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A Look Into the Innovative and Growing World of Whey Proteins

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Food & Agribusiness
far.rabobank.com

Tom Bailey

Senior Analyst – Dairy
+1 (212) 916 7831

Summary

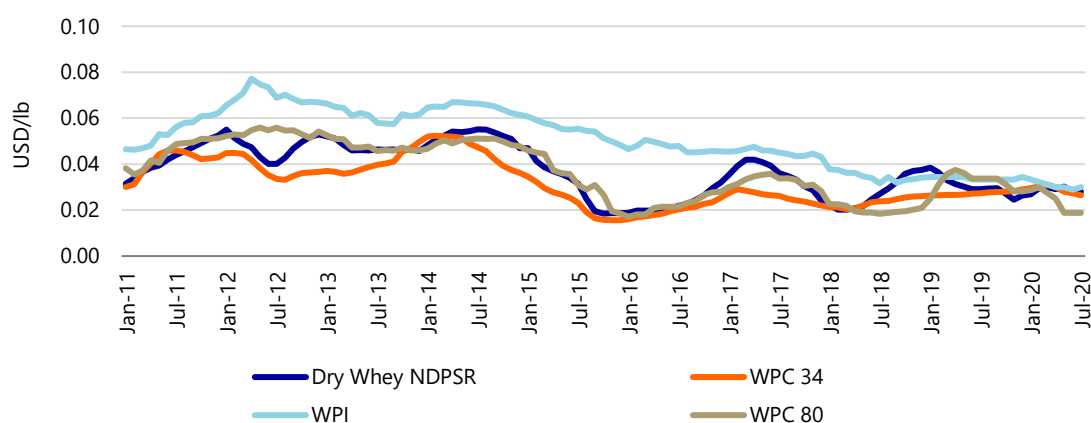
- **Around 95% of the world's whey comes as a by-product of cheese production.** The whey ingredient industry has done a stellar job of turning the whey stream, which was once a waste product, into arguably one of the most technical and nutrient-dense ingredients of the global food ingredient sector.
- **Whey is a favored source of complete protein** due to its impressive essential amino acid profile, which includes branched amino acids that are also highly functional and digestible.
- **As awareness of whey's benefits has grown among consumers, demand has increased.** For high-end whey concentrates, such as whey protein isolate (WPI), the global market is set to increase at a 12% compound annual growth rate (CAGR) through 2022, according to 3A Consulting.
- **The whey ingredient complex has seen strong returns** in the sports-nutrition, clinical-nutrition, and infant-formula industries, which have driven investments across the globe. As a result, over 90% of the global whey stream is now utilized, bringing value to dairy farmers, manufacturers, and consumers alike.
- **There has been an influx of competition** and some commoditization of whey ingredients as investments and volumes have grown. This has led to rising pricing pressure across the whey complex. Attempting to regain margins and differentiate in myriad ways, many ingredient players have leveraged their core R&D strength to seek further value, including focusing on the remaining by-products of whey concentrates, such as whey permeate, procream, and lactose.
- **The R&D push has opened the doors to more complex product-development opportunities** for the whey stream, such as galacto-oligosaccharides (GOS), human milk oligosaccharides (HMO), and beta-lactoglobulin, which are sold in highly valuable and rapidly growing categories, such early-life nutrition (ELN). Prices for these whey derivatives are often high and relatively stable, helping whey ingredient manufacturers regain margin.
- **The whey ingredient landscape has a bright future** with more new products on the horizon and a continued consumer focus on health and wellness, particularly in the post-Covid-19 landscape. But manufacturing and capital costs are high, and it is necessary to have a strategy, including flexibility along the whey stream, for the utilization of whey's derivative streams. Due to the increased supply, competition, and smaller margins, many manufacturers may need to seek strategic partnerships, mergers, and acquisitions to gain equity and core competencies and to secure whey streams, market share, and emerging technologies.

Turning a Waste Stream Into a Highly Nutritious and Valuable Product

Ironically, a product that is by most classifications the best source of protein for human nutrition today – and an industry¹ worth over USD 6bn and growing at a 3.3% CAGR through 2022² – was a waste product from cheese production³ not too long ago. It has taken a few decades, but growing demand and higher prices incentivized investment in innovation, and in turn innovation unlocked new products and opportunities and new demand. As this pattern has continued, the dairy industry has managed to turn a waste stream into a valuable product stream. Dairy companies have gone to great lengths to further process whey into a wide range of value-added products for specialty ingredients, from infant formula to clean-label protein supplements, for the growing number of health-conscious consumers. In 2005, roughly 70% of the global whey stream was further processed, but growing demand and prices saw whey stream utilization increase to around 90% by 2019, according to 3A Consulting. The whey industry has proven itself to be one of the most innovative, sustainable, and technologically advanced in the food industry. As a result of increased manufacturing capabilities and demand growth, all of the scalable whey pools in the world have been captured and provided value-added products across the feed, food, nutrition, and pharmaceutical industries. Rabobank estimates that only some fragmented, specialty whey pools remain. (The growing list of added-value derivatives and fractions derived from the whey permeate stream are listed in the appendix.)

Between 2013 and 2018, whey and lactose investments likely exceeded USD 2.5bn, according to 3A Consulting. The majority of current whey ingredient investments are focused on a few high-end whey concentrates and their derivatives. Whey protein concentrate 80 (WPC 80), whey protein isolate (WPI), and whey permeate derivatives, such as pharmaceutical lactose, are core ingredients many manufacturers have established for future growth. With an increasing number of global companies investing in these higher-end ingredient products, the once attractive margins have eroded. From a total price standpoint, WPC 80 and WPI still command a premium over products like dry whey powder and whey protein concentrate 34 (WPC 34). However, when you look at the crude value⁴ of the protein, it appears the premium once commanded by WPI has diminished (see Figure 1).

Figure 1: The crude value of whey



USDA, Rabobank 2020

¹ Includes dry whey, demineralized whey, WPC 35, WPC 80, and WPI

² According to 3A Consulting

³ 95% of the world's whey comes from cheese production, and roughly 5% comes from casein production. For a full breakdown of the whey stream and to better understand its streams, check out "Understanding the Whey Stream" and "Whey stream schematic" in the appendix.

⁴ Crude value is the commodity price adjusted to the concentration of protein in the product.

WPC 80 and WPI still command a pricing premium on a product basis, but margins remain tight. This is because the costs of producing WPC 80 and WPI are not linear, as their protein concentration might suggest. Rather, the cost increase is better described as exponential. For example, the cost increase from WPC 80 to WPI is disproportionately high relative to the increase in processing costs from WPC 34 to 80. The higher the whey concentrate, the more time and energy required and the more whey permeate by-product remains. Industry experts estimate that concentrating whey from WPC 80 to WPI comes with a 20% increase in cost. However, crude protein value does not reflect this additional cost, due to ample supply. As a result, whey manufacturers have to find ways to improve stream returns.

Whey ingredient companies are adding value to their whey streams through coproducts of WPC 80 and WPI, and in the case of WPI, the coproduct is sometimes a high-fat WPC 70, like pro cream. Another method whey manufacturers use to add value to their portfolio is further processing the whey permeate stream, a by-product of whey concentration and a new waste stream.⁵ Whey permeate composition varies but generally contains 85% lactose, 5% protein, and 10% 'ash'.⁶ Previously, whey permeate was either land spread as a fertilizer or sold as animal feed. Gradually, land spreading has become unacceptable, due to its environmental impacts, forcing companies to find other means of utilization. This has resulted in technical and R&D investments, which ultimately yielded numerous food-grade products and higher-end animal feed. Through innovation and developing new consumer products, companies continue to capture additional value from this previous waste stream.

Investments into the whey complex have been lumpy. That is, they follow a cycle of demand growth leading to price increases until prices reach a threshold justifying investments. And, as the next era of investments gets underway, the industry may face pricing challenges, as demonstrated by the decline in crude value WPI. However, there are also opportunities with discounted WPI pricing. For example, it can enable new market development and broader demand growth as new products and markets incorporate WPI, which can help to speed up the cycle.

The Whey Forward

As of 2019, around 10% of the world's annual whey production remains unrefined (i.e. not further processed). Much of this unprocessed whey originates from small cheese plants scattered around North America and Europe. Still, the largest producers of cheese, primarily the US and Europe, account for around 80% of the world's whey solids and have respective levels of refinement of 92% and 95%.

Looking at the variances in whey pools between the EU and US, the most glaring difference is the types of cheese made. Both countries manufacture wide varieties and styles of cheese, but the EU has a larger and more fragmented list of cheese manufacturers and styles of cheese. Meanwhile, the US has more large-scale cheese facilities, producing a consistent core of cheese varieties, such as American and mozzarella. The whey produced from white American-style cheese and mozzarella is preferred, as it is colorless and has a neutral flavor, and is sought after for products such as WPI and whey permeate derivatives.

With the increased value of whey products, companies such as US-based Milk Specialties Global (MSG), which does not produce cheese, recognized the opportunity in unrefined whey streams and made the strategic move to consolidate and process this whey into an optimizable portfolio of more valuable products. For several years, MSG has been the largest consolidator of whey pools in North America, turning liquid whey from 17 US states and Canada into value-added whey products in numerous plants across North America.

⁵ The higher the whey concentration, the more whey permeate is produced as a by-product.

⁶ General term for the broad list of leftover minerals found in milk.

Europe is the world's largest processor and consumer of cheese, accounting for 46% of total cheese produced globally, and thus is the world's largest producer of whey (68m metric tons of whey solids). With 86% of its whey solids marketed as dry ingredients, Europe processes the largest share of whey into whey ingredients of any global market. But given Europe's scale, it accounts for 31% of the world's unmarketed whey. Furthermore, the vast majority of European whey goes into whey products of lower concentrations. Around 47% of total European whey solids go into whey powder. Given the growing demand for higher concentrations of whey and whey fractions, Europe is well placed to seek upcycling and consolidation of both its existing whey ingredient product suite and its remaining unrefined whey streams.

Globally, most existing whey facilities may consider expanding their existing footprints, enabling production of higher-end whey products. At the same time, consolidation is likely to occur among smaller regional cheese players for the remaining unprocessed whey. In respect to the latter, small groups of cheese manufacturers might explore the possibility of pooling their equity and whey to build whey processing facilities to extract value from their whey themselves. The opportunity for an MSG-type player in the EU exists. Still, the equity commitment is considerable and requires agreement from the cheese manufacturers, who may opt to go at it alone or form a partnership in which the value from the investment is shared. Other considerations exist, such as traceability, which is becoming increasingly relevant for end-users of ingredients, such as infant formula. European dairy companies are on the front lines of these products. For example, Friesland Campina launched an infant formula-sourcing tool called TrackEasy to trace milk products back to the farm, and Arla Foods launched a similar tool called ArlaGarten. It is important for consolidators of whey that aim to produce higher-end whey ingredients, like WPC 80 and pharmaceutical-grade lactose, to ensure transparency of their supply chains.

For now, the way forward for many cheese and whey investments will be big cheese plants with more generic styles of cheese, such as mozzarella, and with whey processing capabilities planned, including derivatives and fractionation. But it won't all be large-scale facilities, consolidators may step in to pool the remaining unrefined whey around the world, as MSG has done in North America. But, it may be more reasonable for smaller cheese manufacturers to work together through various partnerships to capture the added whey value for their businesses.

The Markets Behind Whey Ingredient Demand Growth

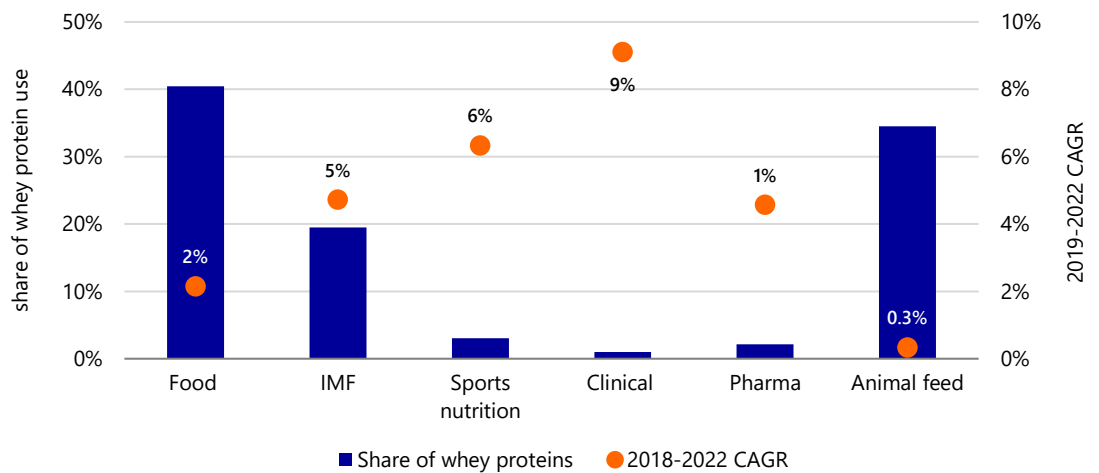
Given that 95% of whey is derived from cheese production, the most significant consideration for most companies deciding to invest in whey proteins begins with the decision to invest in cheese. As covered in the [Rabobank report "Global Cheese Trade Dynamics,"](#)⁷ over USD 3.0bn has been invested into new cheese capacity in recent years. When combined, over 1m metric tons of new cheese production capacity can be brought online, producing between 80,000 and 110,000 metric tons of whey solids. The majority of these plants will be large scale, manufacturing common cheese styles, such as mozzarella, and yielding a colorless whey, which is preferred for processing premium whey-derived ingredients. This new whey stream will need to be flexible, allowing for product mix optimization, to get the most value out of the whey stream under various market conditions.

As of 2019, utilization of whey solids in consumer food products and animal feed took up 60% of total whey proteins (see *Figure 2*). Moving forward, food and feed will remain relevant because of their large shares, and optionality can act as a relief valve for optimization when market pressure builds. This means that flexibility in processing will be important. The growth rate in the general

⁷ It should be noted that there is potential for a fallout in cheese demand in the coming 12 months due to Covid-19, which makes this a relatively conservative growth profile for cheese.

food and feed segments is considerably lower than in other categories. The fastest-growing categories – primarily based in higher-end human nutrition such as clinical and sports nutrition – will be the focus of whey ingredient players going forward, not only because of their rapid rate of growth but also because they carry the greatest margin potential (see Figure 2). Friesland Campina is an innovative global ingredient company that has developed its whey-product portfolio so that over 70% of its whey is processed into higher-value products, including whey derivatives, with the remainder used in the food and feed market segments.

Figure 2: Global utilization and demand growth of whey proteins, 2019-2022f



Source: 3A Consulting and Rabobank 2020

Based on our interviews with industry executives, investments at this stage are primarily focused on WPC 80 and WPI, the higher-end spectrum of whey ingredients, with some flexibility into lower-level concentrates. Demand growth for WPC 80 and WPI has been particularly strong in North America due to its large and growing sports nutrition market, which consists of 73% protein powders, 11% ready-to-drink beverages, 5% protein bars, and 11% non-protein products, such as energy-boosting products.⁸ North America accounts for over 60% of the global sports nutrition market and is set for 9% CAGR through 2023, reaching USD 14.4bn by 2023, according to 3A Consulting. Historically, a large portion of these nutritional protein products were consumed by bodybuilders. But increasingly, the demographic has shifted to the general population, particularly females, as consumers become more health conscious, and health-conscious consumers are increasingly driving much of the growth in the sports nutrition channel. Industry sources have also indicated that this trend has intensified in growth, due to the Covid-19 pandemic.

Europe is the second-largest market for WPC 80 and WPI, accounting for 27% and 17% of global demand, respectively. WPC 80 and WPI demand is slated to grow by 4% and 6% through 2022, according to 3A Consulting. Infant formula accounts for 45% of WPC 80 usage in Europe and is growing at 4% annually, but sports and clinical nutrition is growing more rapidly at 5% and accounts for 42% of European use of WPC 80. WPI, meanwhile, is primarily a sports nutrition ingredient in Europe and is forecast to grow at 7% CAGR through 2022. Similar to the North American market, avid gym goers and increasingly health-conscious consumers are driving the trend. The UK, Germany, France, the Netherlands, and Sweden account for 70% of the European sports nutrition market.

It's important to note that the trend of focused nutrition is occurring outside of North America and Europe, requiring global marketing and distribution to capture the expanding opportunities globally. Asian markets, in particular, are set for exceptional expansion. Consumers throughout

⁸ According to 3A Consulting

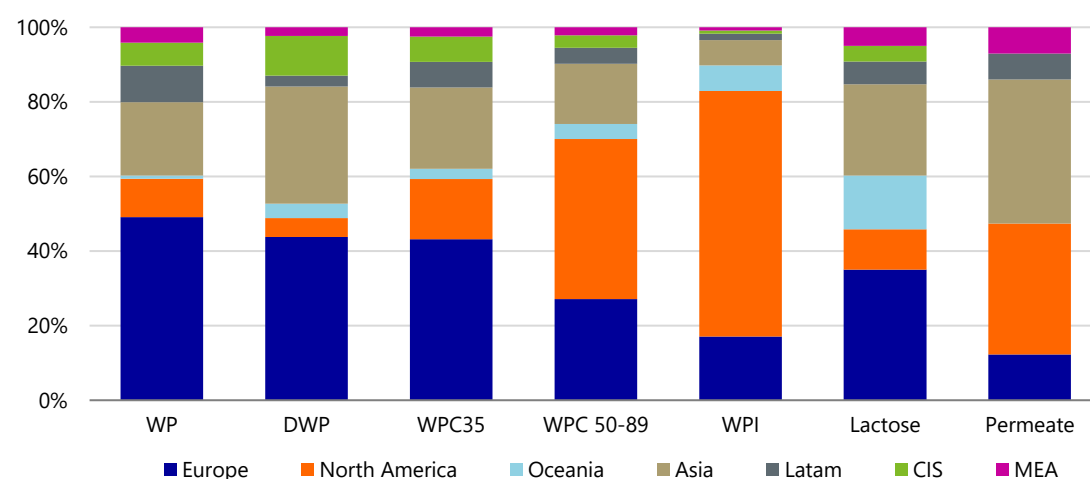
the region, including China, India, and Vietnam, are experiencing an increased focus on health and wellness. This focus is occurring as both grassroots initiatives and top-down government initiatives to help educate consumers, thereby encouraging the consumption of dairy proteins. As a result, the Asian sports nutrition market is forecast for a global CAGR of 16% in value terms, reaching USD 2.6bn by 2023. This translates to rising demand for WPC 80 and WPI, estimated at a CAGR of 12% and 6%, respectively, through 2022, according to 3A Consulting.

Infant milk formula (IMF) is also an essential category for whey ingredients. The primary ingredients used in the IMF industry are WPC 34, WPC 80, and demineralized whey powders. IMF accounts for roughly 60% of demineralized whey powder usage and 30% of WPC 80 usage. The global IMF category is forecast to grow at a CAGR of 6% through 2023, according to 3A Consulting, reaching USD 73bn. The driving forces behind this are a growing global population and developing market demand from a rising number of working mothers. At USD 37bn as of 2018, Asia Pacific is the largest global IMF market, accounting for 50% of total sales, and the region is forecast to grow by a 7% CAGR through 2023. Maternal nutrition is a growing subsegment of the IMF market and worth considering. With 2019 sales estimated at USD 50m, it is on track to grow by more than 20% CAGR in the coming decade, with a particularly strong demand increase in Asia.

Another market category slated for substantial development is nutrition for weight management and aging. Driven by a vast, aging global population, continued health consciousness, longer life expectancy, and a relatively undeveloped competitive landscape, it is a promising category. The global weight-management and aging nutrition industry is estimated to be worth USD 17.6bn as of 2019, and is expected to grow by around 5% annually through 2024, according to 3A Consulting.

With global demand for whey ingredient products growing at different rates across the world, whey manufacturers need to consider their footprint by region. By 2022, Europe is expected to consume 39% of all whey protein solids produced globally, with the largest share (50%) going into whey powders (see Figure 3). But, as previously noted, WPC 80 and WPI demand is forecast for strong growth in the sports and clinical nutrition markets, accounting for nearly 20% of total whey protein solid utilization. North America's consumption of whey protein solids is second globally, at 24%, with Asia at 19%. Although Asia's demand for whey ingredients is not as high as Europe or North America's, it is forecast for the most rapid growth (3% to 4% CAGR through 2022), with WPC 80 and WPI growing at 6% and 9%, respectively, over the same period. The remaining markets of the Middle East/Africa, Latin America, and the Commonwealth of Independent States account for a combined 15% and are also growing at rates in the range of 2% to 3% through 2022.

Figure 3: Estimated share of demand by whey ingredient product and region through 2022



Source: 3A Consulting and Rabobank 2020

In terms of meeting these growing demands, North America, Europe, and Oceania – which currently account for around 70% of total whey solids processed into ingredients – will be the core suppliers to these markets. Milk-deficit markets are anticipated to continue to encounter challenges in expanding their milk supplies, and deficits are expected to continue to grow. Furthermore, with the largest share of incremental demand for whey ingredients coming from Asia, suppliers may want to plan to export a greater share of volumes. As a result, it will be important for ingredient players to develop their knowledge of foreign markets, deepen relationships, and build global sales forces, or perhaps consider partnerships that open doors for international customers.

In addition to developing global flexibility, it is important to emphasize product optimization when assessing whey ingredient investments. New plants that are able to move between whey products and markets to meet new and changing customer specifications will tend to outperform plants with more limited functionality. The decline in WPI prices caused by Covid-19 is an example of the risks in specific categories like sports nutrition. Companies that could not produce other whey products were forced to take lower WPI returns as the outbreak caused a decline in sales of sports nutrition products when gyms temporarily closed.

In order to capture all the value from the whey stream and to enhance/stabilize margins, ingredient manufacturers' strategies for whey permeate are becoming increasingly important. The primary strategy employed by manufacturers today is making whey permeate powder for human and animal feed applications and/or producing pharmaceutical-grade lactose, GOS, and HMO. The latter three show increasing demand, with good premiums in early-life and aging nutrition products.

Fractions can also be leveraged from whey to bring greater value to the entire stream. Whey fractions, such as beta-lactoglobulin, can be produced and then added back to WPI to improve functionality and nutrition and to help differentiate products. As a result, whey fractions tend to have higher and more stable pricing, and are utilized in specialized and rapidly growing applications.

Lactoferrin is an example of a product created via early-stage extraction of whey processing.⁹ Lactoferrin is a small but increasingly important part of infant-nutrition products. It accounts for around 15% of mother's milk, but is found in much smaller quantities in cow's milk. For this reason, it is very important in early-life nutrition (ELN) products and is a highly valuable product.

Extracting lactoferrin via early-stage processing can have an impact on downstream products. Regulations are changing in such a way that if lactoferrin is extracted downstream, products such as WPI are no longer technically classified as WPI in the EU. So, it is important to consider your product mix when investing in lactoferrin capacity. The global lactoferrin market remains very small, at around 400 metric tons, but is growing at a CAGR of around 5% to 10%, according to the American Dairy Products Institute (ADPI). The main markets for lactoferrin are China and the US, with utilization in IMF and sports and clinical nutrition. Changing requirements for lactoferrin to be 95% pure for IMF use in China have pushed prices to around USD 2,000/kg. Lactoferrin also has immune-support properties, which are still being researched for better understanding and for more targeted use in products. There are likely to be more companies leveraging this quality in the coming months and years as the world combats coronavirus and more attention is focused on immune-system support.

⁹ Lactoferrin is more commonly extracted along the skim milk stream today, due to higher yields.

Conclusion

Consumers worldwide are anticipated to be more health conscious, resulting in a growing customer base that is focused on consuming more nutritional products across all stages of life. Whey and its derivative products will continue to play a crucial role in new products being developed for the full cycle of life, from early-life nutrition to aging nutrition. This will bring more opportunities for the whey ingredient industry to grow, but technical prowess and global scope with a customer focus is a must. Growth will also be complicated, due to the global nature of the market, complex product portfolios, expensive investments, and the underlying need for cheese to secure whey. Planned expansions and new plants within the cheese industry are on track to provide a sufficient whey stream for now. But, future expansions will need to consider a multitude of factors in their next steps, including securing whey pools, utilizing whey derivatives, developing new technologies, ensuring product mix flexibility, and building trusted relationships with customers. But for many, this might be too tall of an order. As a result, partnerships, mergers, and acquisitions will be an important strategy for big and small companies to overcome these hurdles.

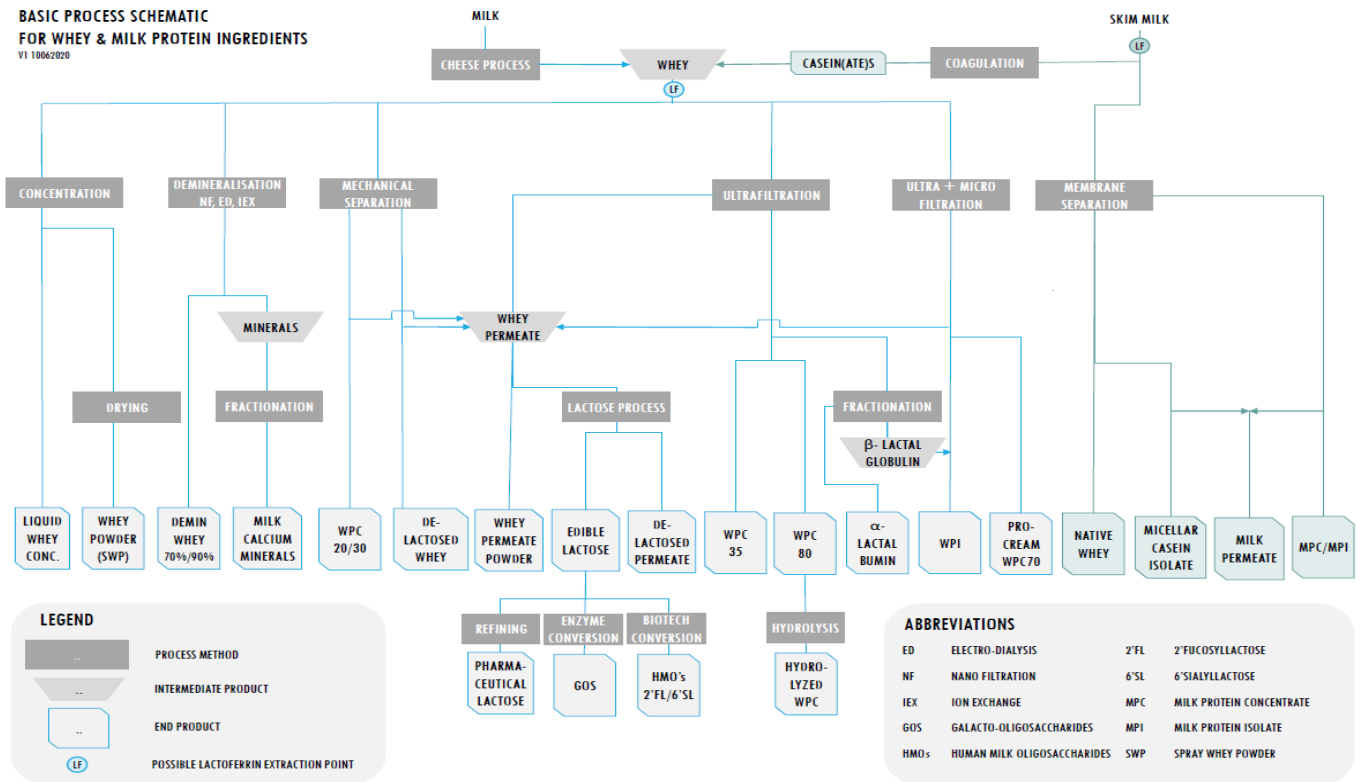
APPENDIX

Understanding the Whey Stream

Whey protein accounts for about 20% of the protein in milk, with casein accounting for the remaining 80%. When cheese is made, the casein and the milk fat form the bulk of the cheese, leaving liquid whey as a by-product. From 100kg of milk, you can make approximately 10kg of cheese, the remaining 90kg is liquid whey, the bulk (~90%) of which is water. Once the water is removed, you are left with about 5.5kg solids, comprising 4.2kg carbohydrates/sugars (lactose), 0.60 kg minerals and other components, and 0.6kg protein. So, in short, the good stuff – whey protein – is just 5.0% of milk solids. For the purposes of this report, we will generally be focused on the 5.5% solids left from cheese production referred to above.

The first add-value step of whey processing is to manufacture dry whey. One hundred kilograms of liquid whey yields nearly 5.5kg of dry whey powder, which comprises about 11% whey protein, 85% lactose plus minerals, and 4% moisture. The next level of liquid whey processing concentrates the proteins by using selective membranes to retain the proteins, while allowing the lactose and minerals to 'permeate' through the membrane. Whey protein concentrate (WPC) varies in protein levels from 34% to 80%, and at the top end of the scale, whey protein isolate (WPI) contains a minimum of 90% protein. Just as whey is a by-product of cheese production, whey protein concentrate production results in a by-product, whey permeate, which is comprised mainly of lactose plus minerals with a small amount of protein. The whey-permeate yield from production of WPCs varies across the different whey products manufactured – the higher the whey protein concentration, the more whey permeate is generated. Of 50kg whey dry solids, about 15.5kg of WPC 35 plus 34.5kg permeate can be produced, or about 6.9kg of WPC 80 plus 43.1kg of permeate. With modern-day WPI production using microfiltration, a high-fat WPC 70 product such as procream can be generated as by-product.

Figure 4: Whey stream schematic



Source: Industry Consultant with express permission for Rabobank use, 2020

Whey derivatives, coproducts, and fractions:

1. Liquid whey permeate concentrate – often sold to farmers and used as feed.
2. Whey permeate powder – sold to the global feed industry (mainly for piglet feed). It requires considerable investment in specialized drying and is increasingly used in the food industry.
3. Lactose – comprised of edible, refined edible, and pharmaceutical grades (used in food, infant formula, and asthma inhalers/pills). Lactose can be made from whey permeate. The yield is about 65% lactose and 35% DLP (de-lactosed permeate).
 - a. DLP – is a coproduct of most lactose-manufacturing processes. It has very high salt content, so it is very difficult to dry. Some DLP is used in animal feed, but the majority is disposed of in biodigesters at a cost.
4. Galacto-oligosaccharides (GOS) – is a prebiotic used in early-life nutrition (ELN). It is made via the enzymatic transformation of lactose. GOS stimulates the growth of good bacteria in the large intestine, such as bifidos, that carry out many biochemical transformations and are major contributors to immunity.
5. Human milk oligosaccharides (HMO) – 2'FL and 6'SL – are value-adding factors in infant formula that are found in human milk. Over 200 HMO have been identified in human milk; 2'FL and 6'SL are two of the most abundant. Among other things, they act as prebiotics and have many influences on infant health. These products are made through the biotech conversion of lactose.
6. High-fat WPC 50 and WPC 70 – often known as procream in the US – is a coproduct of WPI production using microfiltration. Procream is essentially a whey concentrate with a high phospholipid content. Most procream is used in animal feed. In the EU, where it is associated with improved cognition, some is used in very high-end ELN products.
7. Lactoferrin – can be obtained at an earlier stage of the whey stream, and is often used in IMF and other value-add consumer products, primarily in Japan.
8. Beta-lactoglobulin (beta-lac) – is the major whey protein component from cow's milk, and is not present in human milk. It is sold in high-end ELN products, as it is rich in BCAA, and incorporated into WPI. Some companies are now separating alpha-lactalbumin from beta-lac.
9. Alpha-lactalbumin (alpha lac) – is used in high-end ELN products.

Imprint

RaboResearch

Food & Agribusiness

far.rabobank.com

Tom Bailey

Senior Analyst – Dairy

thomas.bailey@rabobank.com

+1 (212) 916 7831

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