

Evolution of Commercial Whey Protein Products

A Presentation to the Royal Society of Chemistry &
the Society of Dairy Technology

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Evolution of Commercial Whey Protein Products

- Historical context
- Membrane Filtration: the driver for WPC development
- Whey Protein Isolates
- Volac case study
- A look into the future

Historical Context

- Whey Characteristics
- Cheese / Whey Industry Structure
- Initial Drivers for Whey Processing Technology

Membrane Technology & Whey Valorisation

- RO (Reverse Osmosis: Solids Concentration)
- UF (Ultrafiltration: Protein Concentration)
- NF (Nanofiltration: Salts Removal)
- MF (Microfiltration: Fat & Bacteria Removal)

People & technology drivers

RO Development: Donald Bray



Donald Bray; photos courtesy of website desalination.com

- Nuclear technology background; joined General Atomics in late 1950s
- ROGA formed to work on sea water desalination using Cellulose Acetate Membranes

RO Development: Bray's Contribution

- 1st Multi-Leaf Spiral Wound Membrane Filtration Element (1964)
- Founded Desalination Systems Inc (Desal)
- Founded Nimbus Water Systems



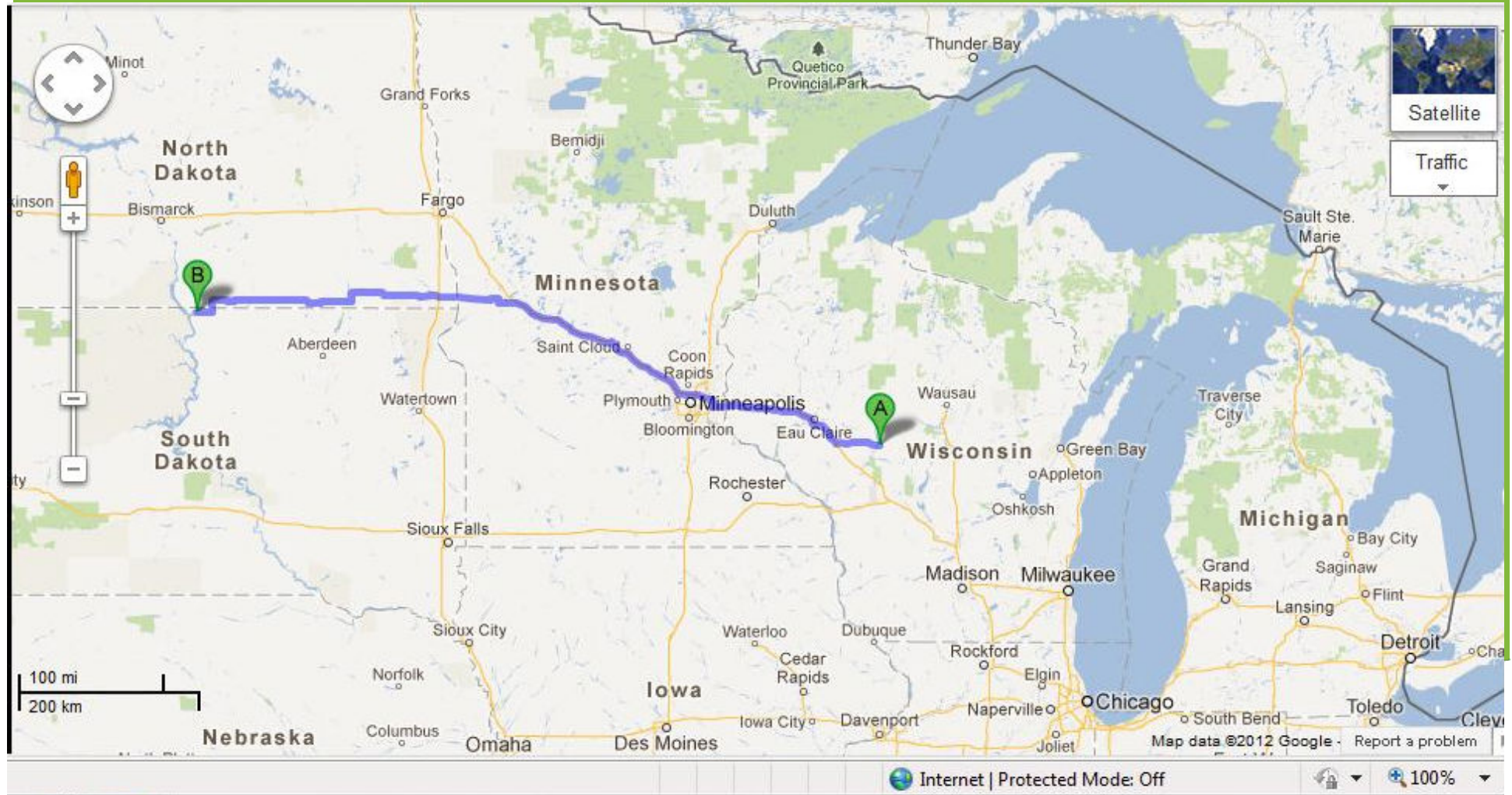
1st multi-leaf spiral element;
photo courtesy of Mark Chilton

Proliferation of RO in the US

- >100 RO Systems built in the US in the decade from 1975
- Most built by either DDS in their Plate & Frame format or PCI using their tubular design
- By the late 1980s these systems were obsolete

UF Development: Frank Thomas

The Achievements of a former Dairy Farmer



Neillsville WI to Pollock SD, a car journey of over 500 miles, which Frank Thomas undertook frequently in 1971/2, when he used to listen to correspondence courses on his tape player to further his education

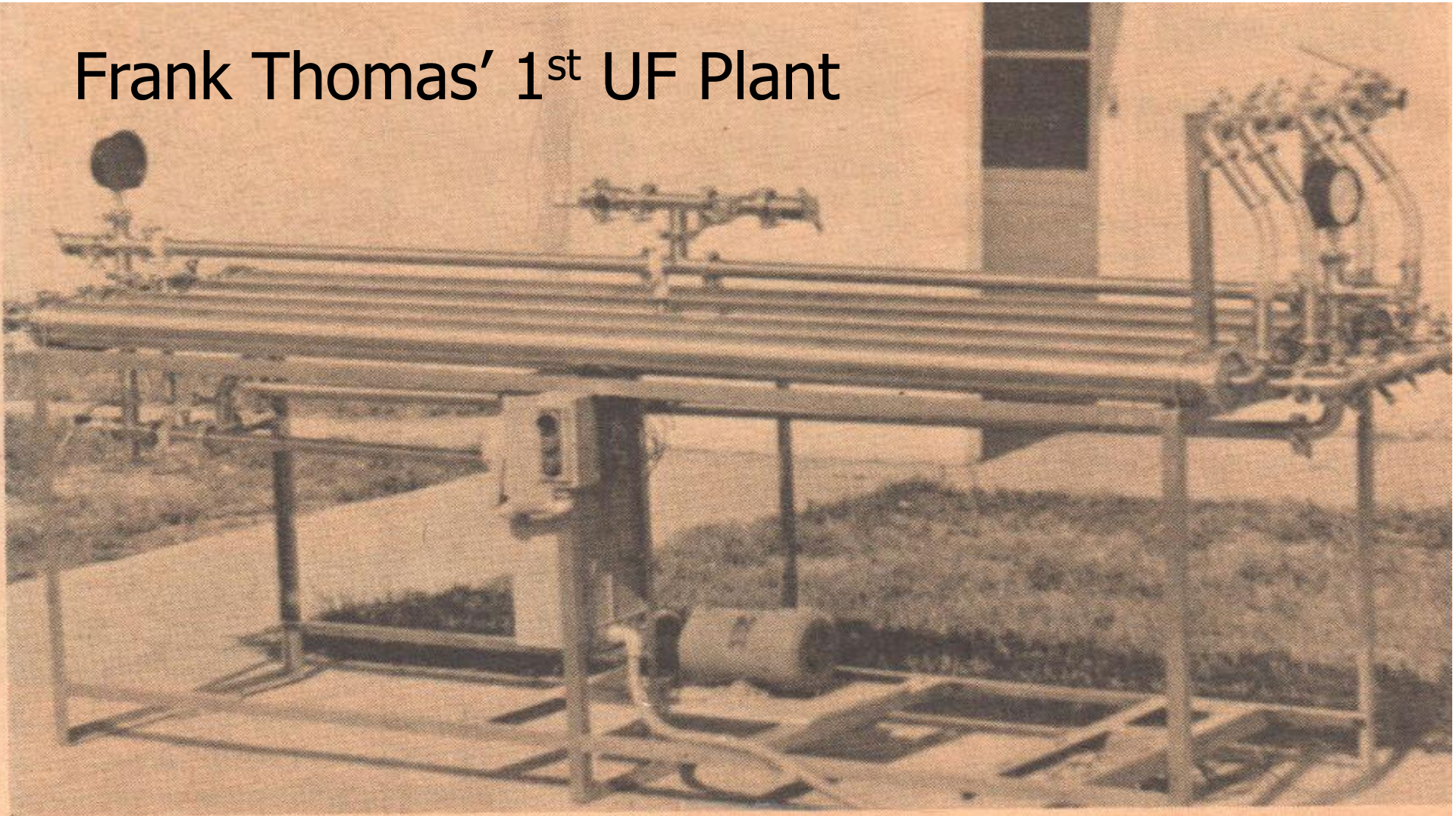
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UF Development: Thomas' Contribution

Four remarkable achievements:

- Understood the potential for WPC in both animal & human nutrition
- Worked with Desal to produce a patented spiral membrane
- Invested \$250k to design & build a system to deploy the membrane
- Successfully marketed to dairies & food companies

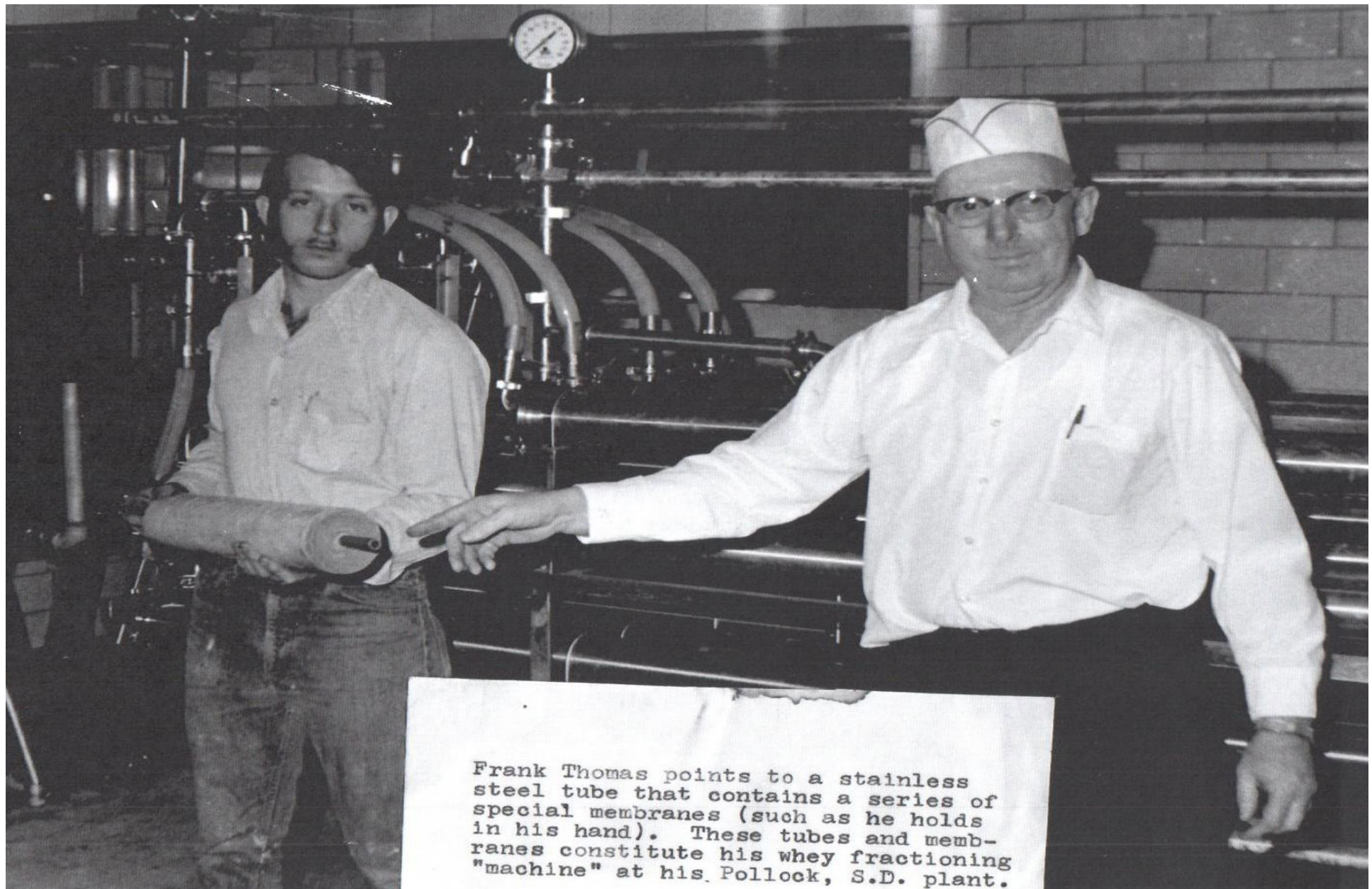
Frank Thomas' 1st UF Plant



This machine invented and developed by Frank Thomas is based on the principle of the cream separator to extract pure protein from whey.

Frank Thomas' 1st UF System, Pollock SD; Rushmore Ads / News, June 28th 1972; courtesy of Thomas Technical Services Inc, Neillsville, WI

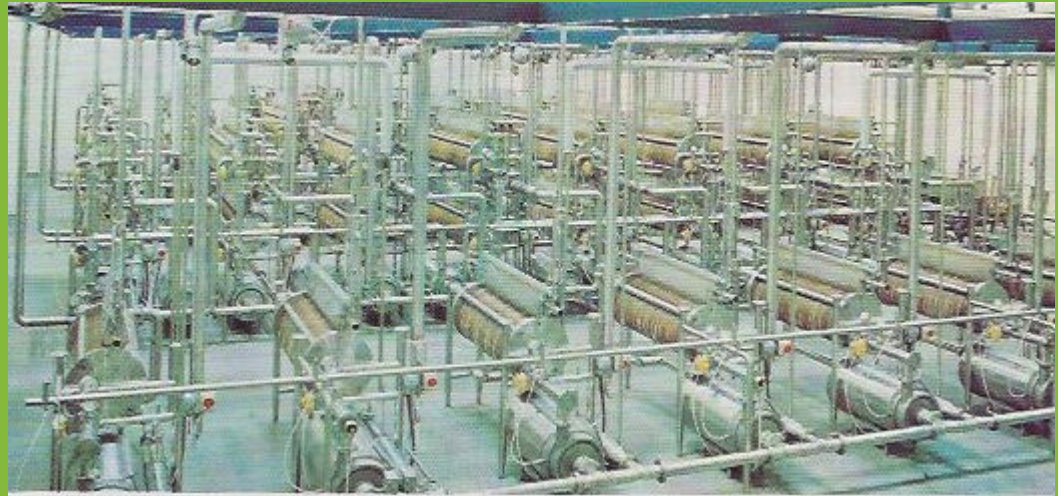
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Frank Thomas with his 1st UF, together with a spiral wound membrane element, c1972; photo courtesy of Thomas Technical Services Inc

Ultrafiltration in Europe

- UF in Europe started later than in US, but was quicker to embrace WPC80 from ~1978
- DDS main player in Europe & Aus/NZ
- PCI builds UK's 1st Whey UF at MMB Aspatia in 1979 - WPC76 for Japan



Multi-stage high protein UF system comprising many M35 DDS Plate & Frame modules at Danmark Protein (now Arla) at Nr. Vium Mejeri, Videbæk, Jutland; Photo courtesy of Bjarne Nicolaisen



A PCI Tubular UF System, similar to the plant installed at MMB in Aspatia; photo courtesy of Mark Chilton

Developments Down Under

- By 1971 NZDRI was the world authority on UF of whey – having developed a new unique product for a new application using a new technology
- Worked with tubular (Abcor), P&F, flat leaf & hollow fiber pilot plants, as well as IX/ED a little later
- One problem – no customer!!
- After another 2 years the 1st commercially viable application was found – the pumping of hams
- NZ maintained their technical lead over Europe / USA for a number of years

The Emerging Dominance of Spirals

- Spirals are low tech & cheap compared to the more highly engineered systems
- The development of:
 - New Membrane materials (PS/PES for UF, TFC for RO)
 - Techniques for better membrane element construction
 - Better engineered systems
- By the late 1980s spirals had displaced all other formats from virtually all dairy processing

1984 - 1985: An Accidental Invention

- FilmTec tries to make a Thin Film Seawater RO, but one version does not reject NaCl!!!
- R&D Director Bob Peterson relates this to George Hutson of Filtration Engineering, who asks 'will it reject Lactose?'
- 'I have no idea – let's try it'
- A new application is born to remove monovalent ions as well as water from whey:
- What shall we call it?
 - Nanofiltration / Ultra Osmosis

The Birth of Nanofiltration / Ultra Osmosis

- 1st system for salt whey built in 1985 in Winsted
- Then FilmTec stopped making the membrane, Hutson went to Desal
- DK membrane developed
- Further work on acid whey; 1st system sold to Avonmore on 8-8-88



First NF/UO for Salt Whey, at Mid-American Dairyman's plant in Winsted MN in 1985; photo courtesy of George Hutson

WPC Reprise

Composition in % of some whey protein concentrate powders

Product	1	2	3	4
Protein in dry matter	35	50	65	80
Moisture	4,6	4,3	4,2	4,0
Crude protein (Nx6,38)	36,2	52,1	63,0	81,0
True protein	29,7	40,9	59,4	75,0
Lactose	46,5	30,9	21,1	3,5
Fat	2,1	3,7	5,6	7,2
Ash	7,8	6,4	3,9	3,1
Lactic acid	2,8	2,6	2,2	1,2

Product specification:

- 1 Skim milk substitute, 35 % protein in dry matter
- 2 Protein supplement to other foods, 50 % protein in dry matter
- 3 Practical limit of protein by ultrafiltration alone, 65 % protein in dry matter
- 4 Product of ultrafiltration plus diafiltration, 80 % protein in dry matter

Courtesy of Tetrapak

Whey Protein Isolate (WPI):

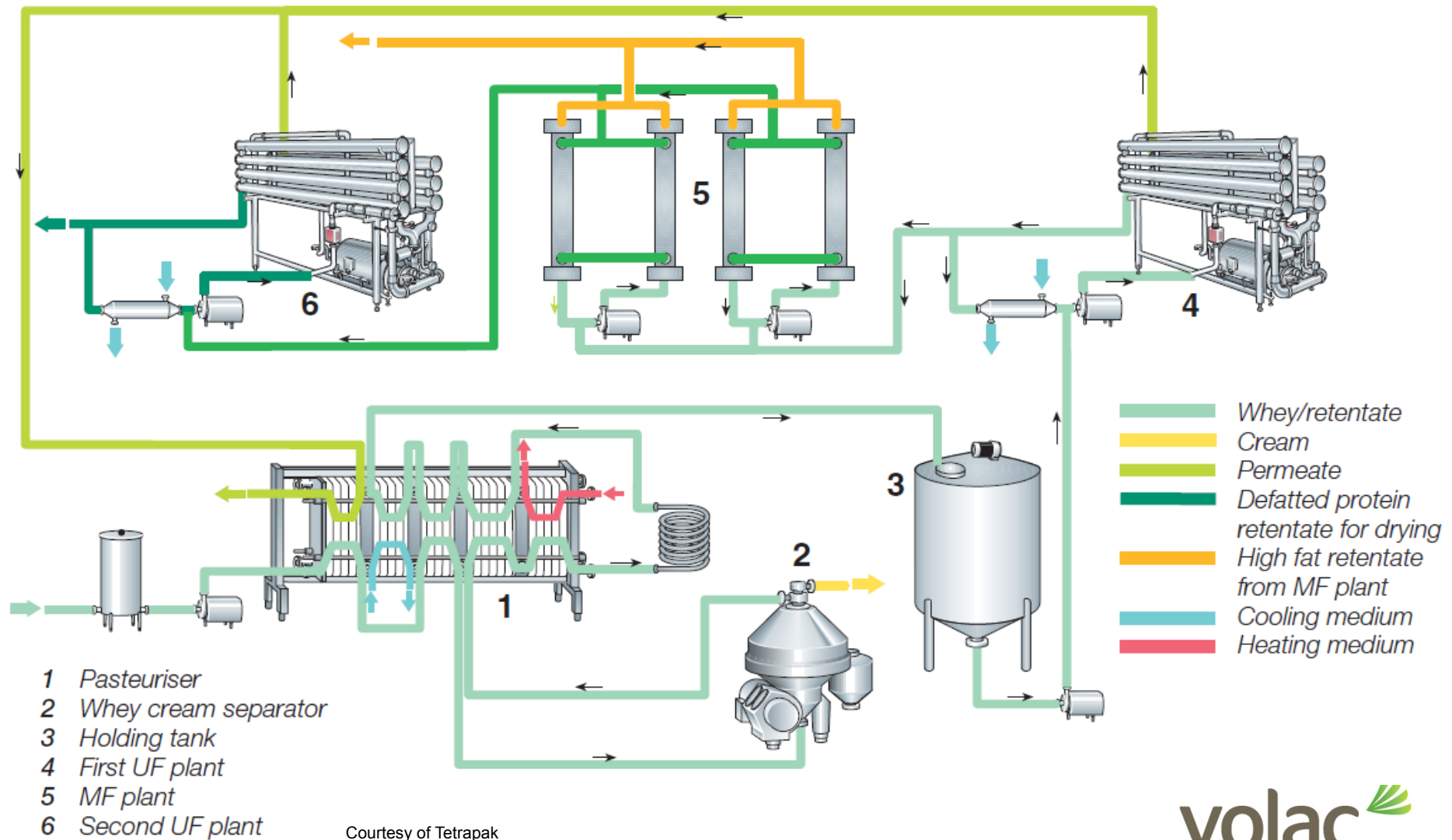
A New Generation of Whey Proteins

- Invented in UK; Commercialised in US in 1983
- Protein content >90%
- Technology to eliminate Fat, Colloidal Material & Lactose
- Two Technology approaches:
 - - Ion Exchange Chromatography
 - - Membrane Filtration (Microfiltration)

WPI: Bio-Isolates process

- Development stems from resin work to recover proteins from slaughterhouse waste in 1960s
- Whey 1st used as substrate in 1970s at Bath University
 - Absorption of whey protein onto a cellulose cation exchanger in a stirred tank reactor (pH<4.6)
 - Washing to remove lactose & other non-protein materials
 - Elution of adsorbed protein by raising pH with alkali
 - Concentration by UF, followed by spray drying
- Commercialised by Bio-Isolates from Swansea
- Acquired by Davisco Foods, Le Sueur MN - BiPRO

WPI: Membrane Filtration Approach



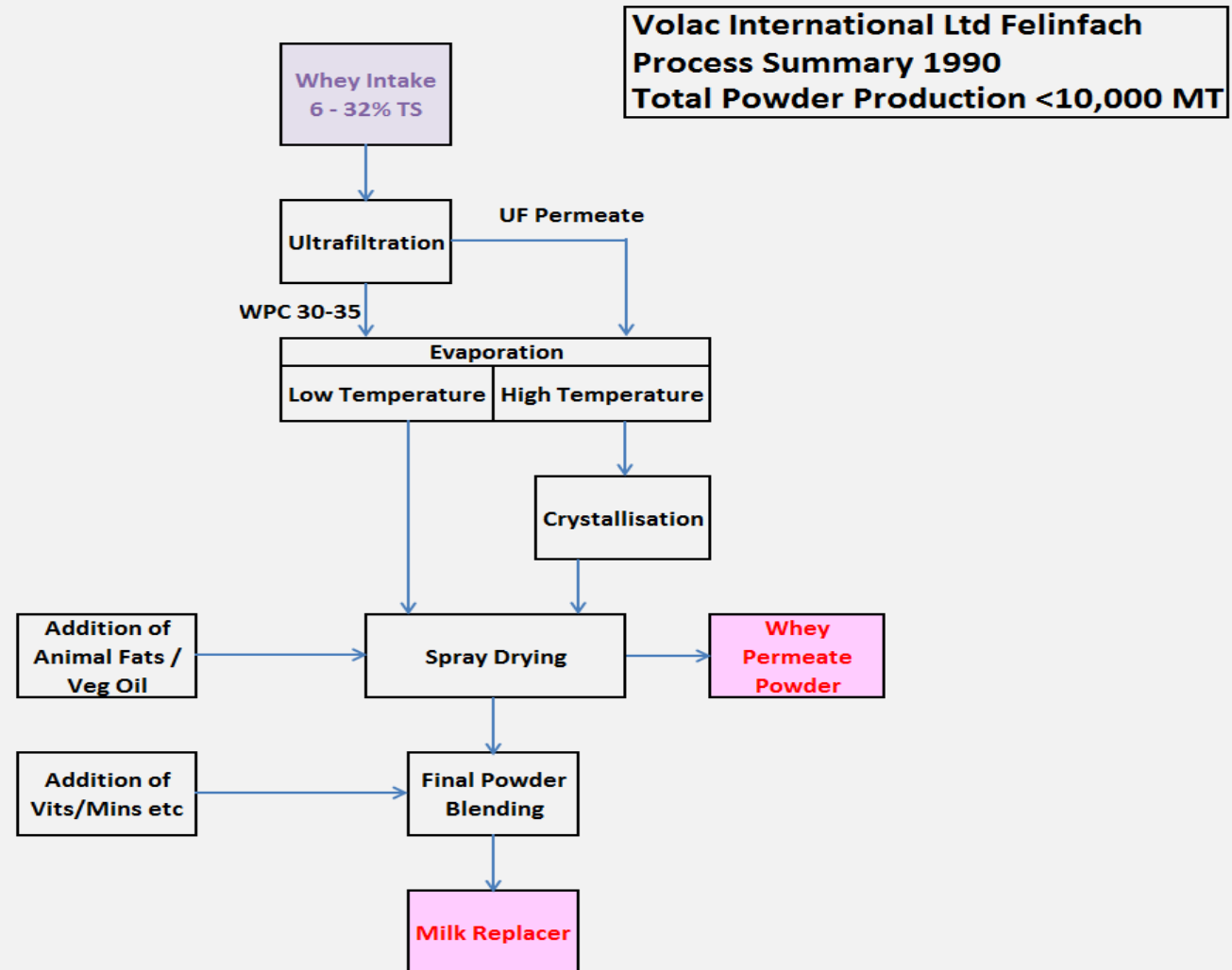
IX vs MF WPI Analytical Specification

	IX	MF
Moisture	Max 5%	Max 5%
Protein, dry basis (N x 6.38)	Min 95%	Min 92%
Fat	Max 1%	Max 1%
Ash	Max 3%	Max 3%
Lactose	Max 1%	Max 1-3%

Volac Case Study

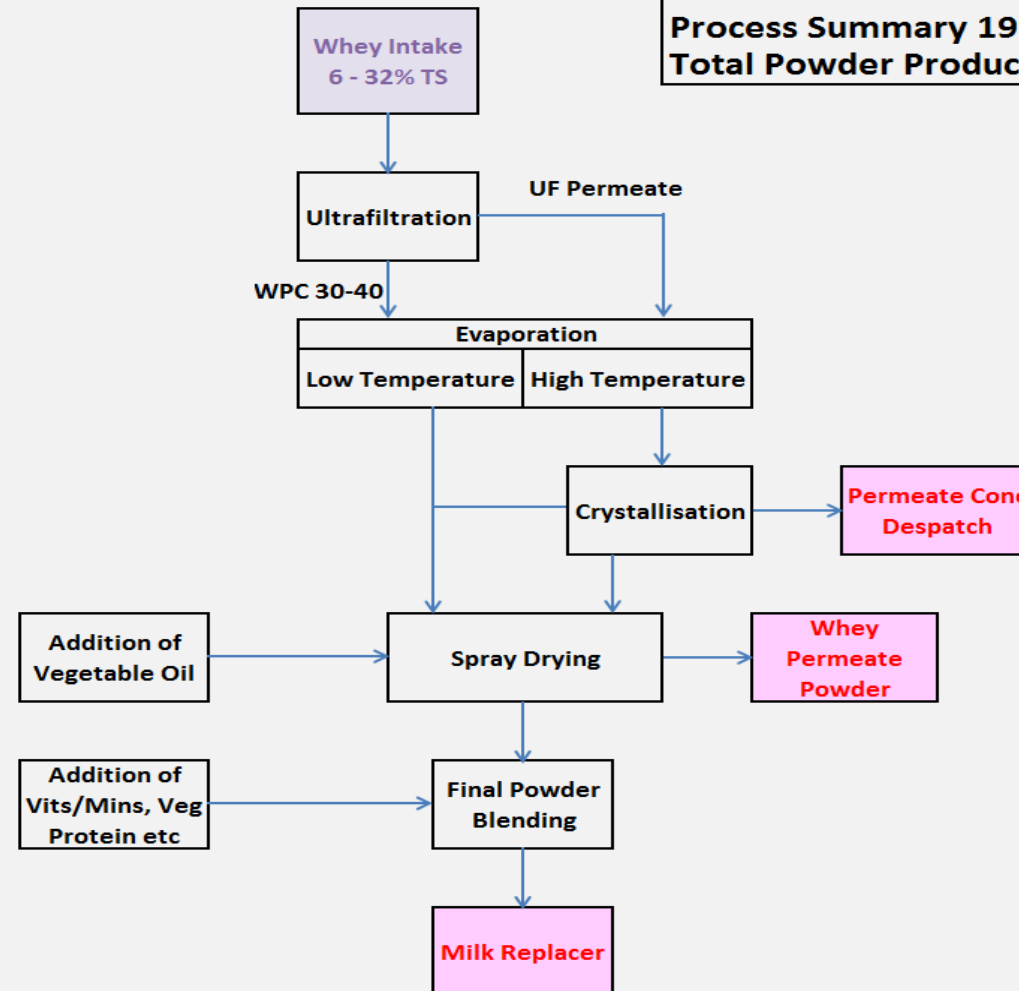
20+ Years of Whey Product, Process & Market Development

- One man's vision to turn a waste product into premium Calf Milk Replacer
- Making it happen
- Continuous Product & Process Development
- Diversification into Food Ingredients and becoming a major player in the UK Dairy Industry
- Continuing Innovation



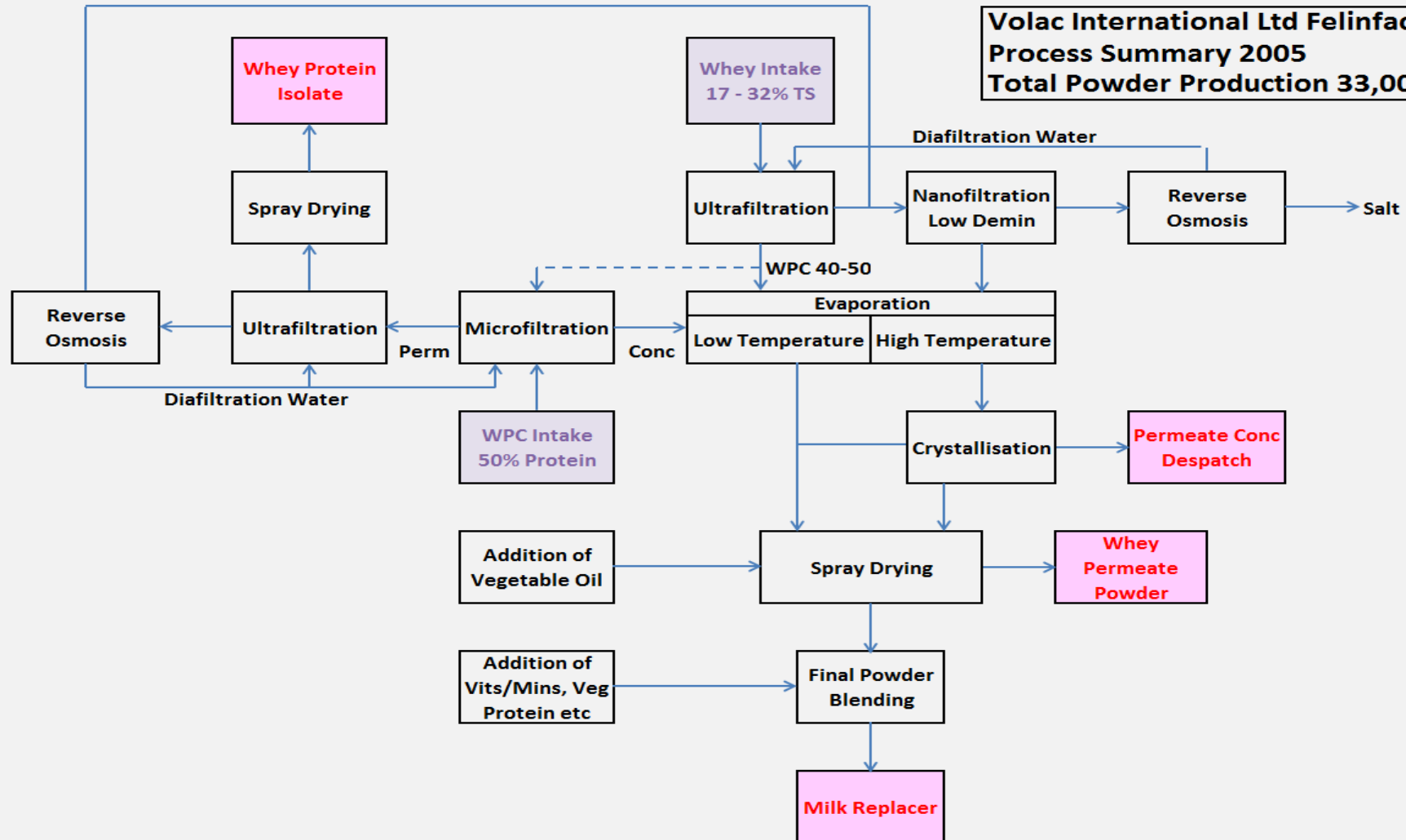
The original process – 100% whey protein based milk replacer with animal fats, together with whey permeate powder

**Volac International Ltd Felinfach
Process Summary 1995
Total Powder Production 15,000 MT**



Early Developments – moving to 100% vegetable oils, incorporation of some vegetable protein to 'stretch' whey protein, increasing outputs through standardising WPC protein using UF Permeate concentrate as milk replacer business developed

**Volac International Ltd Felinfach
Process Summary 2005
Total Powder Production 33,000 MT**



Expanded WPI Operation; investment in Nanofiltration to preconcentrate UF Permeate to give processing advantages. Milk Replacer production increasing such that excess UF Permeate had to be sold as concentrate for very low returns

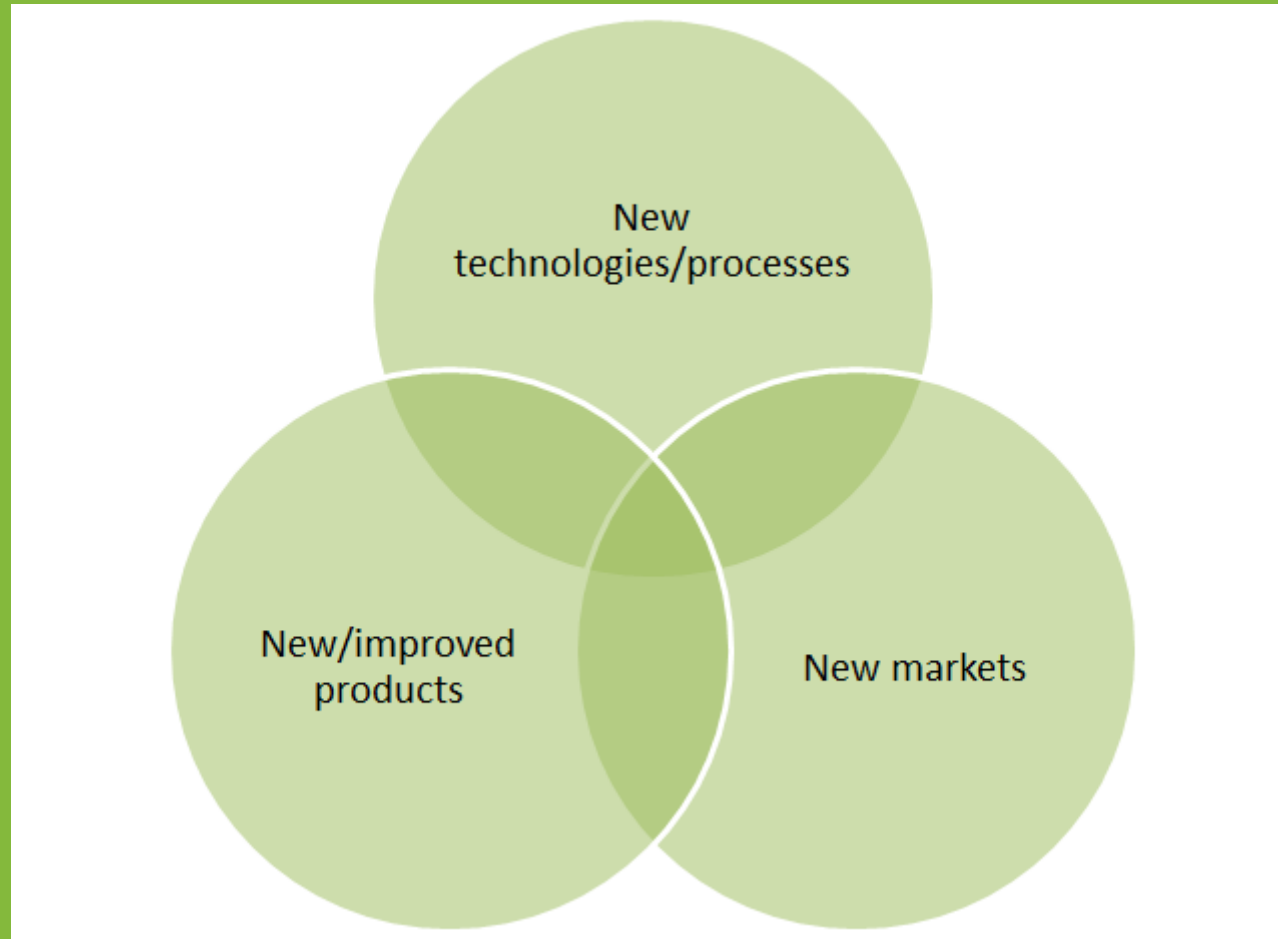
Whey Protein Innovation

Important Trends over the past 15 Years

- Sports Nutrition
 - Instantising of WPC80 / WPI
- Infant Formula Developments
 - Humanising of WPC80 / WPI
 - Whey Protein Fractions & Hydrolysates
- Whey Proteins in Dairy Products
 - Whey Proteins in Cheese – eg Microparticulation

Whey Protein Innovation

Thoughts & Predictions for the Future



Whey Protein Innovation

New Markets

- Scientific research will further underpin the benefits of whey protein as part of a healthy lifestyle, eg:
 - Post-exercise recovery
 - Weight management
 - Sarcopenia
 - Bone density maintenance
- But needed in a high quality, ready to use form.....

The Best Whey Protein – Healthy Nutrition – Good Whey Company - Microsoft Internet Explorer provided by Volac International Ltd

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WHY GOOD WHEY PROTEIN?

Healthy muscles

Good Whey is not about bigger muscles – it's about healthy muscles. Good Whey provides your muscles with the **essential amino acids** they need to replenish themselves after they've worked hard for you every day.

Most people's muscle mass slowly declines throughout their 40's and 50's – or even from mid-30's for some - so maintaining **healthy muscles** by consuming high-quality protein such as Good Whey can really help you to keep active, to live an independent life.

And of course, **healthy muscles** are leaner muscles which mean a more toned body, as long as you complement Good Whey with a healthy and active lifestyle.

Healthy bones

Bones are not the sort of thing we walk around thinking about (although we wouldn't be walking anywhere without them) but truth to tell your bone density is critical to you leading a **healthy, mobile life**. Normally, our bone density reduces with age. Protein is instrumental in helping our bodies **absorb calcium** to support strong and **healthy bones** to help keep us mobile as we get older.

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Whey Protein Innovation

New Technologies / Processes

- Incremental improvements to existing processes
 - eg Affinity Membranes, which could become a hybrid IX/MF process to simultaneously defat WPC & bind minor proteins such as Lactoferrin
- Whey processing 'holy grail': Cold Pasteurisation
 - Micro control on Whey Protein stream is notoriously difficult due to sensitivity to heat
 - eg high pressure, electric field, electromagnetic radiation

Whey Protein Innovation

New / Improved Products

- Edible films & coatings (with antimicrobials, antioxidants)
- Microfiltered milk as a source of purer whey protein (fat free whey with no cheese additives, GMP etc.)
- Blander flavour WPI
- Protein fortified consumer products
- Bioactive whey proteins and peptides

Commercial Whey Protein Products

Summary

1. Adding Value to Whey Protein was initially driven mainly by Industry / Process needs. Now it is firmly Market (Consumer) driven
2. Several examples of Innovation drawing on Technology from unrelated industries by enlightened individuals
3. Future Innovation likely to come from both of these drivers

Evolution of Commercial Whey Protein Products

Thank You for Listening

Thanks also to:

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Any Questions?

