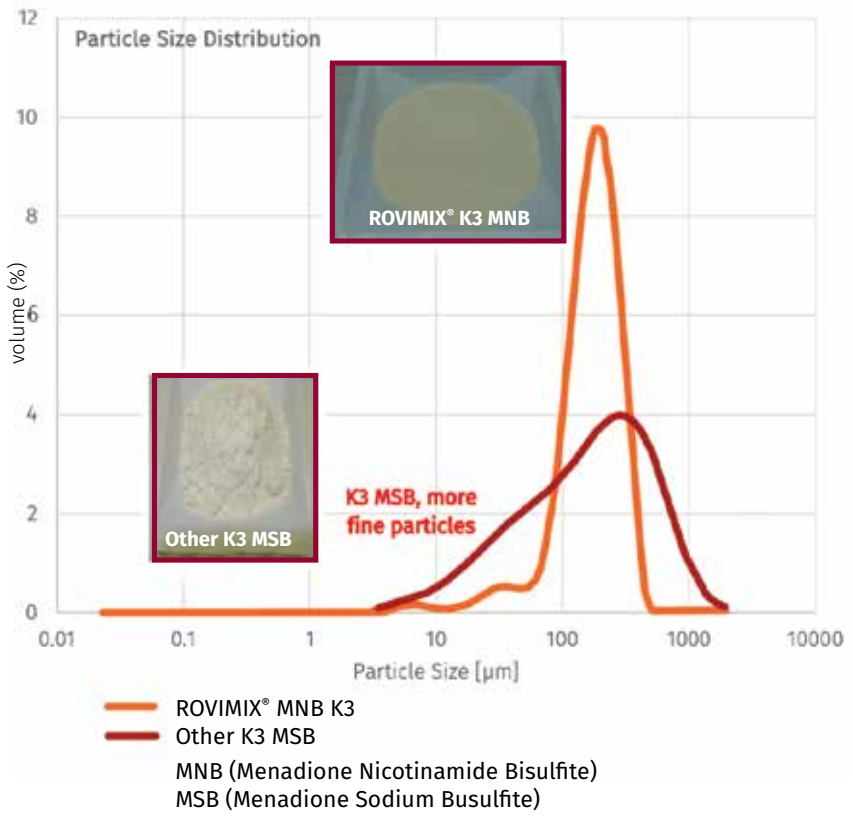
Flowability

Free-flowing products are easier to handle. They flow faster and are more precise to dose into premix and feed. When large quantities of feed additives are required their **flow properties will influence the ease of use and dosing time.** Therefore, flowability is an important criterion for feed ingredients' choice.

Lump formation of additives can be challenging for handling and dosing in premix and feed plants. Products like ROVIMIX® K3 MNB are developed to prevent this problem seen when using other vitamin K3 MSB forms with higher number of fine particles which may lead challenges in flow properties and generate more dust formation (Figure 5).

DSM uses several formulation processes including coating, compaction or adhesion with suitable carriers and binders to enlarge fine and dusty ingredients, resulting in additives that are practically dust-free compared with other ingredients.

Figure 5. *Flowability and dustiness when dosing ROVIMIX® K3 MNB vs vitamin K3 MSB*



MNB (Menadione Nicotinamide Bisulfite)
MSB (Menadione Sodium Busulfite)

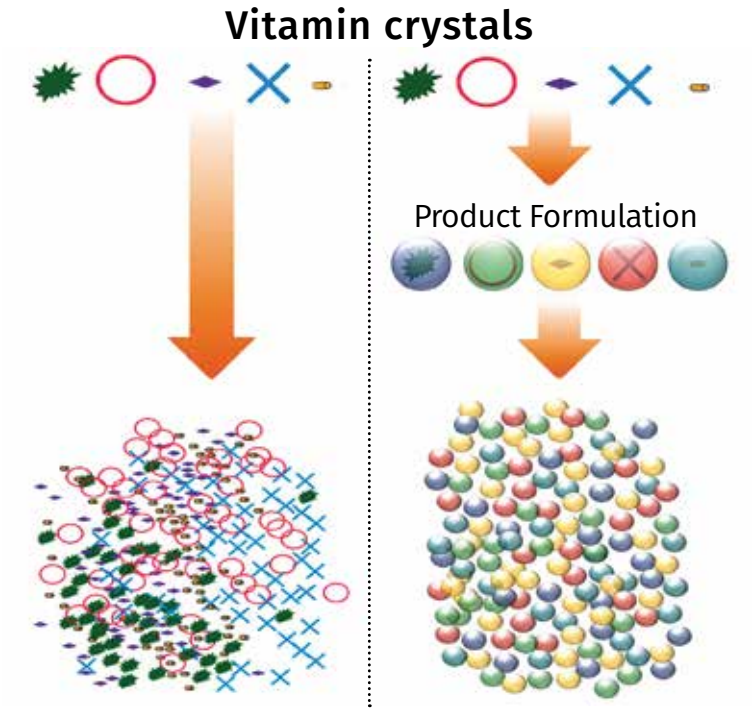
	ROVIMIX® MNB K3	Other K3 MSB
Flowability	high	no free-flowing
Dusting potential	medium (70% less dust vs MSB)	high



Mixability

Feed additives are developed as unique product forms that target different application challenges where the **number of particles as well as particle size and shape are key features to achieve best handling and mixing** (Figure 6).

Figure 6. *Mixability: importance of particle shape, size and number*



Distribution in premix and feed

A major requirement of today's quality feeds is high uniformity of content. This requires well-designed and well-controlled manufacturing processes as well as high quality additives with good mixability.

DSM, gives high priority to these factors in product design.

In the case of feed enzymes, an optimal number of particles is needed per feed portion, in order to deliver the promised effects.

In the case of HiPhorius™ 40 , small particles with high concentration ensure homogeneous distribution in premix and in feed (Figure 7).

Another example is ProAct 360™, where a tailored number of particles per gram ensures good homogeneity in premix and feed (Figure 8).

Figure 7. *HiPhorius™ microscopic images*

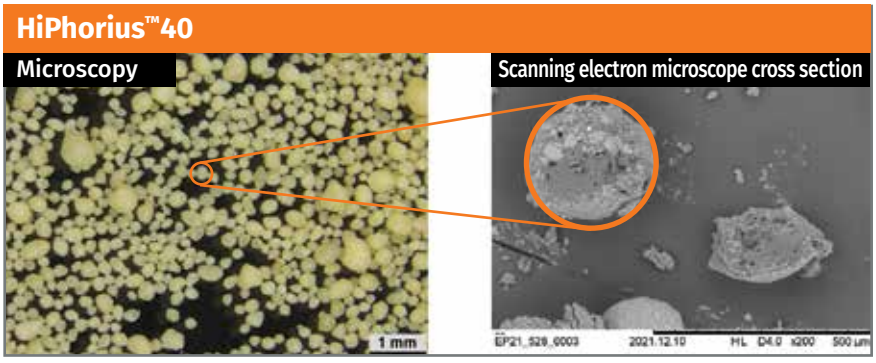


Figure 8. *ProAct 360™ microscopic image*



For additives used in very small amounts such as biotin, a spray-dried product ROVIMIX® Biotin with high particle counts is available to meet high uniformity in feed (Figure 9 opposite).

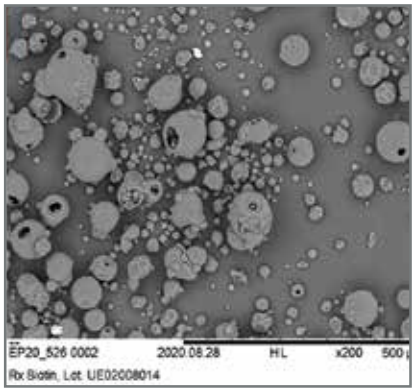
Continuous updating of our product range with innovative solutions proves that DSM responds to changes in market requirements and helps the industry deliver improved quality standards.

Figure 9. *ROVIMIX® Biotin Spray Dried vs Biotin Triturates, 2021*

ROVIMIX® Biotin 2% SD

Spray dried

All particles contain biotin!

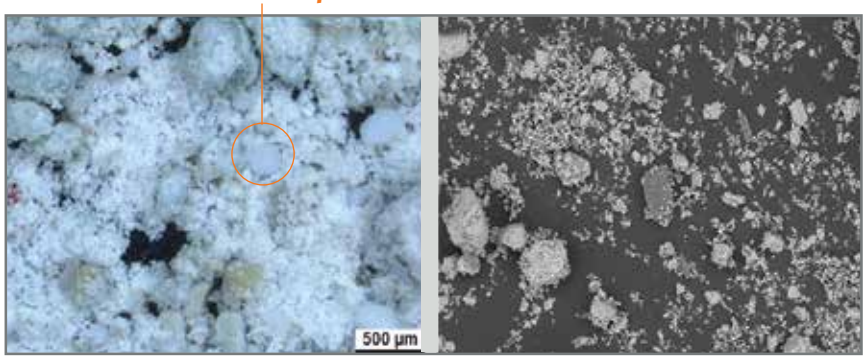




Other Biotin 2% Triturates

Triturates

ONLY 2% particles contain biotin!

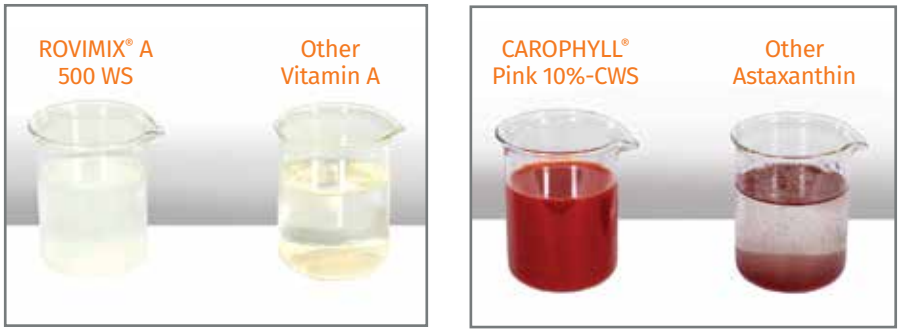


This is the amount of biotin which must be homogeneously mixed to feed per year for approx. 20 birds, or 1 pig, or 1 heifer, or 1 dog, or 4 salmon.

Water solubility

An efficient way to meet the additional vitamin needs of animals for short periods such as during transport or vaccinations is via the drinking water.
DSM provides special product forms containing stabilized vitamins that disperse easily when added to water (figure 10).

Figure 10



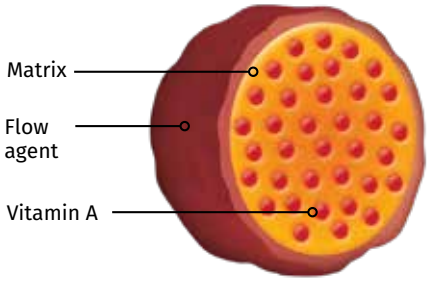
Stability

Feed additives need to:

- **withstand severe processes used in the feed industry** (e.g., high pelleting or extrusion temperatures, long retention times)
- **resist prolonged contact with aggressive components in premixtures** (e.g., minerals, choline chloride)
- **comply with** nutritional requirements and feed manufacturing guidelines **throughout storage time**

In the case of ROVIMIX® A1000, vitamin A stability is achieved by triple protection. The sensitive vitamin is stabilized with an antioxidant, embedded in a matrix, which is encapsulated to provide additional stability (Figure 11).

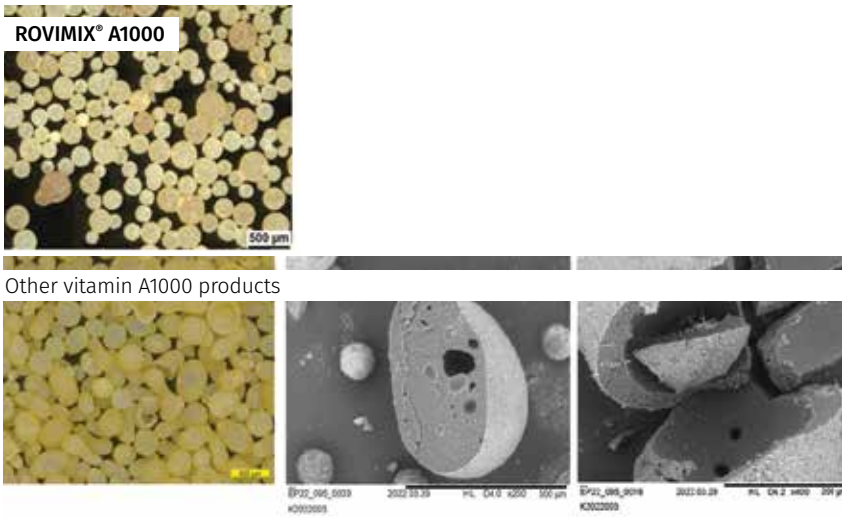
Figure 11. Section through an encapsulated beadlet (ROVIMIX® A1000)



Other vitamin A product forms contain a high number of broken particles with irregular size, holes and even air bubbles and cavities in the cross section of the vitamin product, making particles more brittle.

This could lead to poor mixability and lower stability since vitamin A will be more accessible to aggressive elements like oxygen, humidity and light (Figure 12).

Figure 12. *Microscopic images of vitamin A1000 particles*



Independents trials under practical pelleted feed industry conditions confirmed that ROVIMIX® A1000 proved to be much more stable than other vitamin A product forms (*Figure 13*).

Figure 13. *Vitamin A stability in pelleted feed, EU Premixer 2020*

	70°C (% vs target in feed)	80°C (% vs target in feed)	90°C (% vs target in feed)	Average (% vs target in feed)	Efficiency vs RX A1000
ROVIMIX® A1000	88%	106%	101%	98%	100%
Prod. A	49%	61%	52%	54%	55%
Prod. C	65%	57%	54%	59%	60%

- Premixes produced with three different vitamin A products
- Target vitamin A in feed = 10,000 IU vitamin A/kg feed
- Feed corn/wheat/soy produced by Kolding Technological Institute, Denmark
- Tests with 70-80-90ºC pelleting temperature and 30-60-120 seconds holding time
- Vitamin analyses carried out by LUFA Kiel lab, Germany (method REG(EC) 152/2009, IV, A)

The formulation of CAROPHYLL® products as beadlets makes them far more stable towards aggressive components in premix and feed (*Figure 14*)

The stability of vitamin C can be ensured either by coating the powder with ethyl-cellulose (ROVIMIX® C-EC) or by phosphorylation (ROVIMIX® STAY-C® 35). ROVIMIX® C-EC is designed for use in mash and pelleted feeds produced by using milder processing conditions. ROVIMIX® STAY-C® 35 is the form of choice in expanded and extruded feeds (*Figure 15*).

Figure 14. *Effect of storage time on total stability of red carotenoid products compared with CAROPHYLL® Red 10% for as-is (3 month), and mash feed (1 month)*

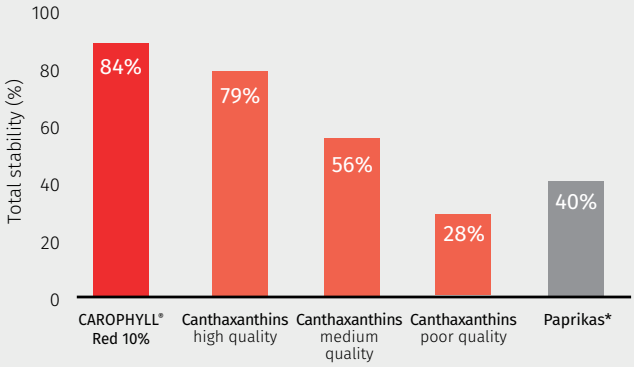
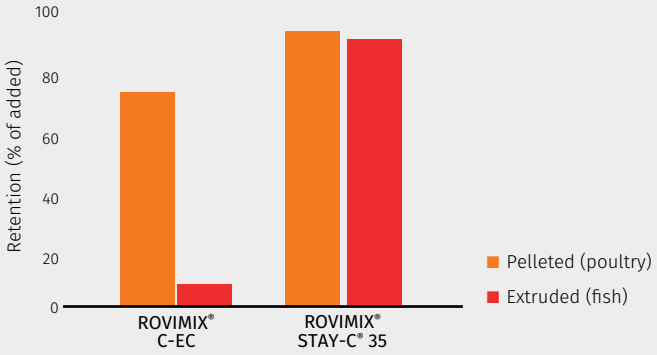


Figure 15. *Stability of vitamin C forms in pelleted and extruded feeds*



RONOZYME® (CT) and (GT) are coated and granulated thermo-stable product forms for enzymes. The unique CT and GT formulations ensure virtually dust free products with excellent mixability and best in class stability throughout the feed production processing (*Figures 16, 17, 18*).

Only extremely well formulated feed additives will survive a challenge such as increased retention time in the conditioner before pelleting (*Figure 19*).

Figure 16. *Heat stability of RONOZYME® WX 2000 (CT) and other xylanases*

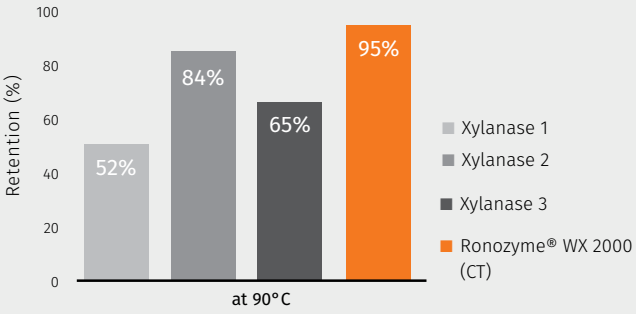


Figure 17. *Stability of RONOZYME® HiPhos 20,000 (GT) throughout the whole feed manufacturing process*

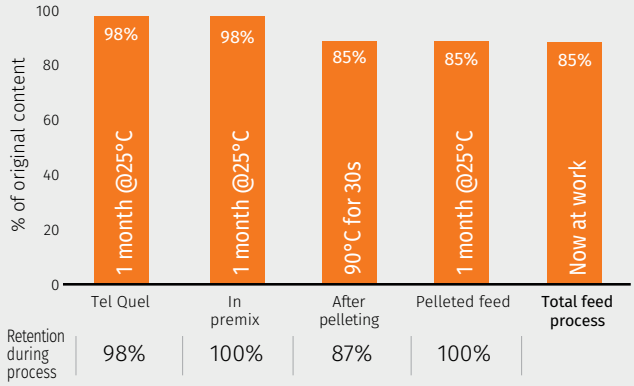


Figure 18. *HiPhorius™ pelleting stability (at 90ºC for 20 sec) vs other phytases*

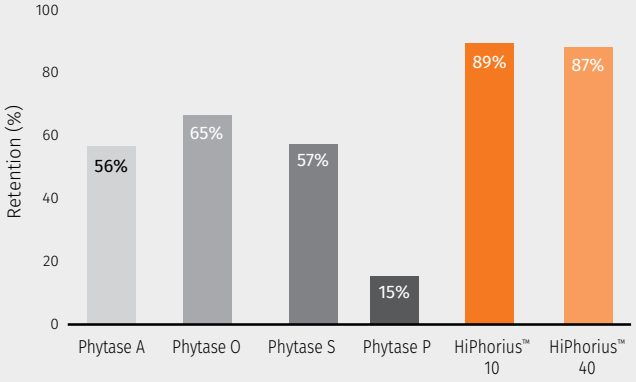
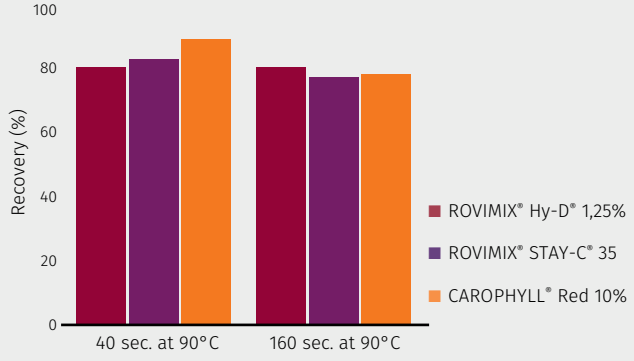


Figure 19. *Stability of DSM feed additives after two different retention times*

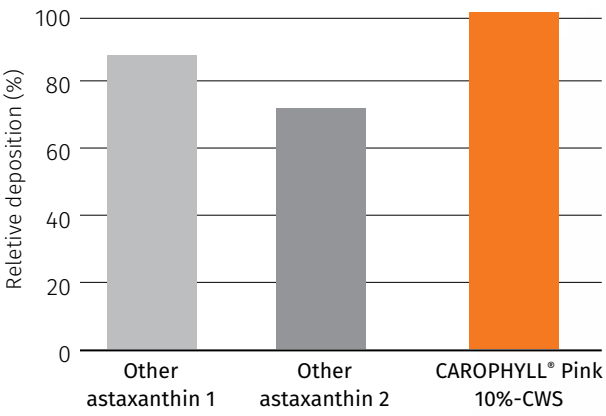


Bioavailability

Today´s farmers need to optimize the use of feed to grow productive and healthy animals. The bioavailability of the nutrients included in modern, high-efficiency feeds has therefore become an even more important factor. **Bioavailability, the proportion of a nutrient that is absorbed and used appropriately by the animal, is influenced considerably by the way it is formulated as a feed additive.**

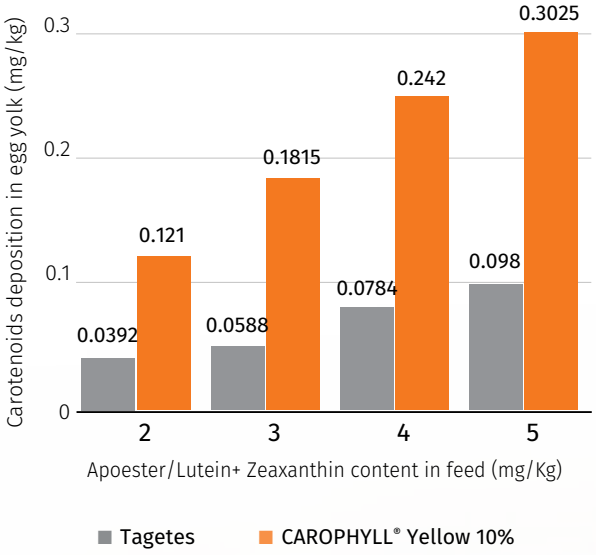
A good example of how product form influences bioavailability in products is carotenoids. The pure crystals, produced by chemical synthesis or fermentation, are seldom sufficiently bioavailable, reducing their effectiveness. With a well-developed formulation such as CAROPHYLL® Pink 10% CWS, bioavailability is increased significantly (*Figure 20*).

Figure 20. *Relative deposition rate (%) of astaxanthin products in trout fillets*



The formulation of CAROPHYLL® Yellow 10% is optimized to enable maximum stability during feed processing combined with high deposition rate in eggs (Figure 21).

Figure 21. *Carotenoids deposition (apoester or Lutein/ zeaxanthin) in egg yolk (mg/yolk)*



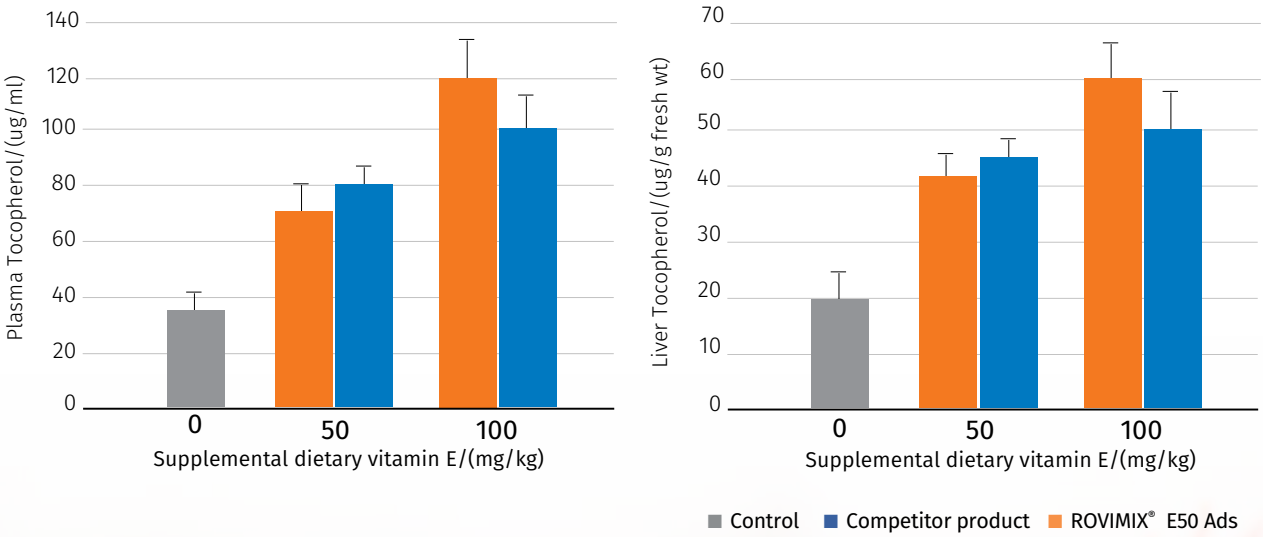
While the bioavailability of vitamin E is normally high, efforts to improve its physical characteristics can have a negative effect on its bioavailability. The formulation of ROVIMIX® E50 Adsorbate makes the product free flowing, no dusting potential characteristics for a proper mixability while maintaining a high rate of uptake by animals (*Figure 22*).





Figure 22. *Bioavailability of two Vitamin E 50 Ads forms: plasma and liver tocopherol concentration in chicks*

ROVIMIX® E50 Ads shows a better bioavailability in broilers at 100 mg vit E/kg



Whitehead, McCormack & McTeir, 2006



Commitment to Sustainability

As the world's population grows, demand for animal protein will continue to rise. Over time, this need for ever-increasing quantities of animal protein, which is already placing tremendous pressure on our planet's finite natural resources, will lead to significant environmental strain, and take our food systems well beyond the planet's boundaries.

Consequently, animal protein production is under pressure to reduce its environmental footprint, cutting levels of carbon dioxide, nitrous oxide and methane, and reducing nitrogen and phosphorus emissions which lead to eutrophication and subsequent biodiversity loss.

Sustainability is our core value and it underpins our Purpose Led. Performance Driven strategy

Right levels of quality and sustainable micro-nutrients (vitamins, enzymes, eubiotics, carotenoids, with premix and other specialty solutions) provided to feed manufacturers, integrators and farmers can help to improve animal health wellbeing and performance while protecting the environment.

DSM, the partner of choice to support your sustainability journey

To be a leader in climate action it's important to lead by example. Therefore we, at DSM, have introduced six sustainability platforms as part of our strategic initiative WE MAKE IT POSSIBLE, aligned to the United Nations Sustainable Development Goals (SDGs).



To support our customers on their journey of decarbonization and more sustainable business, we offer a series of services such as the Environmental Product Declarations (EPDs) of our main products, the carbon footprint of our premixes and our Sustell™ service which combines full life cycle assessment (LCA) of animal protein production with practical, science-based, proven solutions to unlock the value of more sustainable business practices.

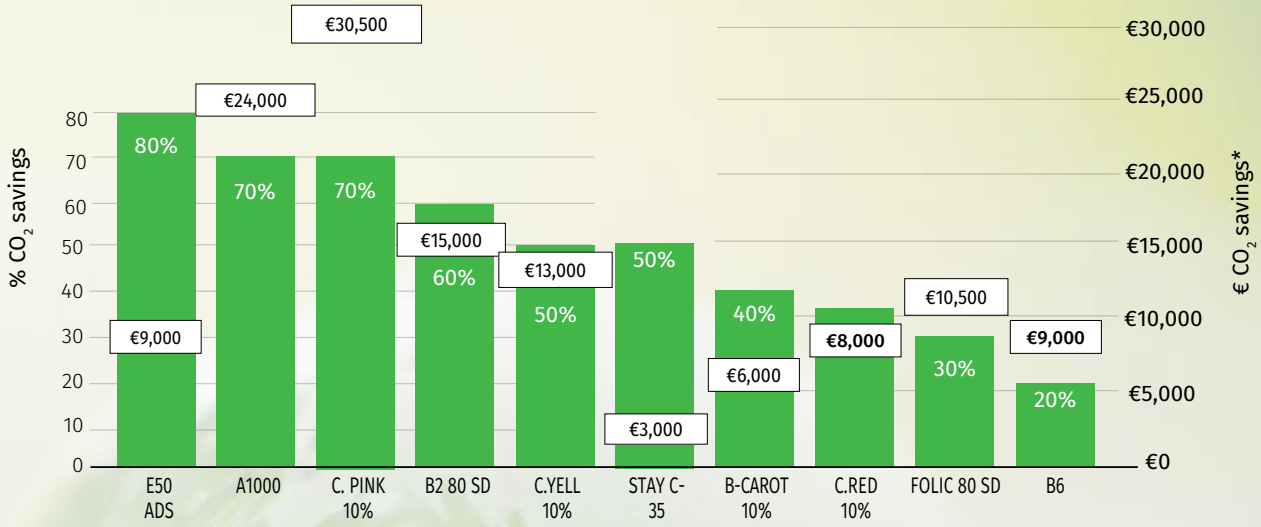
Environmental Product Declarations

As part of our sustainability commitment, we have developed the Environmental Product Declarations (EPDs) which transparently provides environmental footprint information to support purchasing decisions and to help you to assess your own product sustainability.



Reducing the carbon footprint of vitamin and other feed additive operations enable feedmills and farmers to become more sustainable, reduce their risk profile and to potentially benefit from value created from future carbon tax savings (*Figure 23*).

Figure 23. *CO_2 savings and potential € value (carbon tax) per 10 t product form (DSM vs main alternative, 2021)*



** Value of CO_2 saving assuming a Carbon Credit or Tax of €50 per t CO_2*

Carbon pricing

Carbon pricing – whether implemented as a tax or cap and trade system - seeks to reduce greenhouse gas (GHG) emissions by putting a direct financial liability on industries and activities which are large GHG emitters. It is a policy intervention to encourage the reduction of harmful activities.

This transition to a lower carbon future for animal proteins can be facilitated by supplying nutritional ingredients with industry-leading performance, improving the efficiency of animal production systems while reducing the carbon footprint of these feed additives and those premixes and feed within which they are utilized.

Critical review

Our EPDs are based on DSM LCA expertise and prepared according to an assured process from DNV following ISO 14021.

DSM CO_2 Reduce programme

CO2REDUCE is our supplier engagement program, which was started in 2018 to work in close collaboration with our key suppliers on sharing ambitions, exchanging carbon footprint information and the creation of reduction roadmaps for achieving our emissions targets. As a consequence , the greenhouse gas performance of a supplier is a key criterion in supplier selection and volume contracting. In 2020 DSM already achieved a 5% reduction on Scope 3 emissions through the CO2REDUCE program.

Sustell™

Doing well by doing good

Sustell™ is a user-friendly, intelligence platform for improving the sustainability of animal protein production.

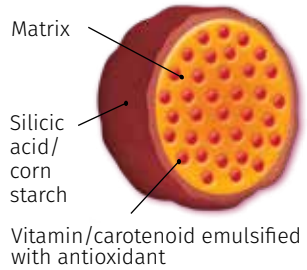
Sustell™ utilizes primary, farm-level data to simplify the complexity of measuring and validating animal protein production in order to improve the farm`s environmental sustainability footprint. Sustell™ utilizes data farm by farm, system by system and always transparently and scientifically.

At your fingertips, Sustell™:

- Measures the environmental footprint of all major sources of animal protein per kg of dairy produces, eggs and meat
- Features ISO Certified Environmental Footprint calculations, verified and analyzed by the Sustell™ experts. Also compliant with the internationally recognized FAO LEAP guidelines and Product Environmental Footprint Category Rules (PEFCR)
- Sustell™ provides a comprehensive environmental footprint beyond CO_2 eq. considering 19 environmental variables e.g. acidification, water scarcity, LUC, eutrophication (N,P), setting Sustell™ apart from competitors
- Empowers users with real-time knowledge of the environmental footprints of feed and farm operations
- Enables users to take ownership of their footprint and not be judged on industry averages
- Ensures greater precision in animal farming through the use of internationally validated, up-to-date, science-based data analysis
- Is proven to help identify improvement areas with followed interventions for tangible, actual emission reduction.

Product forms

Beadlet/ Cross linked beadlet





Active substance

β-carotene

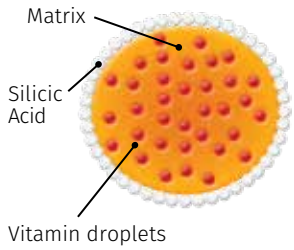
Canthaxanthin
Apo-ester
Astaxanthin

Vitamin A
Vitamin AD_3
Essential oils

DSM product

ROVIMIX® β-Carotene 10%
ROVIMIX® β-Carotene 10% P
CAROPHYLL® Red 10%
CAROPHYLL® Yellow 10%
CAROPHYLL® Pink 10%-CWS
CAROPHYLL® Pink
ROVIMIX® A 1000
ROVIMIX® AD_3 1000/200
Digestarom® P.E.P. MGE

Spray dried





Active substance

Vitamin A
Vitamin E
25 hydroxy cholecalciferol
Vitamin D_3
Vitamin C
Vitamin B_2
Vitamin B_{12}
D-Pantothenic acid (Vit B_5)
D- Biotin (Vit B_7)

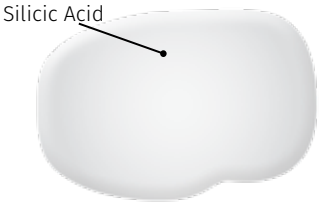
Folic acid (Vitamin B_9)

Autolyzed yeast
Saccharomyces cerevisiae

DSM product

ROVIMIX® A 500 WS
ROVIMIX® E 50 SD
ROVIMIX® Hy-D® 1,25%
ROVIMIX® D_3 500
ROVIMIX® STAY-C® 35
ROVIMIX® B_2 80-SD
ROVIMIX® B_{12} 1% Feed Grade
ROVIMIX® Calpan
ROVIMIX® Biotin
ROVIMIX® Biotin HP
ROVIMIX® Folic 80 SD
Levabon®

Adsorbate



Active substance adsorbed on silicic acid



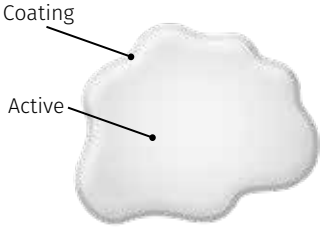
Active substance

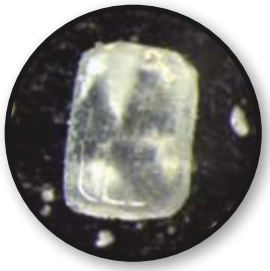
Vitamin E
Glycans
Essential oil + extracts

DSM product

ROVIMIX® E-50 Adsorbate
Symphiome™ Poultry
CRINA® Ruminants
Digestarom® P.E.P. Poultry
Digestarom® Finish
Digestarom® Sow
Digestarom® Dairy
Digestarom® Calf

Coated





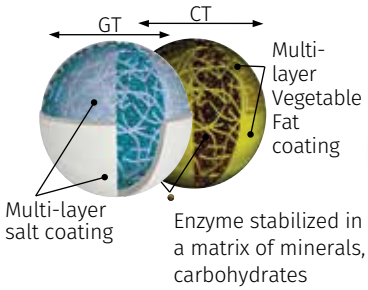
Active substance

Vitamin C
Cobalt
Iodine
Selenium

DSM product

ROVIMIX® C-EC
Microgran® Co 5% BMP
Microgran® I 10% BMP
Microgran® Se 1% BMP
Microgran® Se 4,5% BMP

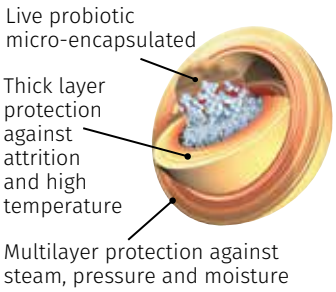
CT & GT Granule





Active substance	DSM product
Phytase	HiPhorius™10 HiPhorius™40 RONOZYME® HiPhos 20,000 (GT) RONOZYME® HiPhos (GT)
Xylanase	RONOZYME® WX 2,000 (CT) RONOZYME® WX 5,000 (CT)
Beta-glucanase Pectinases Alpha-amylase	RONOZYME® MultiGrain (GT) RONOZYME® VP (CT) RONOZYME® HiStarch (CT) RONOZYME® HiStarch 900 (CT)
Protease	RONOZYME® RumiStar® 600 (CT) RONOZYME® ProAct (CT) ProAct 360™ (GT)
Muramidase	Balancius® C

Micro-encapsulated





Active substance	DSM product
	Multilayer micro-encapsulated
Enterococcus faecium (Probiotic)	CYLACTIN® LBC ME20 plus
Enterococcus faecium *Pediococcus acidilactici* *Bifidobacterium animalis* *Lactobacills reuteri* *Lactobacillus salivarius* (Probiotic)	PoultryStar® me.* PoultryStar® me conc.*
Essential oil compounds	**Micro-encapsulated** CRINA® Digest

* probiotic species vary between regions

Crystalline Powder/Powder

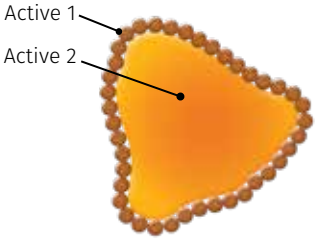


Vitamin in crystalline form



Active substance	DSM product
	Crystalline Powder
Vitamin B_1 Vitamin B_6 Niacin	ROVIMIX® B_1 ROVIMIX® B_6 ROVIMIX® Niacin ROVIMIX® Niacinamide
Vitamin K_3 Vitamin B_{12}	ROVIMIX® K_3 MNB Vitamin B_{12} 1% Feed Grade
Vitamin C	STAY-C® 50
	Powder
Bentonite FUM*zyme*® ZEN*zyme*® BBSH® 797 Bioprotection Mix	Mycofix® Plus Mycofix® Select Mycofix® Secure Mycofix® Focus Mycofix® PRO-Tect

Flake & Flavor flake





Active substance	DSM product
Benzoic Acid	VevoVitall®
Essential oil compounds + benzoic acid	CRINA® Poultry Plus
DHA	DHAgold™ DHAgold™ S17-B

Technical information

Category/Product	Critical issue	Formulation Technology for solving critical issue	DSM Product
Carotenoids			
β-carotene	Stability	Beadlet	ROVIMIX® β-Carotene 10%
	Stability	Cross-linked beadlet	ROVIMIX® β-Carotene 10% P
Canthaxanthin	Stability, bioavailability	Beadlet (Cold Water Soluble)	CAROPHYLL® Red 10%
Apo-ester	Stability, bioavailability	Beadlet (Cold Water Soluble)	CAROPHYLL® Yellow 10%
Astaxanthin	Stability, bioavailability	Beadlet (Cold Water Soluble)	CAROPHYLL® Pink 10%-CWS
	Stability, bioavailability	Beadlet	CAROPHYLL® Pink
Vitamins			
Vitamin A	Stability, bioavailability	Beadlet	ROVIMIX® A 1000
	Water solubility, stability	Spray-dried powder, water dispersible	ROVIMIX® A 500 WS
	Stability in oily solutions	Oily liquid, may cristalize on storage	ROVIMIX® A Palmitate 1.6
Vitamin D_3	Uniform mixing, stability	Spray-dried powder, water dispersible	ROVIMIX® D_3 500
Vitamin AD_3	Stability	Beadlet	ROVIMIX® AD_3 1000/200
25-OH-D_3 (25 hydroxy-cholecalciferol)	Uniform mixing, stability	Spray-dried powder, water dispersible	ROVIMIX® Hy-D® 1,25%
Vitamin E	Handling, flowability	Adsorbate on silicic acid	ROVIMIX® E-50 Adsorbate
	Solubility, stability	Spray-dried powder, water dispersible	ROVIMIX® E 50 SD
Vitamin K_3	Stability	Fine crystalline powder	ROVIMIX® K_3 MNB
Vitamin B_1	Stability, flowability	Fine crystalline powder	ROVIMIX® B_1
Vitamin B_2	Handling, flowability	Spray-dried powder	ROVIMIX® B_2 80-SD
Vitamin B_6	Stability, handling, flowability	Fine crystalline powder	ROVIMIX® B_6
Vitamin B_{12}	Uniform mixing	Fine powder	Vitamin B_{12} 1% Feed Grade
	Uniform mixing	Spray-dried powder	ROVIMIX® B_{12} 1% Feed Grade
Niacin ((Nicotinic acid, vitamin B_3)	Handling	Fine crystalline powder	ROVIMIX® Niacin
Nicotinamide (Vitamin B_3)	Handling	Fine crystalline powder	ROVIMIX® Niacinamide
D-Pantothenic acid (Vitamin B_5)	Handling	Spray-dried powder, water dispersible	ROVIMIX® Calpan
Folic acid (Vitamin B_9)	Stability, flowability	Spray-dried powder, water dispersible	ROVIMIX® Folic 80 SD
D-Biotin (Vitamin B_7)	Uniform mixing	Spray-dried powder, water dispersible	ROVIMIX® Biotin
	Uniform mixing	Spray-dried powder, water dispersible	ROVIMIX® Biotin HP
Vitamin C	Stability	Ethylcellulose coated powder	ROVIMIX® C-EC
	Stability, bioavailability	Spray-dried powder	ROVIMIX® STAY-C® 35
	Stability, bioavailability	Fine crystalline powder	STAY-C® 50

Application					Retention (%) of formulated products after 3 months storage at room temperature			
Mash	Pellet	Expansion	Extrusion	Milk replacer /water	Complete premix (60% RH)	Pelleting (80°C)	Expanding (100°C)	Extruding (120°C)
●	●			●	80 - 95	70 - 90	60 - 85	50 - 75
●	●	●	●		75 - 90	80 - 90	80 - 90	70 - 95
●	●	●	●	●	90 - 100	95 - 100	90 - 100	90 - 100
●	●	●	●	●	90 - 100	80 - 100	80 - 100	70 - 90
●	●	●	●	●	90 - 100	80 - 100	80 - 100	70 - 90
●	●	●	●		90 - 100	80 - 100	80 - 100	70 - 90
●	●	●	●		70 - 90	85 - 95	70 - 90	70 - 90
				●	60 - 90			
				Oily solutions				
●	●	●	●	●	80 - 100	90 - 95	80 - 95	75 - 100
●	●	●	●		70 - 90	85 - 95	70 - 90	70 - 90
●	●	●	●	●	80 - 90	90 - 100	80 - 100	75 - 100
●	●	●	●		90 - 100	90 - 100	90 - 100	90 - 100
●	●	●	●	●	90 - 100	90 - 100	90 - 100	90 - 100
●	●	●	●		65 - 85	70 - 90	50 - 70	40 - 70
●	●	●	●		70 - 80	85 - 100	70 - 80	60 - 80
●	●	●	●	●	90 - 100	90 - 100	90 - 100	90 - 100
●	●	●	●	●	80 - 90	90 - 100	80 - 90	80 - 90
●	●	●	●		50 - 80	60 - 90	50 - 80	40 - 80
●	●	●	●		50 - 80	60 - 90	50 - 80	40 - 80
●	●	●	●		90 - 100	90 - 100	90 - 100	90 - 100
●	●	●	●	●	90 - 100	90 - 100	90 - 100	90 - 100
●	●	●	●	●	80 - 100	90 - 100	80 - 100	80 - 100
●	●	●	●	●	50 - 70	70 - 90	50 - 70	50 - 65
●	●	●	●	●	80 - 100	90 - 100	70 - 90	70 - 90
●	●	●	●	●	80 - 100	90 - 100	70 - 90	70 - 90
●	●			●	30 - 70	30 - 70	30 - 50	10 - 30
●	●	●	●		90 - 100	90 - 100	90 - 100	90 - 100
●	●	●	●	●	90 - 100	90 - 100	90 - 100	90 - 100

Technical information

Category/Product	Critical issue	Formulation Technology for solving critical issue	DSM Product
Enzymes			
Phytases	Stability, uniform mixing, low dust	Granulated Thermostable	RONOZYME® HiPhos 20,000 (GT)
	Stability, uniform mixing, low dust	Granulated Thermostable	RONOZYME® HiPhos (GT)
	Stability, uniform mixing, low dust	Micro granule	RONOZYME® HiPhos (M)
	Post pelleting application	Liquid	RONOZYME® HiPhos (L) added post process
	Post pelleting application	Liquid	RONOZYME® HiPhos 50,000 (L) added post process
	Stability, uniform mixing, low dust	Coated Thermostable	HiPhorius™ 10
	Stability, uniform mixing, low dust	Coated Thermostable	HiPhorius™ 40
	Post pelleting application	Liquid	HiPhorius™ 20 (L) added post process
	Post pelleting application	Liquid	HiPhorius™ 50 (L) added post process
NSP-enzymes	Stability, uniform mixing, low dust	Coated Thermostable	RONOZYME® WX 2,000 (CT)
	Stability, uniform mixing, low dust	Coated Thermostable	RONOZYME® WX 5,000 (CT)
	Post pelleting application	Liquid	RONOZYME® WX 2,000 (L) added post process
	Stability, uniform mixing, low dust	Coated Thermostable	RONOZYME® VP (CT)
	Post pelleting application	Liquid	RONOZYME® VP (L) added post process
	Stability, uniform mixing, low dust	Granulated Thermostable	RONOZYME® MultiGrain (GT)
	Post pelleting application	Liquid	RONOZYME® MultiGrain (L) added post process
Protease	Stability, uniform mixing, low dust	Coated Thermostable	RONOZYME® ProAct (CT)
	Post pelleting application	Liquid	RONOZYME® ProAct (L) added post process
	Stability, uniform mixing, low dust	Granulated Thermostable	ProAct 360™ (GT)
Amylases	Stability, uniform mixing, low dust	Coated Thermostable	RONOZYME® HiStarch (CT)
	Stability, uniform mixing, low dust	Coated Thermostable	RONOZYME® HiStarch 900 (CT)
	Stability, uniform mixing, low dust	Coated Thermostable	RONOZYME® RumiStar® 600 (CT)
Mycotoxin Risk Management			
Mycotoxin Risk Management	Handling, Dust emission	Powder	Mycofix® Plus
	Handling, Dust emission	Powder	Mycofix® Select
	Handling, Dust emission	Powder	Mycofix® Secure
	Handling, Dust emission	Powder	Mycofix® Focus
	Handling, Dust emission	Powder	Mycofix® PRO-Tect

Application					Retention (%) of formulated products after 3 months storage at room temperature			
Mash	Pellet	Expansion	Extrusion	Milk replacer /water	Complete premix (60% RH)	Pelleting (80°C)	Expanding (105°C)	Extruding (120°C)
●	●				90 - 100	85 - 95	apply (L) form	apply (L) form
●	●				85 - 100	85 - 100	apply (L) form	apply (L) form
●					80 - 100		apply (L) form	apply (L) form
	●	●	●			90 - 100	90 - 100	90 - 100
	●	●	●			90 - 100	90 - 100	90 - 100
●	●				85 - 100	85 - 100	apply (L) form	apply (L) form
●	●				85 - 100	85 - 100	apply (L) form	apply (L) form
	●	●	●			90 - 100	90 - 100	90 - 100
	●	●	●			90 - 100	90 - 100	90 - 100
●	●				85 - 100	85 - 100	apply (L) form	apply (L) form
●	●				85 - 100	85 - 100	apply (L) form	apply (L) form
	●	●	●			90 - 100	90 - 100	90 - 100
●	●				85 - 100	75 - 90	apply (L) form	apply (L) form
	●	●	●			90 - 100	90 - 100	90 - 100
●	●				85 - 100	85 - 100	apply (L) form	apply (L) form
	●	●	●			90 - 100	90 - 100	90 - 100
●	●				85 - 100	85 - 100		
	●	●	●			90 - 100	90 - 100	90 - 100
●	●				90 - 100	85 - 100		
●	●				90 - 100	85 - 100		
●	●				90 - 100	85 - 100		
●	●				90 - 100	85 - 100		

●	●				80 - 100	80 -90		
●	●				80 - 100	80 -90		
●	●				100	100		
●	●				90 - 100	80 -90		
●	●				90 - 100	90 -100		

Technical information

Category/ Product	Critical issue	Formulation Technology for solving critical issue	DSM Product
Eubiotics			
Gut health enzyme	Stability	Coated thermostable	Balancius® C
	Pos pellet application	Liquid	Balancius® L added post process
Microbials Modulators (Probiotics)	Stability, efficacy	Multilayer Microencapsulation	CYLACTIN® LBC ME20 plus
	Water solubility, stability	Micro granule	CYLACTIN® LBC G35
	Stability, efficacy	Multilayer Microencapsulation	PoultryStar® me
	Stability, efficacy	Multilayer Microencapsulation	PoultryStar® me conc.
	Water solubility	Carrier	PoultryStar® sol
	Water solubility	Carrier	PoultryStar® sol conc.
	Stability, efficacy	Carrier	AquaStar® Hatchery; AquaStar® GH
	Stability, efficacy	Carrier	AquaStar® Pond, AquaStar® PondZyme,
Microbials Modulators (Prebiotics)	Handling, Dust emission	Spray-dried powder	Levabon®
Microbials Modulators (Precision biotic)	Moisture uptake, flowability	Powder	Symphiome™ Poultry
Phytogenics	Stability, efficacy	Adsorbate	CRINA® Ruminants
	Stability, efficacy	Flavor flake	CRINA® Poultry Plus
	Stability, efficacy	Microencapsulation	CRINA® Digest
	Stability, efficacy	Adsorbate	Digestarom® P.E.P. Poultry
	Stability, efficacy	Adsorbate	Digestarom® Finish
	Stability, efficacy	Adsorbate	Digestarom® Sow
	Stability, efficacy	Adsorbate	Digestarom® Dairy
	Stability, efficacy	Adsorbate	Digestarom® Calf
	Stability, efficacy	Beadlet (matrix-encapsulation)	Digestarom® P.E.P. MGE
	Water application	Emulsifier	Digestarom® P.E.P. sol
	Fast oral application	Oral applicator	Digestarom® P.E.P. liquid
	Dust emission	Flake	VevoVitall®
Organic acids	Stability, handling	Carrier with high liquid absorbing capacity	Biotronic® Top3
	Stability, handling	Carrier with high liquid absorbing capacity	Biotronic® Top forte
	Stability, handling	Carrier with high liquid absorbing capacity	Biotronic® SE
	Stability, handling	Carrier with high liquid absorbing capacity	Biotronic® PX Top3
	Handling	Buffered	Biotronic® Top Liquid
Other additives			
Nutritional lipids	Handling	Flake	DHAgold™
	Handling	Flake	DHAgold™ S17-B
Trace minerals	Dust emission, handling, uniform mixing	Coated	MICROGRAN® Co 5% BMP
	Dust emission, handling, uniform mixing	Coated	MICROGRAN® I 10% BMP
	Dust emission, handling, uniform mixing	Coated	MICROGRAN® Se 1% BMP
	Dust emission, handling, uniform mixing	Coated	MICROGRAN® Se 4.5% BMP

Application					Retention (%) of formulated products after 3 months storage at room temperature			
Mash	Pellet	Expansion	Extrusion	Milk replacer /water	Complete premix (60% RH)	Pelleting (85°C)	Expanding (105°C)	Extruding (120°C)
●	●				80 - 90	90 - 95	Apply L form	Apply L form
	●	●	●			95 - 100	95 - 100	95 - 100
●	●	●			85 - 90	80 - 100		
●				●	40 - 60			
●	●				95 - 100	80 - 100		
●	●				95 - 100	80 - 100		
				●				
				●				
◗●				●				
				●				
●	●	●	●		95 - 100	95 - 100	95 - 100	95 - 100
●	●	●	●		95 - 100	95 -100	95 - 100	95 - 100
●	●				90 - 100	90 - 100		
●	●				90 - 100	80 - 100		
●	●				90 - 100	90 - 100		
●	●				90 - 100	90 - 100		
●	●				90 - 100	90 - 100		
●	●				90 - 100	90 - 100		
●	●				90 - 100	90 - 100		
●	●			●	90 - 100	90 - 100		
●	●	●	●		90 - 100	90 - 100	90 - 100	85 - 100
				●				
				Oral application				
●	●	●	●	●	90 - 100	90 - 100	90 - 100	90 - 100
●	●	●	●		90 - 100	80 - 100	70 - 90	70 - 90
●	●	●	●		90 - 100	80 - 100	70 - 90	70 - 90
●	●	●	●		90 - 100	90 - 100	70 - 90	70 - 90
●	●	●	●	●	90 - 100	90 - 100	80 - 100	80 - 100
●				●	70 - 100			

●	●	●	●		90 - 100	90 - 100	80 - 100	80 - 100
●	●	●	●		90 - 100	90 - 100	80 - 100	80 - 100
●	●	●	●		90 - 100	90 - 100	90 - 100	90 - 100
●	●	●	●		90 - 100	90 - 100	90 - 100	90 - 100
●	●	●	●		90 - 100	90 - 100	90 - 100	90 - 100
●	●	●	●		90 - 100	90 - 100	90 - 100	90 - 100

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