



Matching today's expectations.
Orafti® functional fibres for
modern poultry production.

beneo
connecting nutrition and health



Matching today's expectations.

Ongoing optimisation of poultry genetics and increased flock density have raised the bar on performant poultry production. Modern producers have to comply with the global trend to cut back on antimicrobial growth promoters in feed, and simultaneously live up to rising nutritional requirements, a growing demand for animal protein, environmental restrictions and increased consumer awareness.

They are therefore more than ever in search of **safe, natural and functional feeds** to maximise their animals' digestive health and nutrient uptake and achieve the highest possible growth and bird performance. Global poultry research of the past decades revealed that **Orafti® functional fibres, notably prebiotic fructans extracted from the chicory root, show strong potential** in this respect as they are a **good source of dietary fibre**.

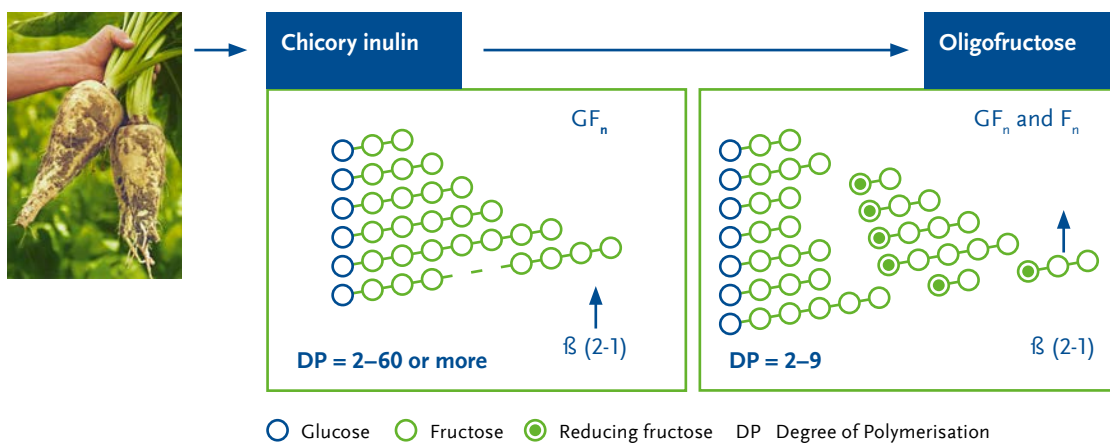
A prebiotic feed ingredient.

The chicory root is widely processed for the creation of highly concentrated inulin-based products because it contains one of the highest levels of crude inulin in comparison to other natural sources ($\pm 17\%$). Inulin-type fibres are fructans that belong to the group of soluble Non-Starch Polysaccharides (NSP). Their specific beta 2-1 glycosidic bond is resistant to degradation by digestive enzymes. As a consequence, chicory inulin and oligofructose end up almost intact in the hindgut. In addition, they can only be fermented by strains of highly selective, beneficial bacteria such as *Bifidobacterium* and *Lactobacillus*, typically present in these lower gut structures. These characteristics make them by definition **genuine plant-based prebiotic compounds**.

After a hot-water extraction process, crude chicory inulin is purified and concentrated, comprising a long chain length (average Degree of Polymerization >10). As native chicory inulin is less soluble, it is hydrolysed enzymatically to obtain smaller oligofructose fibres (DP <10) (Fig.1). This enhances its solubility as well as its palatability.



Fig. 1: Enzymatic hydrolysis of chicory root extracted inulin to oligofructose.



Exceptional product stability.

Our wide range of inulin-type fructans showcase good stability under thermal and acid conditions, as well as prolonged shelf life. They are offered in **varying concentrations and grades of polymerisation**, based on different chicory inulin to oligofructose ratios. This allows for ingredient solutions that can be customised following specific needs and (technical) requirements.

Improved health and animal performance.

Highly targeted fermentation in hindgut.

Poultry require very targeted and effective prebiotic compounds to benefit fully from the effect on microbiota, taking place within the small 'prebiotic window'. Here, mucosal immunity and mineral absorption can be stimulated substantially.

Biological and in-vitro studies confirm the **high robustness of Orafiti® prebiotic fibres throughout the gastro-intestinal tract**. They remain maximally available for highly selective fermentation as they are affected minimally by enzymatic digestion. Chicory inulin and oligofructose undergo a gradual degradation starting as early as distal ileum (oligofructose) or caeca (chicory inulin) (Fig. 2). Dietary inclusion of chicory inulin and oligofructose shows higher microbial counts of beneficial bifidobacteria and lactobacilli and lower levels of detrimental bacteria such as pathogenic *E. coli* and clostridia (Fig. 3).

Fig. 2: Targeted fermentation of inulin-type fructans in avian hindgut (in green).

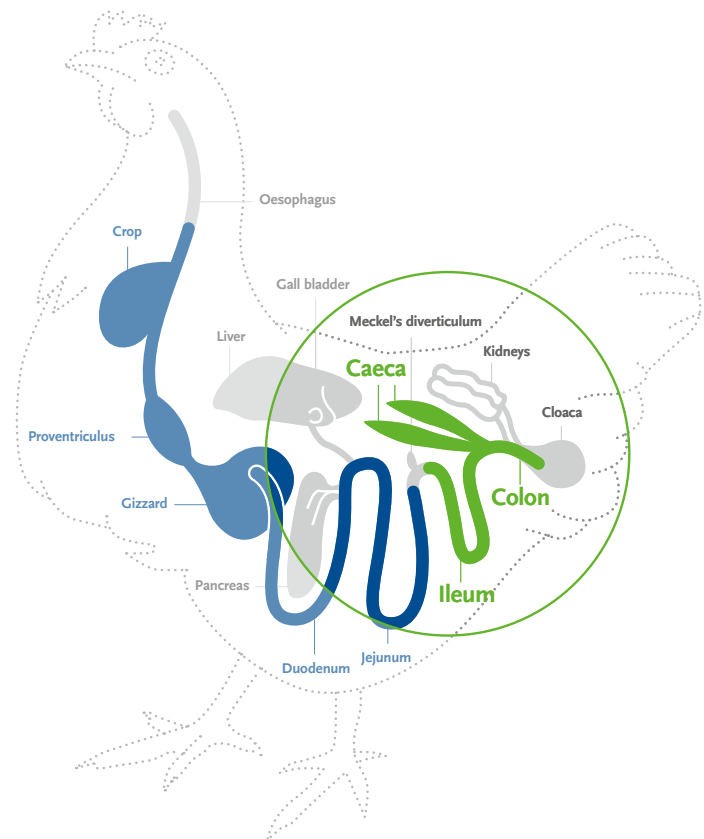
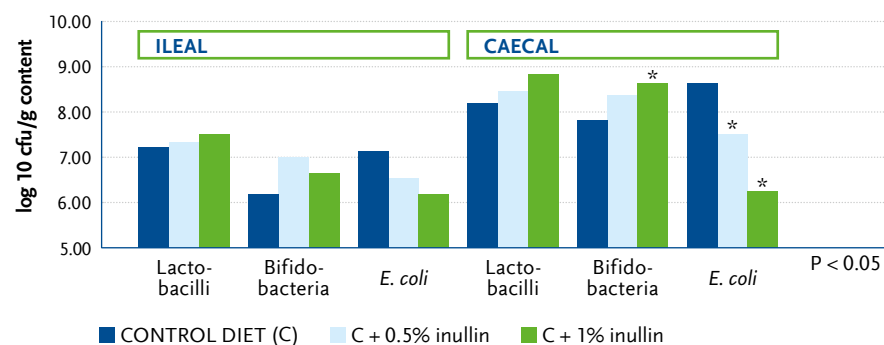


Fig. 3: Beneficial gut microbiota changes in broiler chickens at 42d of age induced by supplementation of Orafiti® chicory inulin (Adapted from Nabizadeh *et al.*, 2012a)



The impact of inulin-type prebiotics on digestive health.

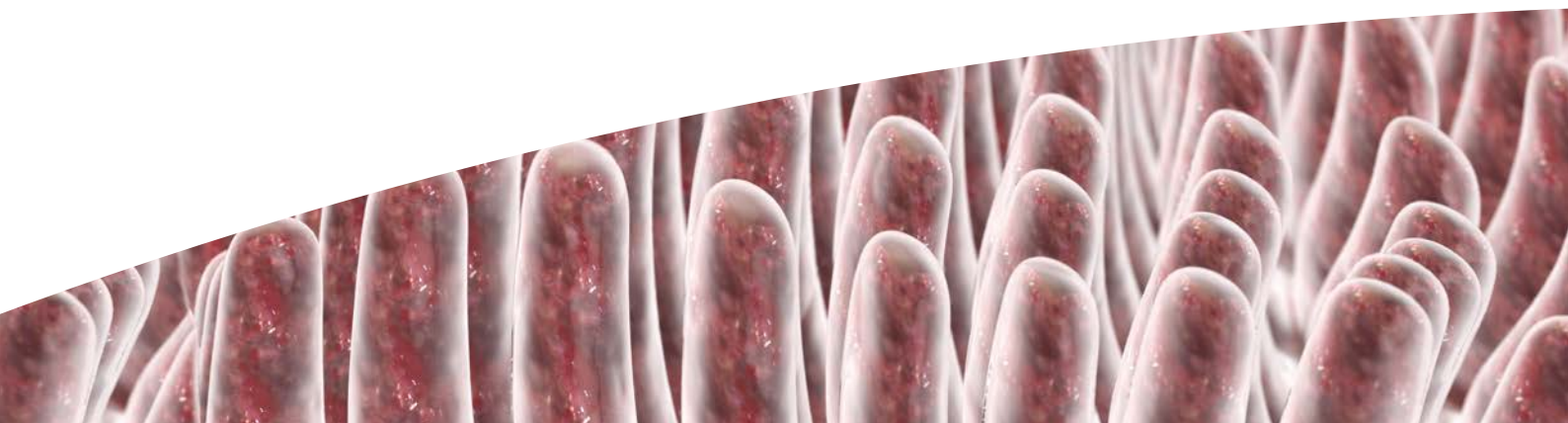
Improved microflora profile & intestinal architecture.

Intestinal health research from previous decades on humans as well as farm animals reveals the high fermentability of inulin-type fructans by very specific beneficial bacteria. Significant increases in microbial counts of mainly **bifidobacteria and lactobacilli** or the levels of volatile fatty acids as their metabolic products (Table 1), were detected in intestinal digesta samples*. **These short-chain fatty acids stimulate growth of mucosal cells resulting in healthier villi structures of the intestinal walls.** Clear prebiotic effects can be observed in ileum, but the strongest microflora changes take place in the caeca and colon.

These **profound changes in microbial composition have shown to improve gut morphology and immune response**, which is especially important during periods of high stress. The higher share of good bacteria suppresses protein-fermenting bacteria (and as a consequence reduce wet litter). This was observed in broiler and laying hen trials that showed lower ammonia levels in hindgut and faecal content. **Inulin-type fructans can therefore contribute to lower farm emissions and cleaner, farmed poultry products***.

Table 1: The effect of supplementing (prebiotic) chicory inulin and oligofructose to poultry diets on intestinal volatile fatty acids and pH levels.

Study	Supplemented prebiotic ingredient and dose	Poultry type	Age at sampling	Intestinal site of sampling	Total SCFA level (µmol/g digesta)		pH in digesta sample	
					Control	Treatm.	Control	Treatm.
Juskiwiecz <i>et al.</i> , 2002	0.4% chicory inulin (diet)	turkey poults	6 weeks	caecum (P<0.05)	119.07	131.43	/	/
Stanczuk <i>et al.</i> , 2005	0.1% chicory inulin (diet)	turkey poults	8 weeks	faecal (P<0.01)	20.58 ^B	46.17 ^A	5.65	5.56
Rebolé <i>et al.</i> , 2010	1% chicory inulin (diet)	broiler chicks	35 days	caecum (P<0.05)	42.6	44.8	6.26	6.15
Peinado <i>et al.</i> , 2013 (in vitro)	10 mg oligofructose from chicory derived inulin per mL of fermentation medium	broiler chicks	21 days	caecum (P<0.05)	14.1 ^b (µmol/mL)	27.9 ^a (µmol/mL)	6.9 ^a	4.2 ^b



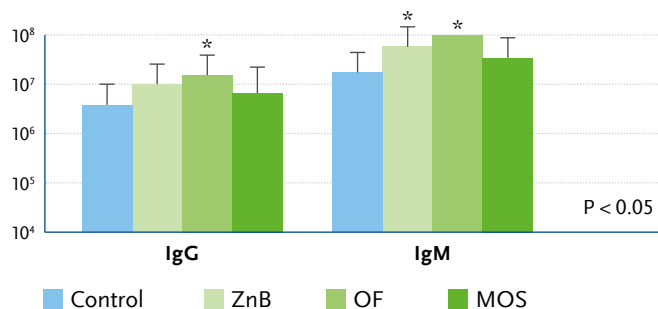


A natural, prophylactic feed ingredient.

Recent research on the application of the chicory root as a dietary growth promoter provided a strong indication of improved immune response. In comparison to preventive antimicrobials inulin as well as oligofructose (OF) show similar or improved antibody synthesis (Fig. 4) and related animal performance*.

Inulin-type fructans are suggested as a dietary solution for the effective and natural replacement of sub-therapeutic, in-feed antibiotics. They **interact directly with immuno-regulating cells of mucosal villi**. Indirectly, their beneficial fermentation favours mucin production via SCFA-induced acidification, but also generates microbial products that bind to mucosal cells' receptors.

Fig. 4: Plasma IgG and IgM antibody levels in broiler chickens fed an oligofructose (OF), mannan-oligosaccharides (MOS) or Zinc bacitracin (ZnB) supplemented or control diet. Adapted from Janardhana *et al.*, 2009



Higher overall nutrient and mineral utilisation.

By strongly promoting the growth of beneficial bacteria in the poultry hindgut, inulin-type fructans increase **solubility and intestinal absorption of important minerals**. Most of them are related to the increased production of short-chain fatty acids, as well as to alterations of the mucosal surface. Supplementation of chicory inulin/oligofructose in broilers and laying hens has shown significant impact on **bone strength or eggshell quality***. Especially in the case of diet-induced mineral interferences, such an enhanced bacterial fermentation pattern can be crucial in achieving the bird's mineral requirements (e.g. calcium, magnesium).



Providing a head start to day-old chicks.

In young bird nutrition like in (pre-)starter diets, prebiotic fibres **stimulate the development of immature gastro-intestinal structures and the juvenile immune system**. This allows young broilers, rearing chicks as well as turkey poults to establish a healthy microflora a lot faster and cope better with dietary stress resulting from first contact with solid feed particles. Above all, they **help to minimise energy depletion of the immuno-regulating villi cells and maximise absorption potential of essential nutrients and minerals**.

To assure **healthy and rapid gut development** (whether or not combined with feed probiotics to obtain a synbiotic effect), inulin-based ingredients are strongly recommended as a standard part of young poultry diets. Various chicory inulin/oligofructose supplementation trials also indicated their support to **better growth and feed efficiency at a very early age***. These benefits were extended to the later stages of production in which a **higher overall yield** was demonstrated.

Improved zotechnical results.

The chicken's health and performance benefits greatly from diets supplemented with prebiotic fibres from the chicory root. Inulin and oligofructose support a healthier, more balanced composition of microflora, and hence help **strengthen the intestinal absorption surface and immune barrier**. They suppress detrimental gut bacteria and reduce the overall microbial degradation of crucial bile acids. This facilitates the **digestion of dietary fat**, jointly to **improving resistance of the gut wall and reducing blood cholesterol levels**.

In broilers and fattening turkeys, similar outcomes have been observed due to improved gut health and more efficient nutrient utilisation. **Regardless of genetic breed or diet composition, a consistent and significant improvement in feed intake, daily growth, final body weight, feed conversion and (tibia) bone health*** could be observed. Additionally, the cholesterol-reducing effect of inulin-type fructans has also been shown to **reduce carcass wastes through lower abdominal fat levels**.

In laying hens, chicory inulin and oligofructose were demonstrated to **significantly improve egg weight, laying rate and feed conversion in commercial laying hens**, but also **fertility- and hatchability rate** of broiler breeder eggs*. Here too the mineralisation effect translated into **thicker or stronger eggshells** and the lipid metabolic effect into **low-cholesterol eggs or eggs with a healthier fatty acid profile**.

The golden standard in prebiotic feed ingredients.

Optimisation of poultry feed – ingredient range and properties.

	Product	Concentration*	Purity	Solubility	Comment
INULIN	Orafti® IPS	90%	Refined	Low	Highly purified and concentrated inulin powder
	Orafti® SIPS	86%	Refined	Good	Refined and concentrated inulin powder
	Orafti® SIP+	90%	Semi-refined	Good	Semi-refined and concentrated inulin powder
	Orafti® SIPX	76%	Semi-refined	High	Economical Solution inulin powder
OLIGOFRACTOSE	Orafti® OPS	95%	Refined	High	Highly purified, concentrated oligofractose powder
	Orafti® OLS	95%	Refined	High	Highly purified, concentrated oligofractose syrup
	Orafti® OLX	70%	Semi-refined	High	Economical Solution oligofractose syrup

Ingredient application is subject to national legislation. Different grades of refinement available.

* Expressed on a Dry Matter basis.



Convincing across all parameters.

BENEO is one of the few ingredient suppliers providing a specific feed-grade portfolio of inulin-type fructans. With two state-of-the-art and food-certified processing plants in Belgium and Chile, we can continuously offer **great flexibility and high product availability** and supply **multiple dry and liquid variations of functional fibres of the purest quality**.

Extended zootechnical and intestinal research confirms that adding chicory inulin or oligofructose to poultry diets yields significant financial benefits on multiple production parameters as a result of strong prebiotic interference with the chicken's microflora. BENEO offers bespoke and cost-effective solutions and poultry-specific dietary recommendations.

Our pure Orafti® chicory inulin and oligofructose, functional ingredients, have been frequently used as a reference in global scientific and animal (e.g. poultry) performance trials. Parallely, in human nutrition Orafti® inulin holds the only proprietary health claim for the promotion of digestive health in the European Union. All references can be acquired upon request.

Characteristics and benefits of Orafti® functional fibres.

Product characteristics Orafti®

- ✓ **100% natural** origin
- ✓ **Broad range** matching various expectations
- ✓ **Stable** during processing & storage
- ✓ **Highly selective fermentation** in hindgut targets
- ✓ Strong beneficial **microbiota modulation**
- ✓ Positive **regulation of intestinal pH**

Proven benefits inulin/oligofructose

(from >20 years of solid scientific data on chicory inulin and oligofructose)

- ✓ Enhanced **gut health & immunity**
- ✓ Accelerated **chick development**
- ✓ Increased **bird performance & yield**
- ✓ Safe & effective **growth promotion**
- ✓ Improved **nutrient and mineral absorption**
- ✓ Better carcass and egg **hygiene**



List of scientific references:

- Abdelqader, A., Al-Fataftah, A.R., Daş, G. 2012. Effects of dietary *Bacillus subtilis* and inulin supplementation on performance, eggshell quality, intestinal morphology and microflora composition of laying hens in the late phase of production. *Animal Feed Science and Technology* 179 (1-4), 103-111.
- Ao, Z., Choct, M. 2003. Early Nutrition for broilers – A two edged sword? *Proc. Aust. Poult. Sci. Sym.* 2003; 15, 149-153.
- Ao, Z., Choct, M. 2013. Oligosaccharides Affect Performance and Gut Development of Broiler Chickens. *Asian-Aust. J. Anim. Sci.* 26 (1), 116-121.
- Biggs, P., Parsons, C.M., Fahey, G.C. 2007. The Effects of Several Oligosaccharides on Growth Performance, Nutrient Digestibilities, and Cecal Microbial Populations in Young Chicks. *Poultry Science* 86 (11), 2327–2336.
- Chen, Y.C., Chen, T.C. 2004. Mineral Utilization in Layers as Influenced by Dietary Oligofructose and Inulin. *Int. Journal of Poultry Sci.* 3 (7), 442-445.
- Chen, Y.C., Nakthong, C., Chen, T.C. 2005. Improvement of Laying Hen Performance by Dietary Prebiotic Chicory Oligofructose and Inulin. *Int. Journal of Poultry Sci.* 4 (2), 103-108.
- Cornescu, G. M., Panaite, T. D., Untea, A.E., Berbaru, A., Grosu, H. 2015. Effects of Organometallic Chelates and Inulin in Diets for Laying Hens on Mn and Fe Absorption Coefficients and their Content in Egg and Tissue. *Food and Feed Research* 42 (1), 67-72.
- Erayeh, A.S., Yildiz, G. 2012. Effects of inulin and β -glucan supplementation in broiler diets on growth performance, serum cholesterol, intestinal length, and immune system. *Turk. J. Vet. Anim. Sci.* 36 (4), 388-394.
- Geier, M.S., Torok, V.A., Allison, G.E., Ophel-Keller, K., Hughes, R.J. 2009. Indigestible carbohydrates alter the intestinal microbiota but do not influence the performance of broiler chickens. *Journal of Applied Microbiology* 106 (5), 1540-1548.
- Janardhana, V., Broadway, M. M., Bruce, M. P., Lowenthal, J. W., Geier, M. S., Hughes, R. J., Bean, A. G. D. 2009. Probiotics Modulate Immune Responses in the Gut-Associated Lymphoid Tissue of Chickens. *The Journal of Nutrition* 139 (7), 1404-1409.
- Jeevalakshmi, A., Sathya, C., Murugaian, P. 2017. Effect of Chicory and Inulin Growth Performance, Serum Biochemical Analysis and Intestinal Microbial Population in Japanese Quail (*Coturnix Japonica*). *Int. J. Adv. Res. (IJAR)* 5 (7), 699-707.
- Juśkiewicz, J., Zduńczyk, Z., Jankowski, J., Król, B. 2002. Caecal metabolism in young turkeys fed diets supplemented with oligosaccharides. *Arch. Geflügelk.* 66 (5), 206-210.
- Juśkiewicz, J., Zduńczyk, Z., Jankowski, J., Król, B., Milala, J. 2008. Gastrointestinal tract metabolism of young turkeys fed diets supplemented with pure nystose or a fructooligosaccharide mixture. *Arch. Anim. Nutr.* 62 (5), 389-403.
- Li, B., Leblois, J., Taminiau, B., Willems, L., Beckers, Y., Bindelle, J., Everaert, N. 2017. The effect of inulin and/or wheat bran in the diet during early life on intestinal health of chicks. *WPSA Proceedings of 21st European Symposium on Poultry Nutrition (ESPN 2017)*, 3295.
- Mohiti-Asli, M., Shivazad, M., Zaghari, M., Rezaian, M., Aminzadeh, S., Mateos, G.G. 2012. Effects of feeding regimen, fiber inclusion, and crude protein content of the diet on performance and egg quality and hatchability of eggs of broiler breeder hens. *Poult. Sci.* 91 (12), 3097-3106.
- Nabizadeh, A. 2012a. The effect of inulin on broiler chicken intestinal microflora, gut morphology and performance. *J. Anim. Feed Sci.* 21 (4), 725-734.
- Nabizadeh, A. 2012b. Effect of Inulin Inclusion in Low Phosphorus Diets on Some Hematological, Immunological Parameters and Broiler Chickens Performance. *Res. J. Anim. Sci.* 6 (4-6), 60-66.
- Ortiz, L. T., Rodriguez, M. L., Alzueta, C., Rebolé, A., Trevino, J. 2009. Effect of inulin on growth performance, intestinal tract sizes, mineral retention and tibial bone mineralisation in broiler chickens. *British Poultry Science* 50 (3), 325-332.
- Park, B. S. 2008. Bifidogenic Effects of Inuloprebiotics in Broiler Chickens. *Journal of Life Science* 18 (12), 1693-1699.
- Park, S. O., Park, B. S. 2011a. Effect of Dietary Microencapsulated-Inulin on Carcass Characteristics and Growth Performance in Broiler Chickens. *J. Anim. Vet. Adv.* 10 (10), 1342-1349.



- Park, S. O., Park, B. S. 2011b. Influence of Inuloprebiotic Supplementation of the Diets of Broiler Chickens on Shelf-Life and Quality Characteristics of Meat. *J. Anim. Vet. Adv.* 10 (10), 1336-1341.
- Park, S. O., Park, B. S. 2012. Effect of feeding inulin oligosaccharides on cecum bacteria, egg quality and egg production in laying hens. *Afr. J. Biotech.* 11 (39), 9516-9521.
- Peinado, M. J., Echávarri, A., Ruiz, R., Suárez-Pereira, E., Ortiz Mellet, C., García Fernández, J. M., Rubio, L. A. 2013. Effects of inulin and di-D-fructose dianhydride-enriched caramels on intestinal microbiota composition and performance of broiler chickens. *Animal* 7 (11), 1779-1788.
- Rada, V., Duškova, D., Marounek, M., Petr, J. 2001. Enrichment of Bifidobacteria in the Hen Caeca by Dietary Inulin. *Folia Microbiol.* 46 (1), 73-75.
- Rebolé, A., Ortiz, L. T., Rodriguez, M. L., Alzueta C., Trevino, J., Velasco, S. 2010. Effects of inulin and enzyme complex, individually or in combination, on growth performance, intestinal microflora, cecal fermentation characteristics, and jejunal histomorphology in broiler chickens fed a wheat- and barley-based diet. *Poult. Sci.* 89 (2), 276-286
- Rehman, H., Rosenkranz, C., Böhm, J., Zentek, J. 2007. Dietary Inulin Affects the Morphology but not the Sodium-Dependent Glucose and Glutamine Transport in the Jejunum of Broilers. *Poult. Sci.* 86 (1), 118-122.
- Rodriguez, M. L., Rebolé, A., Velasco, S., Ortiz, L. T., Trevino, J., Alzueta, C. 2012. Wheat- and barley-based diets with or without additives influence broiler chicken performance, nutrient digestibility and intestinal microflora. *J. Sci. Food Agric.* 92 (1), 184-190.
- Shang, H. M., Hu, T. M., Lu, Y. J., Wu, H. X. 2010. Effects of inulin on performance, egg quality, gut microflora and serum and yolk cholesterol in laying hens. *Br. Poult. Sci.* 51 (6), 791-796.
- Stanczuk, J., Zduńczyk, Z., Juśkiewicz, J., Jankowski, J. 2005. Indices of response of young turkeys to diets containing mannanoligosaccharide or inulin. *Vet. Med. Zootech.* 31 (53), 98–101.
- Świątkiewicz, S., Koreleski, J., Arczewska, A. 2010a. Effect of Organic Acids and Prebiotics on Bone Quality in Laying Hens Fed Diets, with Two Levels of Calcium and Phosphorus. *Acta Vet. Brno*, 79, 185-193.
- Świątkiewicz, S., Koreleski, J., Arczewska-Włosek, A. 2010b. Effect of prebiotic fructans and organic acids on mineral retention in laying hens. *Acta Agr. Scand. Section A* 60, 125-128.
- Świątkiewicz, S., Koreleski, J., Arczewska, A. 2010c. Laying performance and eggshell quality in laying hens fed diets supplemented with prebiotics and organic acids. *Czech. J. Anim. Sci.* 55 (7), 294-306.
- Van Leeuwen, P., Verdonk, J. M. A. J., Van der Klis, J. D., Van Loo, J. 2006. Inulins (chicory fructans) improve performance of young broilers. EPC 2006- 12th European Poultry Conference, Verona, pp. 246.
- Velasco, S., Ortiz, L. T., Alzueta, C., Rebolé, A., Trevino, J., Rodriguez, M. L. 2010. Effect of inulin supplementation and dietary fat source on performance, blood serum metabolites, liver lipids, abdominal fat deposition, and tissue fatty acid composition in broiler chickens. *Poult. Sci.* 89 (8), 1651-1662.
- Verdonck et al., drafted BNEO study, 2003.
- Yusrizal, C., Chen, T. C. 2003. Effect of Adding Chicory Fructans in Feed on Broiler Growth Performance, Serum Cholesterol and Intestinal Length. *Int. J. Poult. Sci.* 2 (3), 214-219.)
- Zduńczyk, Z., Jankowski, J., Juśkiewicz, J. 2005. Performance and intestinal parameters of turkeys fed a diet with inulin and oligofructose. *Journal of Animal and Feed Sciences*, 14, Suppl. 1, 2005, 511–516.

The information in this brochure is presented in good faith and believed to be correct, nevertheless no responsibilities/warranties as to the completeness of this information can be taken. This information is supplied upon the condition that the persons receiving the same will make their own determination as to its suitability for their purposes prior to use. It is strongly recommended to consult and apply all national feed legislation (e.g. legislation on claims, communication towards the consumer etc.) prior to any communication to consumers. This information does not contain any warranty that the supply or the use of the products in any territory is not an infringement of the rights of third parties in industrial or intellectual property. It can also not be regarded as an encouragement to use our products in violation of existing patents or legal provisions in the matter of feed stuffs.

What can we do for you?

If you have any questions about our ingredients, please don't hesitate to contact us.
We will be happy to help you.

BENEO-Animal Nutrition

Aandorenstraat 1

B-3300 Tienen (Belgium)

Phone +32 (0) 16 801 582

Fax +32 (0) 16 801 592