

Whey in animal nutrition A valuable ingredient

A joint publication of the members of EWPA,
the European Whey Products Association

Preface 3

What is whey? 4

Use of whey in animal nutrition 6

Whey for calves, goat kids and lambs

Whey for piglets

**Nutritional properties
of whey products** 8

Lactose

Protein

Minerals

Whey products in milk replacer

Whey products in piglet feed

**Unique whey products
obtained via different
processing techniques** 12

**Composition of different
whey products** 13

Quality & Safety 14

**The influence of whey products
on physical feed quality** 16

Physical characteristics of whey
products

Flowability

Feed pellet quality

Relevant literature 18

Glossary 19

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Preface

Dear Reader,

The fact that you are reading this brochure indicates that you have made a decision. An excellent decision, in our opinion! You have decided to read this brochure and learn more about the many benefits of whey ingredients in animal nutrition. And right you are!

In this brochure, the European Whey Products Association (EWPA) has collected a variety of facts and figures related to whey.

You will find information on the nature of whey and its origin. You will see that the technological progress that has occurred in whey processing in recent years has led to a variety of different, valuable whey products, each with its own special characteristics.

Talking about characteristics, the excellent functional parameters of whey - both nutritional and technological - are highlighted. These special qualities show the benefits of using whey products in animal nutrition.

The quality of whey and whey products is of paramount interest, of course. So, we explain the extent of the quality assurance system throughout the European dairy industry in general, and in the whey processing industry in particular. The detailed European supply-chain control system extends from cow's milk via cheese production through to whey and whey processing, ensuring products of excellent and reliable quality.

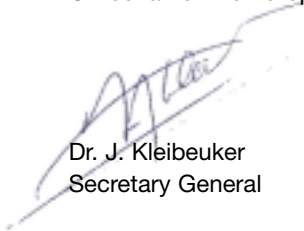
Alongside information on the processing of whey products in the feed industry and on regulatory aspects (i.e. feed regulations and legal aspects in the EU), this brochure provides you with a state-of-the-art overview on whey in relation to animal nutrition.

For the many of you who are already using European whey products in your feed formulations, this brochure confirms that you are doing the right thing!

And for those of you who are not yet using European whey products, we are confident that this brochure will supply all of the information required to convince you to use whey products in future.

The members of the European Whey Products Association (www.euromilk.org/ewpa) are at your disposal for further information or for a commercial follow-up and will be delighted to answer your questions.

On behalf of the European Whey Products Association members,



Dr. J. Kleibeuker
Secretary General

What is whey?

Whey is the valuable co-product resulting after the production of cheese, curd cheese or casein from milk.

The type of whey produced depends on the method of precipitation that is employed to separate the casein.

EU cheese production is estimated to be 8.6 million tonnes per year and annual EU casein production is 175,000 tonnes. At present, annual production of whey products is approximately 1.5 to 2.0 million tonnes of dry matter, which is equivalent to about 40% of the liquid whey available in Europe. Output volumes of both EU cheese (Table 2) and whey products increase every year by about 1.5 to 2.0%.

Table 1 Type and origin of whey

Type of cheese/casein	Type of whey
Cheese	Sweet Whey
Curd/quark cheese	Acid Whey
Fresh, unripened cheese	Acid Whey
Casein	Casein Whey

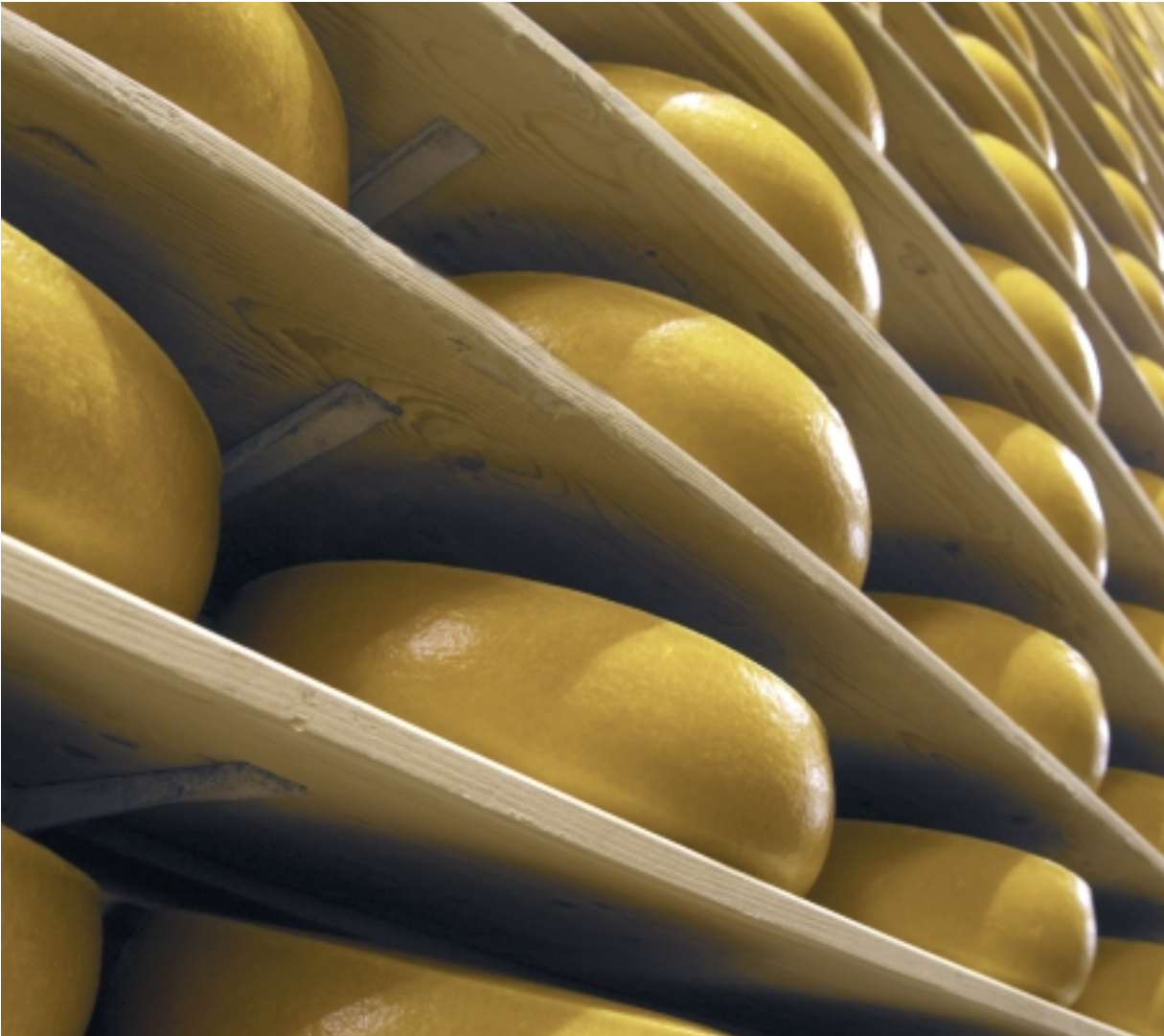
Whey

Origin

Production

Product types

The method used in cheese production is precipitation by rennet, which results in sweet whey. The production of soft, fresh cheese and curd cheese relies on precipitation by lactic acid-producing bacteria and results in acid whey types. The production of casein makes use of mineral acids as the means of precipitation. The resulting whey is known as casein whey. Most whey is recovered as sweet cheese whey. Every tonne of liquid milk that is processed into cheese has the potential to produce 50 kg of dried whey products. Liquid whey contains approximately 6 per cent solids, around half of the milk's dry solids.





The typical composition of the various types of liquid whey is given in Table 3. Lactose is the major constituent, accounting for approximately 77% of the total solids. Other important constituents are proteins (approx. 12%) and minerals (10%). Starting from this liquid source, one alternative is just drying, which results in the production of whey powder. The typical composition of whey

powders is given in Table 4. In Europe, however, a large proportion of liquid whey is processed into several high-value whey products by means of standardisation, fractionation and drying (discussed on page 12).



Table 2 EU cheese production sheet (x 1,000 tonnes)

x 1,000 tonnes	2001	2002	2003	2004	2005*	2006*
	EU15	EU15	EU15	EU25	EU25	EU25
Production	7194	7220	7318	8424	8558	8630

*)Provisional/Forecast. Updated February 2006

Table 3 Typical composition of various types of liquid whey

Composition (%)	Sweet Whey	Acid Whey	Casein Whey
Total solids (%)	6.20	5.70	6.10
Lactose (%)	4.80	4.60	4.70
Proteins (%)	0.75	0.30	0.50
Fat (%)	0.05	<0.01	<0.01
Ash (minerals) (%)	0.60	0.80	0.90
pH	6.1	4.6	4.4

Table 4 Typical composition (as is) of various types of whey powders

Composition (%)	Sweet Whey Powder	Acid Whey Powder	Casein Whey Powder
Total solids (%)	94.0-98.5	93.0-97.0	93.0-98.0
Lactose (%)	69-76	65-69	64-68
Proteins (%)	11-14	7-9	9-11
Fat (%)	0.5-2.0	-	-
Ash (minerals) (%)	6-9	9-12	10-13
pH	6-6.8	4.2-5	4-4.8

Use of whey in animal nutrition

Animal production

Challenges

Whey based benefits

For decades, whey products have been successfully used in feed for young animals (e.g. in milk replacer for calves, lambs and goat kids and also in diets for weaned pigs). Moreover, whey products are increasingly being used in animal feed for both breeding and fattening purposes. In recent decades, millions of young animals have been fed profitably by using European whey products in their diets. Let us focus on the trends in animal production systems and on the solutions whey products can offer you.

Whey for calves, goat kids and lambs

In current farming systems, young animals such as calves, goat kids and lambs are often separated from their mother almost immediately after birth both for economic and health reasons.

The young animals may only be allowed to suckle their mother or be supplied with colostrum for a few hours. Thereafter, in many regions of the world it is most economical to milk the mother and provide the newborn animal with a so-called 'milk replacer'. The composition of the young animals' diet is determined by the production goal - i.e. rearing of female animals for herd replacement or fattening of mainly male animals for meat (beef, veal, lamb, etc). The diet of female animals destined for herd replacement and male animals intended for some type of meat production will consist, for a short period, partly of milk replacer. In fattening systems with specific production goals (e.g. veal, meat from goat kids), the diet will, to a large extent, consist almost exclusively of milk replacer throughout the entire fattening period.

Challenges that whey products can help overcome in calves/goats husbandry:

- Replacing skim milk powder
- Avoiding the use of antibiotics to control digestive disorders and health problems
- Increasing interest in natural ingredients to promote performance and health

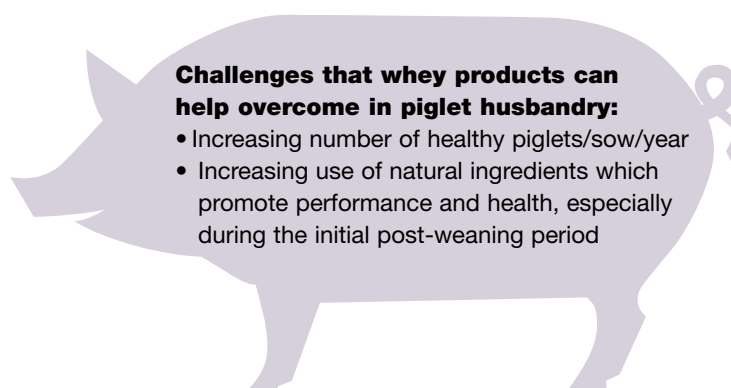




The milk replacer is usually based on high-quality whey and dairy products, supplemented with vegetable proteins, starch and dextrins, fats and oils, vitamins and minerals, emulsifiers and antioxidants. By using whey and milk ingredients, it is possible to formulate the milk replacer so that it meets the nutritional requirements of the young animal, promoting optimal performance and health, while remaining economical. Young animals, especially those transferred from their farm of birth to fattening units and mixed with animals of multiple origin, often face problems related to malfunctioning of the digestive system and poor gut health due to fasting, stress, viral cross contamination, etc. Whey products can help to improve the health of the calf because nowadays, processing technologies maintain and concentrate the nutritional quality of whey.

Whey for piglets

In modern pig husbandry, the number of piglets produced per sow per year is increasing as a result of larger litter sizes and lower weaning age. This results in increased numbers of piglets that are lighter and less viable at birth and more piglets with lower body weight at weaning. Antimicrobial growth promoters have been used to control some of the weaning-related health problems. Restrictions on the use of antimicrobial growth promoters in animal feed have intensified the search for solutions based on nutritional concepts. This has, in turn, increased the interest of nutritionists in whey ingredients that promote gut integrity and animal health.



Challenges that whey products can help overcome in piglet husbandry:

- Increasing number of healthy piglets/sow/year
- Increasing use of natural ingredients which promote performance and health, especially during the initial post-weaning period



Whey-based benefits:

- Whey is a natural ingredient derived from fresh milk
- Whey products are a combination of high-quality proteins, lactose, bio-active components, minerals and vitamins
- Whey has excellent solubility
- Whey does not contain anti-nutritional factors
- Whey is very palatable and easy to digest
- Whey promotes feed intake in the immediate post-weaning period
- Whey promotes animal performance and gut health

Nutritional properties of whey products

Whey products have a special milk-related composition and their excellent functional properties make them very suitable ingredients for young animal feeds. Whey products offer an excellent solution to today's challenges in young animal nutrition. The major constituents in whey products are lactose, proteins and minerals.

Lactose

Lactose, a disaccharide (milk sugar), is an important source of dietary energy and enhances the intestinal absorption of calcium. Lactose can be easily and rapidly converted by the gut epithelium-associated enzyme, lactase, into the mono sugars, galactose and glucose. Galactose and glucose serve as major energy sources for gut epithelial cells and for all body tissues requiring carbohydrate energy (e.g. the brain). Lactose is also used as a readily available substrate for fermentation by intestinal lactic acid-producing bacteria to produce lactic acid. Lactic acid influences the pH in the stomach and small intestine, compensating for insufficient gastric acid production in young piglets. It also suppresses the growth of pathogenic bacteria by virtue of its antimicrobial effects and provides metabolic energy.

Protein

Whey protein is the name given to the collection of globular, soluble milk proteins ^①. In addition to these proteins, whey also contains other nitrogenous components such as non-protein nitrogen sources (i.e. urea, amino acids) ^② and other proteins ^③ and growth factors such as immunoglobulin A, lactoferrin, lactoperoxidase, insulin and insulin-like growth factor. The proteins b-lactoglobulin and a-lactalbumin are involved in vitamin and mineral absorption, respectively. Whey protein is generally rich in amino acids such as lysine, threonine and tryptophan, sulphur amino acids and branched-chain amino acids, which promote gut function and accretion of body mass. The typical amino-acid profile of whey protein is given in Table 5.

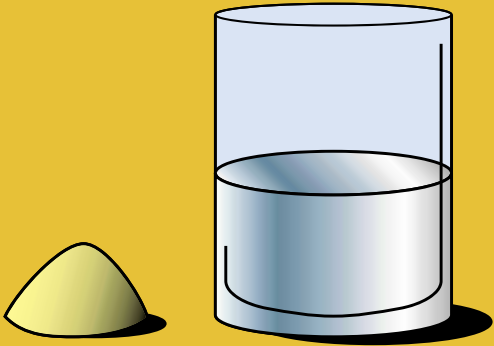
Table 5
Typical amino acid composition of whey powder (g/100g protein)

Amino acid	
Lysine	7.6
Methionine	1.5
Cysteine	1.9
Threonine	5.4
Tryptophan	1.5
Glutamic acid	15.5
Leucine	8.9
Isoleucine	5.1
Valine	4.9
Arginine	2.4
Phenylalanine	3.3
Histidine	1.8
Tyrosine	2.4
Alanine	4.3
Aspartic acid	9.1
Glycine	2.0
Proline	5.5
Serine	4.4

SWEET CHEESE WHEY

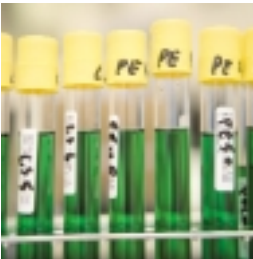
Water (938-943 g/l)

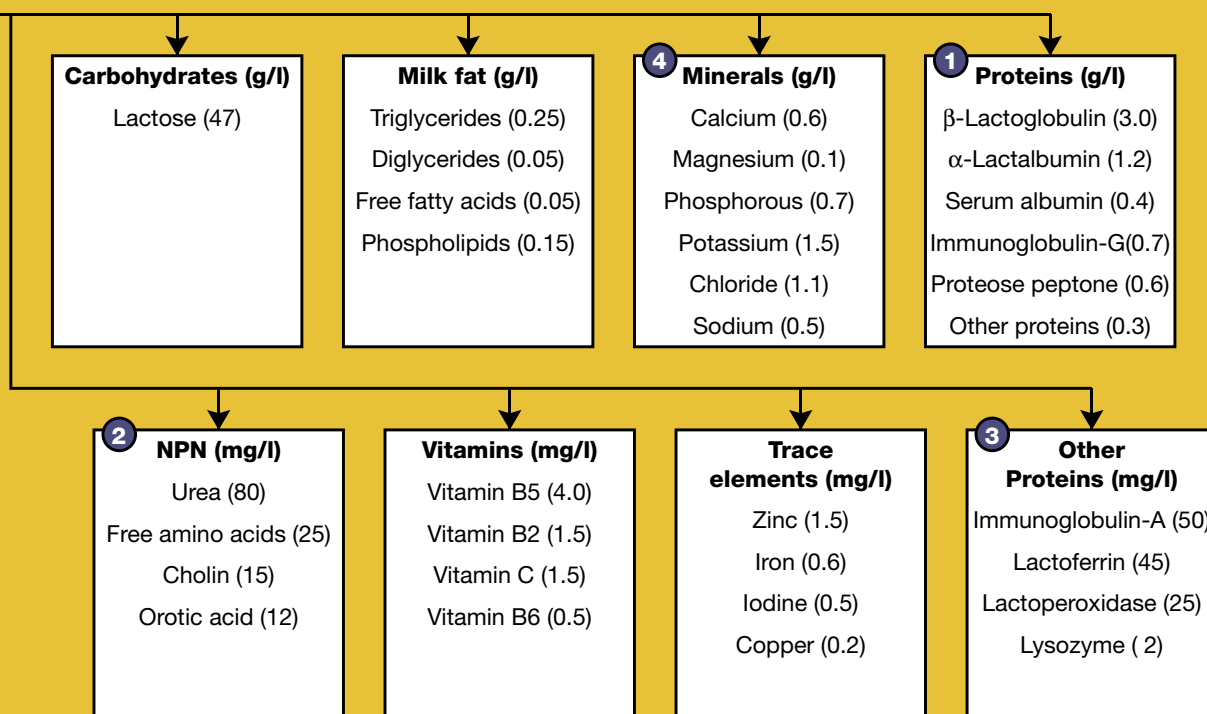
Total solids (57-62 g/l)

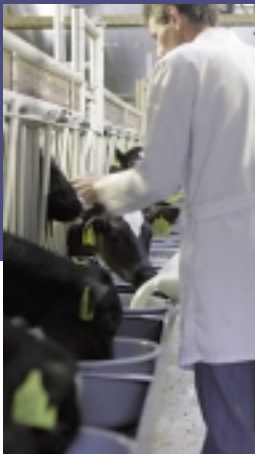


Minerals

Whey products also contain valuable minerals ^④ such as calcium, phosphorus, magnesium and potassium. The minerals in whey have high bio-availability due to the presence of mineral-protein complexes. The minerals in whey are readily absorbed, thus making a useful contribution to the diet.







Feed intake

Digestibility

Gut integrity

Animal health

Whey products in milk replacers

For calves, goat kids and lambs, whey products are highly palatable and digestible “dairy based” feed components that stimulate appetite, feed intake and promote gut health and animal performance. Carefully processed whey products still contain a substantial amount of bio-active components originating from milk. Whey does not contain anti-nutritional factors, which can evoke undesired immune responses, as may be the case with some protein sources of vegetable origin. The enzymatic processes in the intestine of suckling animals are dedicated to the digestion of dairy proteins and lactose as the main source of feed carbohydrate. Lactose should therefore be the major carbohydrate source in the 'first phase' milk replacer for calves, as it is in cows' milk. Together with the bio-active micro-constituents present in milk and whey, lactose is an optimal substrate for the protective intestinal flora, essential for the health of calves in their first weeks of life. In practice, excellent milk replacers are formulated using whey and milk ingredients to meet all the nutritional requirements of the young animal, promoting optimal performance and health at an economical cost.

Whey products in piglet feed

The digestive system of the young piglet is adapted to digest liquid sow milk, which contains highly digestible milk protein, emulsified fats and lactose. The young piglet cannot yet fully digest a weaning diet based on proteins and carbohydrates of vegetable origin (starch, non-starch). Since whey products are highly digestible and contain many functional ingredients, they are a unique nutrient source for piglet feed, promoting vitality, growth, gut functionality and health. Whey proteins are digested almost completely in the small intestine, thereby limiting undesirable protein (proteolytic) fermentation in the large intestine. Whey products are also very palatable, thereby promoting feed intake after weaning. Post-weaning feed intake is increasingly being acknowledged as a critical factor in the survival and performance of young piglets.

The lactose from whey products is the ultimate energy source for weaned piglets but also serves as a fermentable substrate for the microflora in the intestinal tract, promoting the digestive physiology and a quick shift to a desirable, stable, gut microflora in weaned piglets.

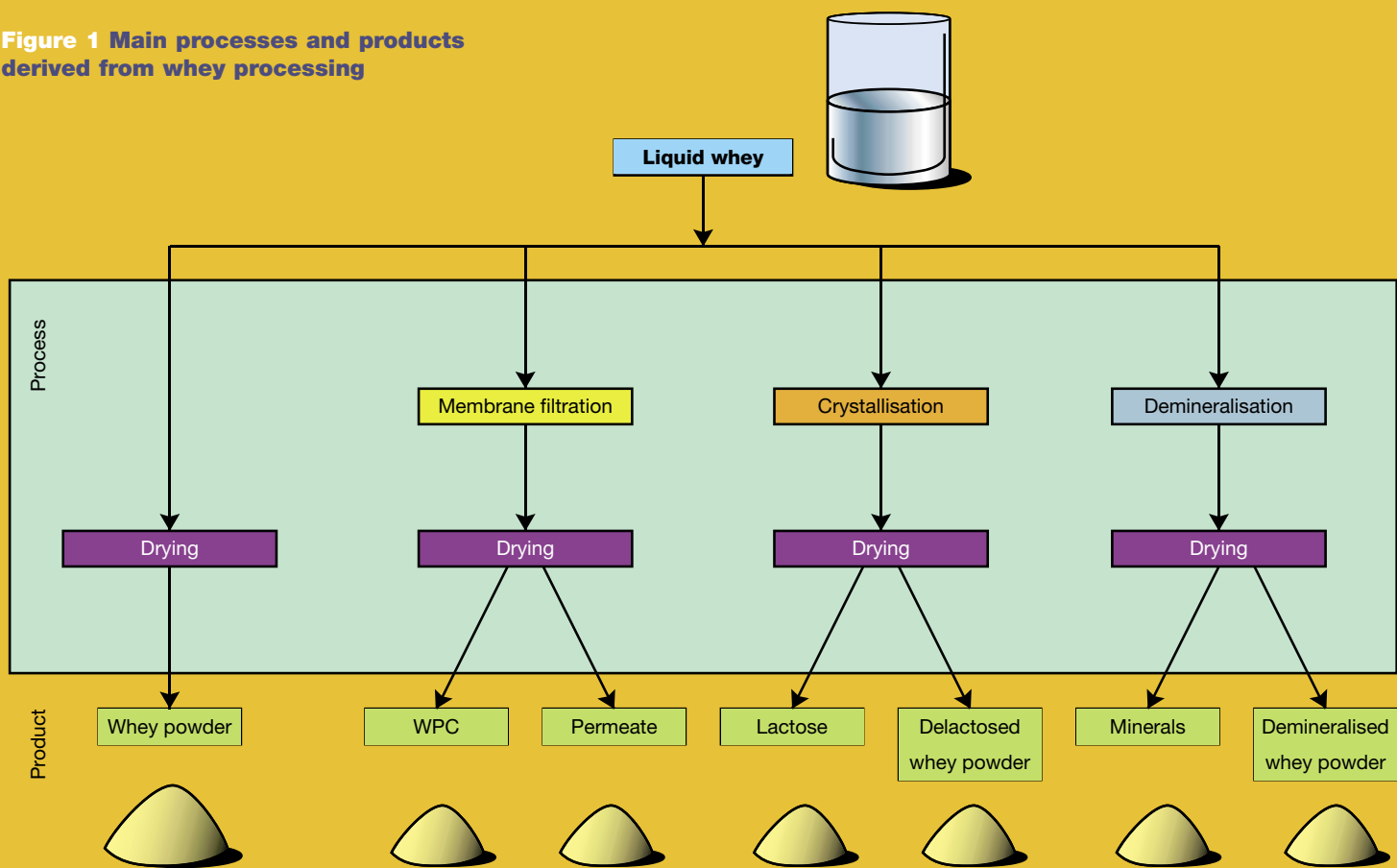




For calves, goat kids and lambs, whey products are highly palatable and digestible “dairy based” feed components that stimulate appetite, feed intake, gut health and animal performance.

Unique whey products obtained via different processing techniques

Figure 1 Main processes and products derived from whey processing



High tech

Great value

Functional properties

Whey processing in the 21st century is sophisticated and "high-tech", producing a wide range of powders with key physical and functional properties as well as specific nutrient values. Modern technologies ensure that the important nutrients in whey are preserved during processing and drying. These nutrients are available to the animal, making whey products ideal for inclusion in diets for calves, lambs, goat kids, piglets and puppies.

Figure 1 shows the most important processes now used to produce whey-based ingredients for animal nutrition.

Table 6 and figure 2 show some of the common powders that are produced and commercially available throughout the year.

They range from "high protein" to "high lactose" powders, formulated to serve different purposes and to provide balanced animal diet standards. This gives the feed-ingredient buyer the opportunity to specify his requirements in order to meet the important standards required in the production of young animal diets.

Composition of different whey products

Demineralisation and delactosing of whey allows protein to be concentrated at levels of up to 15% in demineralised whey powder and up to 27% in delactosed whey powder. Modern filtration techniques allow further concentration of the protein (whey protein isolate, whey protein concentrate). This is achieved with low energy input and at low temperature, and thus the proteins are preserved and contribute valuable nutrients that serve to promote good health and high performance in young animals.

Technology has now been developed to produce lactose-rich powders with excellent physical handling properties (e.g. whey permeate powder). The specifications of the whey products can now be closely controlled and feed industry buyers are able to select products according to the physical requirements of their handling equipment and feed blending facilities. Powders with high lactose content are ideal for blending with the many vegetable-protein ingredients commonly used in animal diets and allow for finished feed blends with a high content of dairy ingredients (essential for optimal growth) at an economical cost. The mineral content of whey products can be modulated using membrane and other techniques.

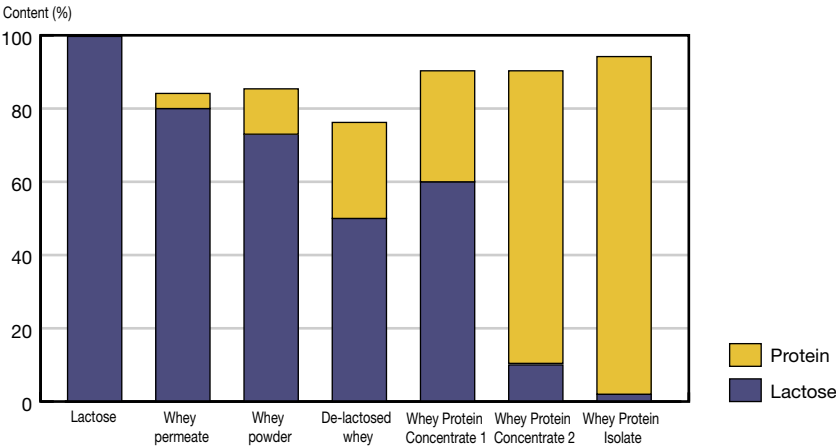


Figure 2 Lactose and protein content in different whey products



Table 6 Composition of different whey products

Composition (%)	Whey Protein Isolate	Whey Protein Concentrate	Whey Permeate Powder	Demineralised Whey Powder	Delactosed Whey Powder	Lactose
Total solids (%)	94-96	96-97	95-98.5	96-97	95-97.5	99.5-99.8
Lactose (%)	1.5-3.0	10-60	75-85	75-80	48-54	99-99.5
Proteins (%)	92-96	30-80	2-6	13-15	18-27	0.1-0.3
Fat (%)	0.1-1.0	3-8	0.2-0.5	1-1.5	1.5-2.5	-
Ash (minerals) (%)	2-3	4-8	7-10	1-5	15-22	0.1-0.3
pH	5.8-6.1	4-6.5	5.8-6.2	6.5	5.5-6.5	6

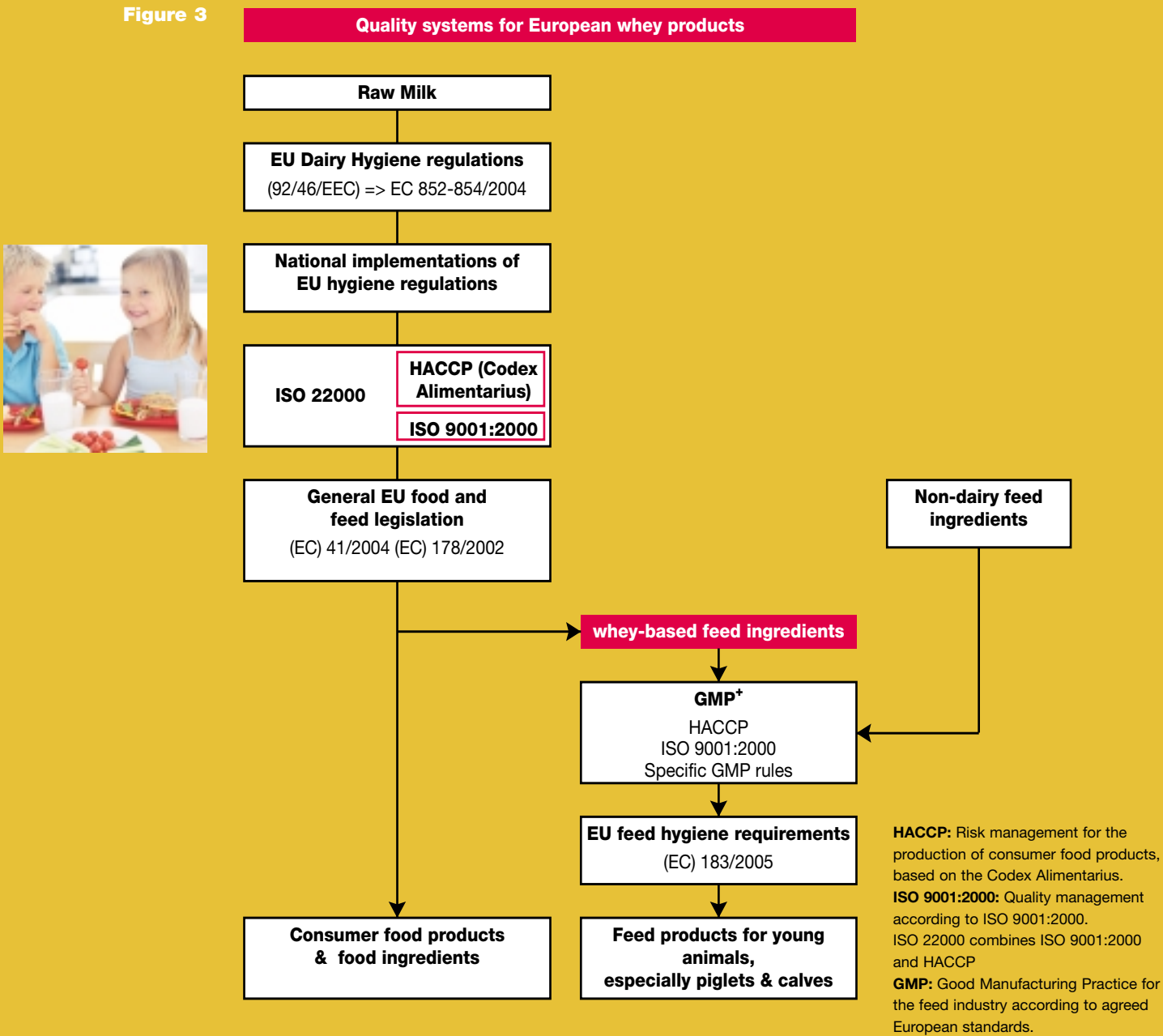
Quality & Safety

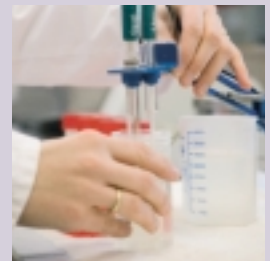
- Product quality and safety
- Food chain
- Customer requirements

Product Quality and Product Safety are major priorities for all European producers of whey products. Because of the intrinsic susceptibility of milk and dairy products to deterioration, strict regulations and inspection systems were established in the early days of the dairy industry in all European countries (along with detailed guidelines for “good practices”). The producers of whey products are part of the dairy industry in

Europe and operate in accordance with the broadly accepted quality standards in the European dairy industry. Because whey product manufacturers are often producing lines for the food (including baby-food) and pharma sectors as well as for feed, a high level of awareness of product quality and product safety is built into company cultures. This awareness covers all aspects of the production and supply chain,

Figure 3





starting from the controlled collection of liquid whey from the cheese factories and the acceptance protocol for whey entering the plant, and continuing through each step of processing, Quality Control of the finished products, intermediate storage and packaging, right through to the labelling, product documentation and the supply chain to the customer. All European producers of whey products with ISO 9001-2000 certification have Quality Assurance programmes in place, under the direct responsibility of general management. Many companies are now in the process of obtaining the novel ISO 22000 accreditation for the food industry. The steady growth of the European whey processing industry in recent decades has resulted in continuous upgrading of installations with “state of the art” processing equipment and quality management systems.

Legal aspects of quality assurance and food safety management of whey products in Europe are directly linked to formal EU quality regulations for the European dairy industry. Over time, these national regulations, guidelines and monitoring practices were brought into line with the European dairy hygiene guidelines (Directive 92/46/EEC). Implementation included the incorporation of the HACCP (Hazard Analysis and Critical Control Points) approach in accordance with the international Codex Alimentarius guidelines. Related EU guidelines and directives for

production and distribution of food, such as the residue and contaminants guidelines (Regulation 194/97/EC), also apply to whey products. The quality and safety of dairy products in the EU have been effectively safeguarded in this way for many decades. As of January 1st, 2006, the new European General Food Law EC/178/2002 and the new set of 5 interrelated regulations, also known as “The Hygiene Package”, came into force and are now replacing many of the former EU regulations.

Whey products destined for use as feed ingredients also have to meet the specific quality requirements for feed ingredients in Europe. These requirements are also now based on the EU General Food Law (EC/178/2002), as well as on the specific new EU Regulation laying down requirements for feed hygiene (EC/183/2005). All EWPA members are fully equipped to meet the requirements of the new EU quality system for food and feed ingredients.

Figure 3 shows the interrelationship of the various procedures and regulations in the EU quality system for whey products as dairy-based ingredients for applications in feed.

Quality control:

- Traceability of milk to farm level
- Cheese and liquid whey
- Dynamic and rapid processing
- Modern processing plants
- Internal laboratories

The influence of whey products on physical feed quality

Carefully controlled conditions during processing of liquid whey result in a product with optimal and uniform nutritional quality. Most whey products are easy to handle and ideally suited to the production of piglet feed and milk replacer for young animals. Effective measures taken during processing, bagging/storage in silo, and in transportation and warehousing, plus improved processing conditions in feed mills, have enabled feed producers all over the world to incorporate whey products in their feed formulae with great success. Some of the main characteristics and processing properties of whey products are mentioned below:

Physical characteristics of whey products

Good whey products have a clean, white-to-cream colour and a very good taste, as they are processed under carefully controlled, mild, conditions. This guarantees a milky colour in solution and high solubility. Modern whey processing plants produce powders with near 100% solubility, resulting in a stable solution without sedimentation when mixed in water. The proteins in whey have emulsifying properties, which can promote the solubility of other dietary ingredients in the mixed feed. Fat-filled whey powders containing high levels of emulsified oils offer a convenient and economical means of producing user-friendly milk replacers, with excellent mixability and good handling properties.

Flowability

Whey products are available with a range of different physical parameters, which can be selected according to the purpose required of the finished feed. Powders range from granular, to free-flow, to instantised. Many feed mills require powders that flow freely, without the risk of bridging in silos, have low hygroscopicity and are free of stickiness. By controlling the crystallisation before drying, the processor can produce whey products with low hygroscopicity and superior, free-flow properties which, when correctly

incorporated with the other ingredients, can ensure an ideal, non-caking, finished feed. Efficient pre-crystallisation of the lactose in the whey products, prior to spray drying, can make a major difference to the physical handling properties of the powder and it is particularly important to select such powders, with low hygroscopicity, when preparing young animal diets in hot, humid, climates. Some feed blenders assist their production processes further by de-humidifying their silo storage and blending facilities, thereby reducing the possibility of moisture absorption, and by adjusting the levels of high moisture ingredients in their finished feed blends.

Agglomerated and instantised whey products are particularly recommended when it is important for the finished diet to be "instant", or "easy mixing", when reconstituted with water by the end user. Agglomerated and instantised powders also serve a useful purpose when it is important to minimise dust levels in using the finished feeds.

All European whey products are supplied with specific, helpful advice on how to store safely, whether in bags or silos. All bags should have a poly-liner and storage in bags and silos should preferably be in dry, cool conditions and away from direct sunlight and other heat sources. The best advice is to follow the storage and handling recommendations of the whey product manufacturer.

Feed pellet quality

The dry nature and moisture-absorbing ability of lactose usually mean that whey products have a beneficial effect on feed-pellet quality when included in formulations. Whey products do, therefore, play an important role in creating firm, well shaped piglet feed pellets with reduced crumbling and less potential wastage by the animals during feeding.





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Glossary

Casein	The major protein in milk that can be precipitated by low pH, calcium or enzymatic cleavage
EWPA	European Whey Products Association
GFL	General Food Law
GMP	Good Manufacturing Practice
Gut health	Capacity of the gut to perform its digestive and protective barrier function
HACCP	Hazard Analysis and Critical Control Points
ISO	International Organization for Standardization
Lactose	Disaccharide, milk sugar
Milk replacer	Mixture of dairy and non-dairy ingredients to be fed as a reconstituted milk to young animals
NPN	Non-protein nitrogen
Whey	Product that remains after the production of cheese, curd cheese or casein
Whey products	Whey that has been processed and dried
Whey proteins	Globular, soluble milk proteins



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