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YOUR FOOD RESEARCHERS

Improving creaminess of yoghurt and fermented products by understanding the role of ingredients and processing routes

NIZO Food Research B.V., Ede, The Netherlands

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NCDEA / Dairy Australia Webinar
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Tuesday, March 04, 2014

Together to the next level

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Dairy Australia

Your presenter

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- Project Manager/Expert
  Dairy Drinks and Desserts
- Marja.Kanning@NIZO.com

NIZO food research

65 proud years of open innovation

Why:
- Good food needs good science

How:
- Science Hub for projects in a global food network:

What:
- Flavor, Texture or Health.
- Process improvement
- From lab to pilot plant

Where:
- HQ in the Dutch Food Valley
- Sales offices in USA, France & Japan

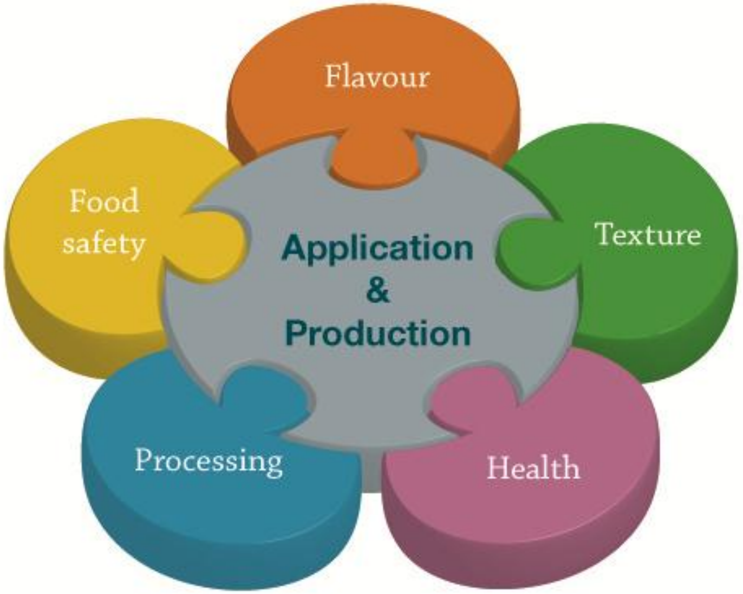
Who:
- 180 professionals

Research Centre

Application & Processing Centre

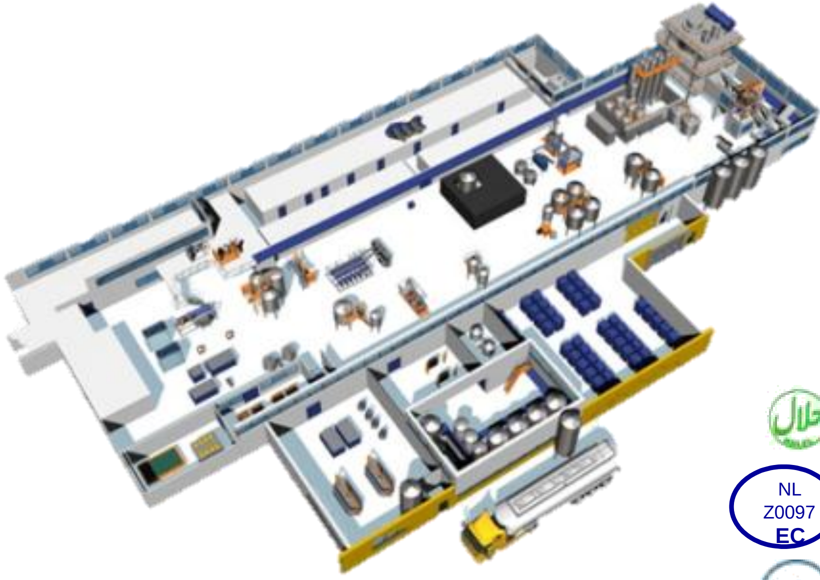
What

Services and deliverables



An open innovation network for:

- Research
- Consultancy
- Product & Process Development
- (test) Productions



Working Together to deliver:

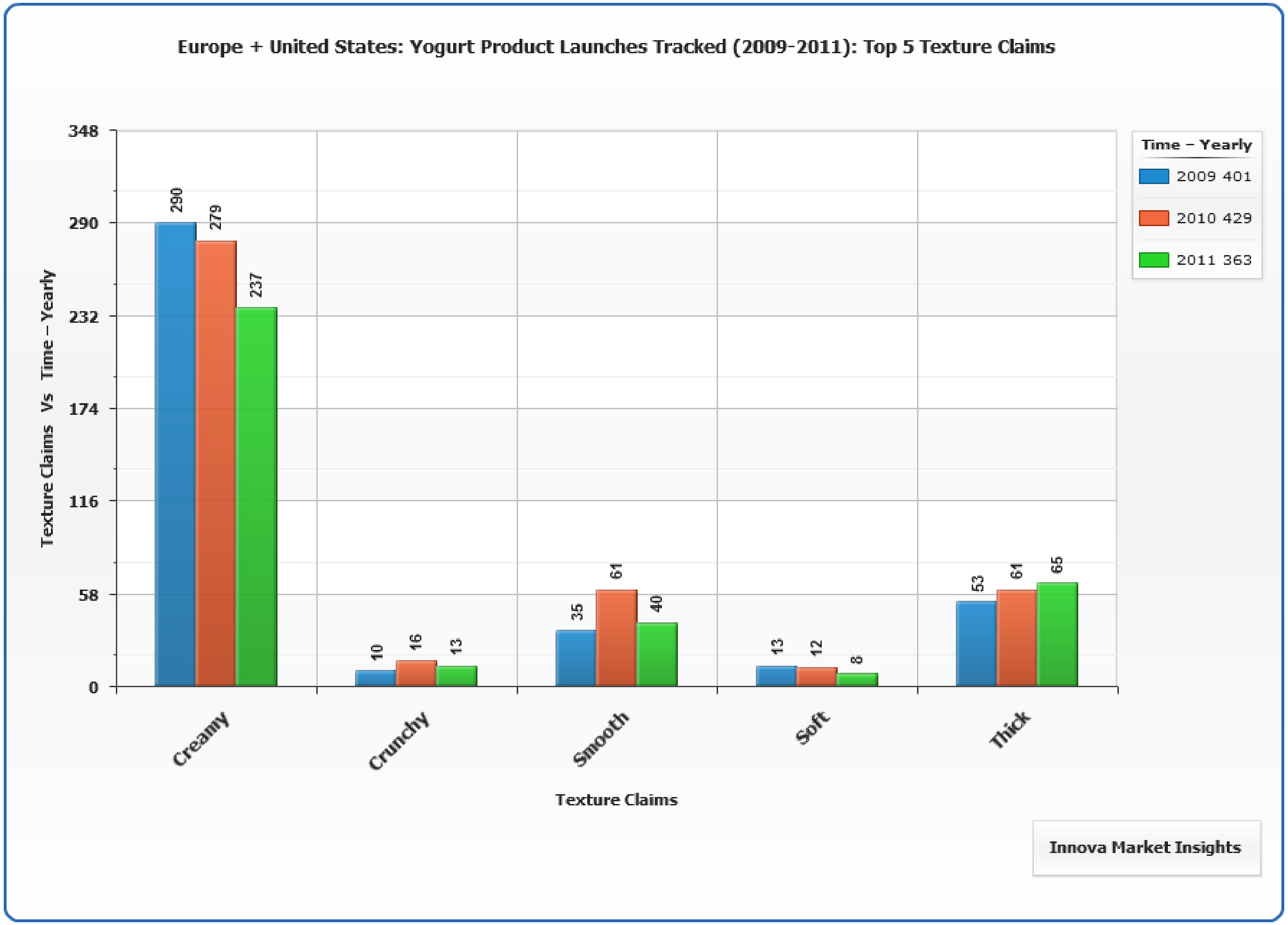
- New processes
- New formulations recipes
- Test productions
- Tolling (for small volume high value ingredients)

Pilot plant: business as unusual!

NL Z0097 EC

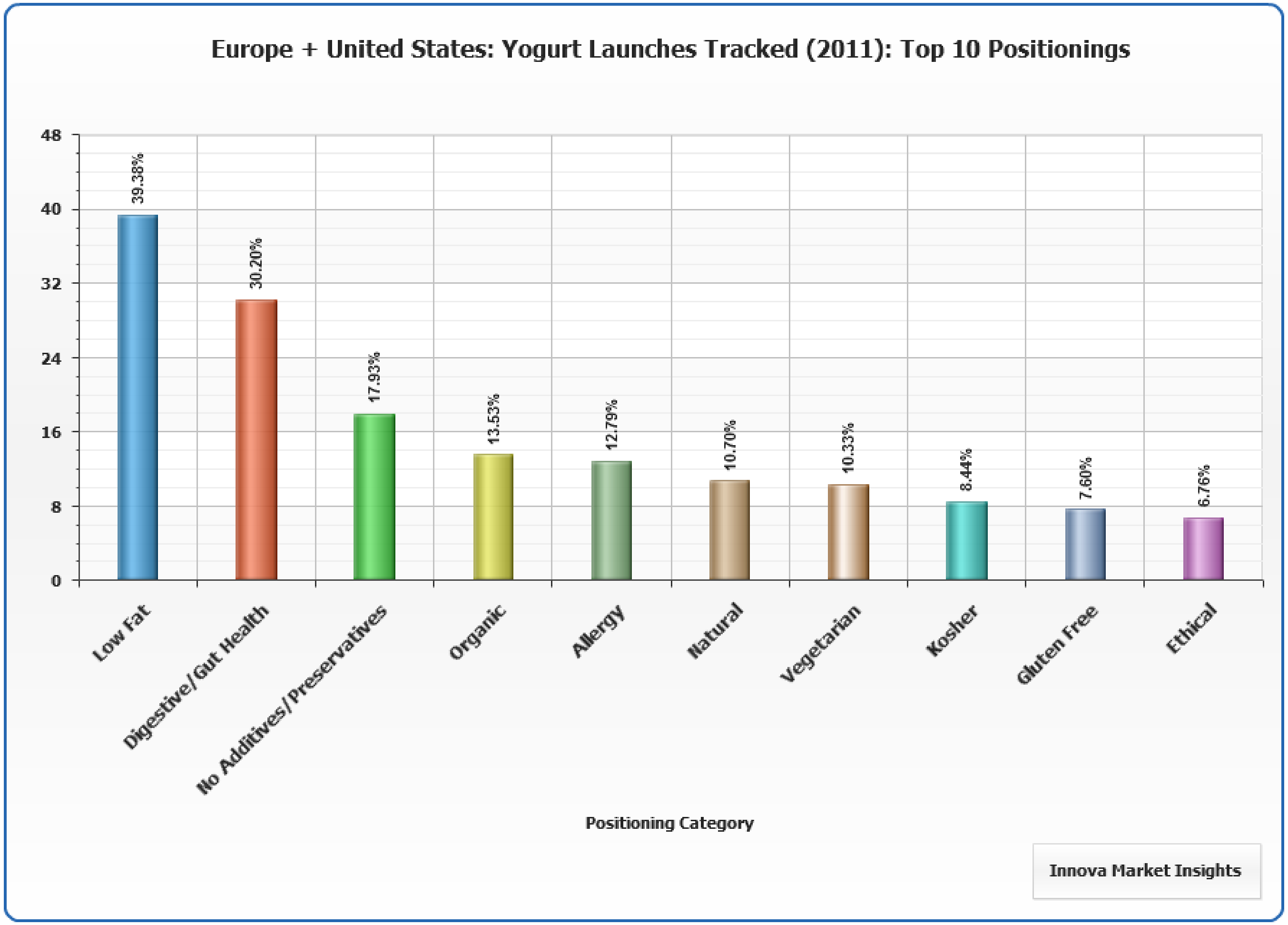
Kosher

Consumer



Consumers prefer yoghurt with a creamy and rich texture.

Consumer

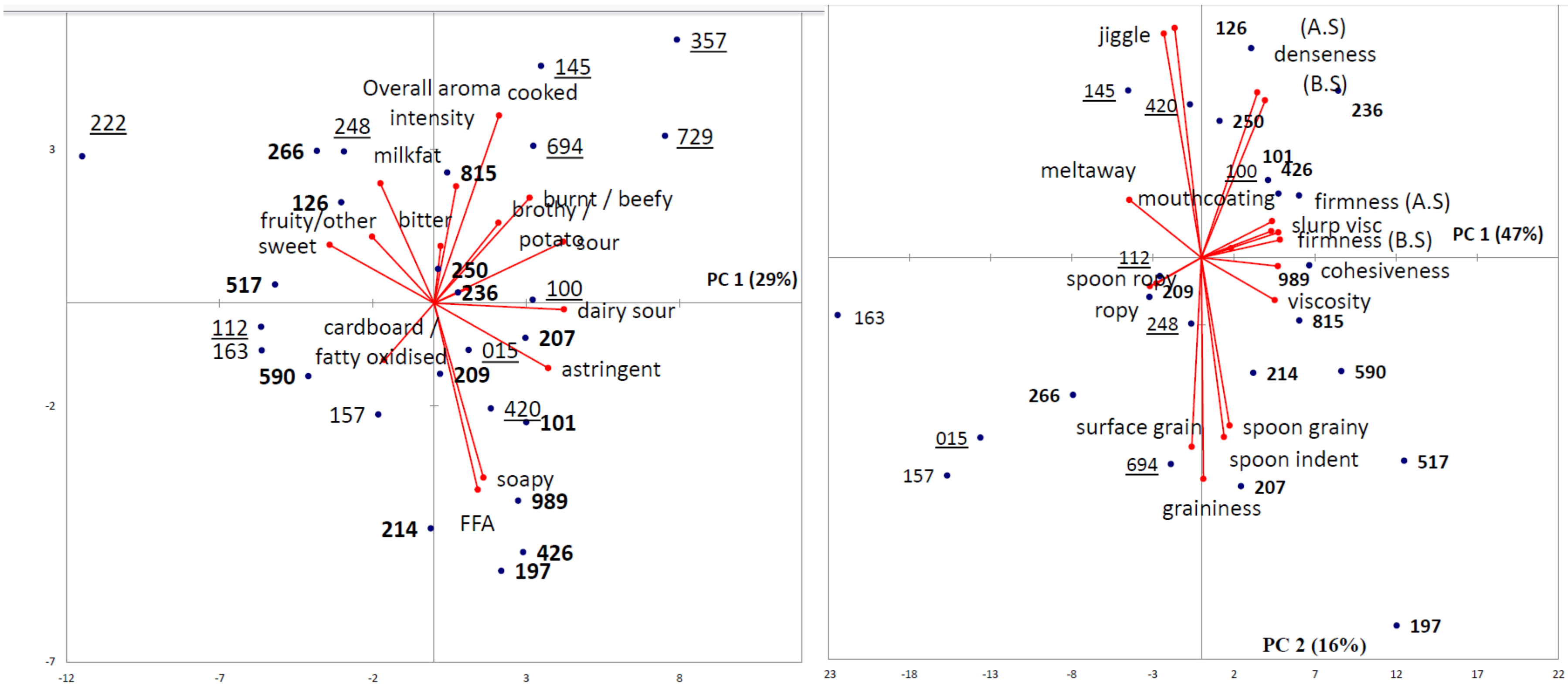


High protein, low fat

- Effect on satiety
- Effect on building/maintaining muscle mass

Greek-style yoghurt products

Clear differences



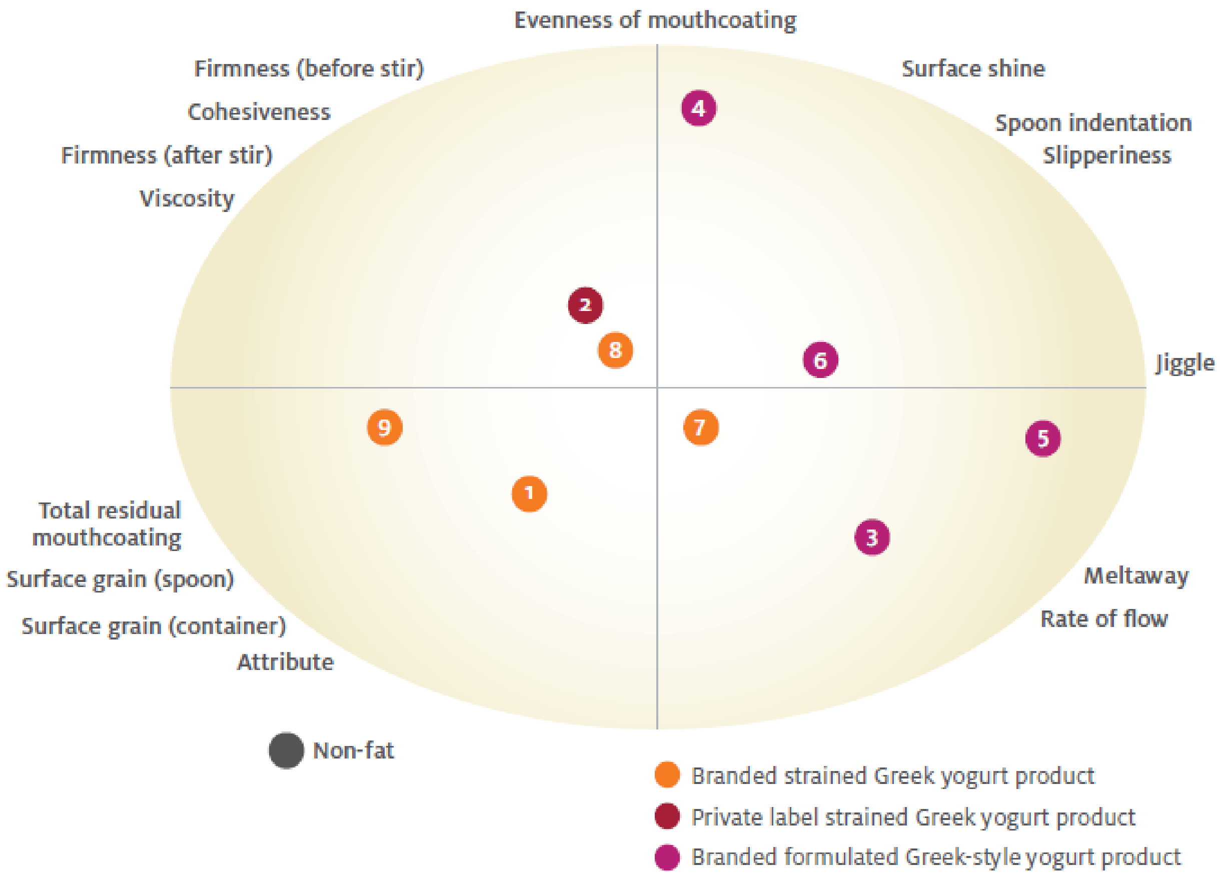
repository.lib.ncsu.edu/ir/bitstream/1840.16/.../etd.pd

Traditional Greek strained yogurts are numbers in bold. Greek style yogurts are underlined numbers and Plain non fat yogurts are numbers.

Greek-style yoghurt products

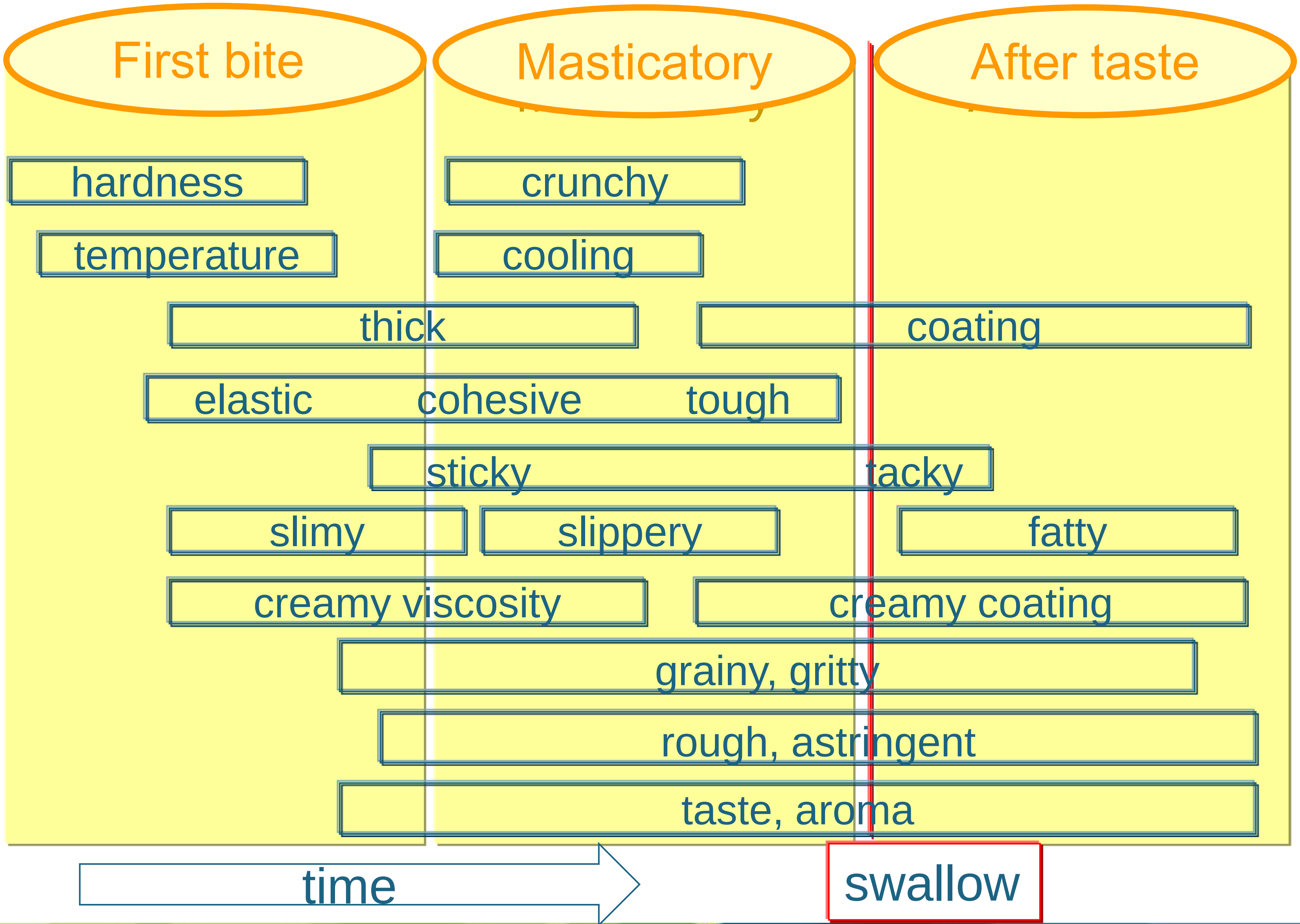
Clear differences

FIGURE 2: TEXTURE MAP OF EIGHT GREEK-STYLE YOGURT PRODUCTS



http://www.foodinnovation.com/foodinnovation/en-us/Innovations/Documents/Ingredion%20Greek%20Yogurt%20White%20Paper--Final.pdf (accessed February 2014)

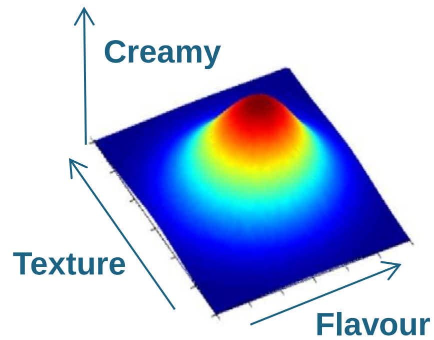
Sensory attributes reflect subsequent stages



Creamy low fat yoghurt

Factors playing a role in creaminess

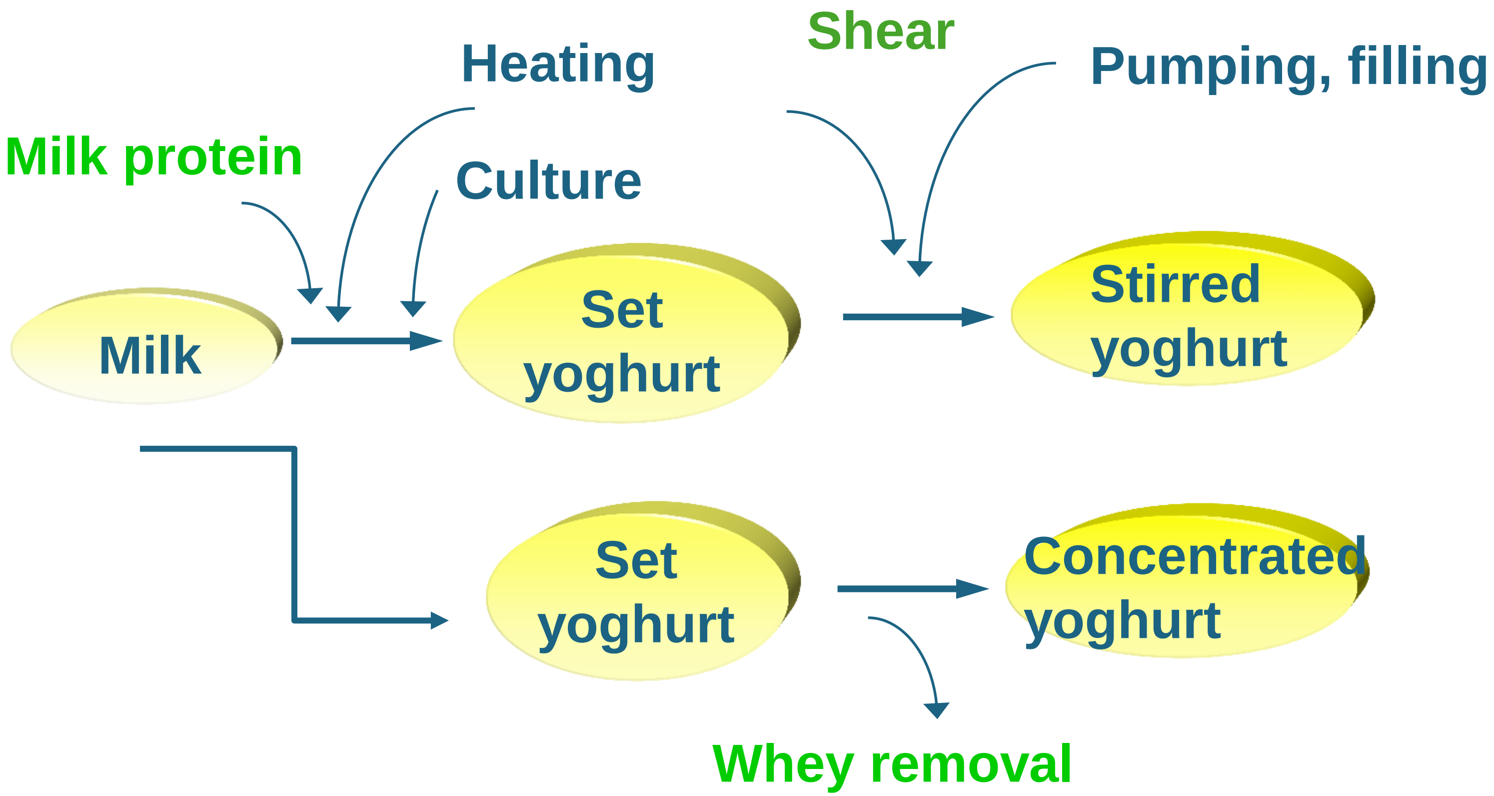
- Texture/mouthfeel
  - Thickness (viscosity) ☺
  - Smoothness ☺
  - Astringency (rough, dry) ☹
  - Chalkiness, powdery ☹
- Flavour
  - Acid 😐
  - Creamy flavour ☺
  - Clean flavour ☺



The choice of processing and ingredients plays a major role in achieving final consumer acceptance and shelf-life of the product.

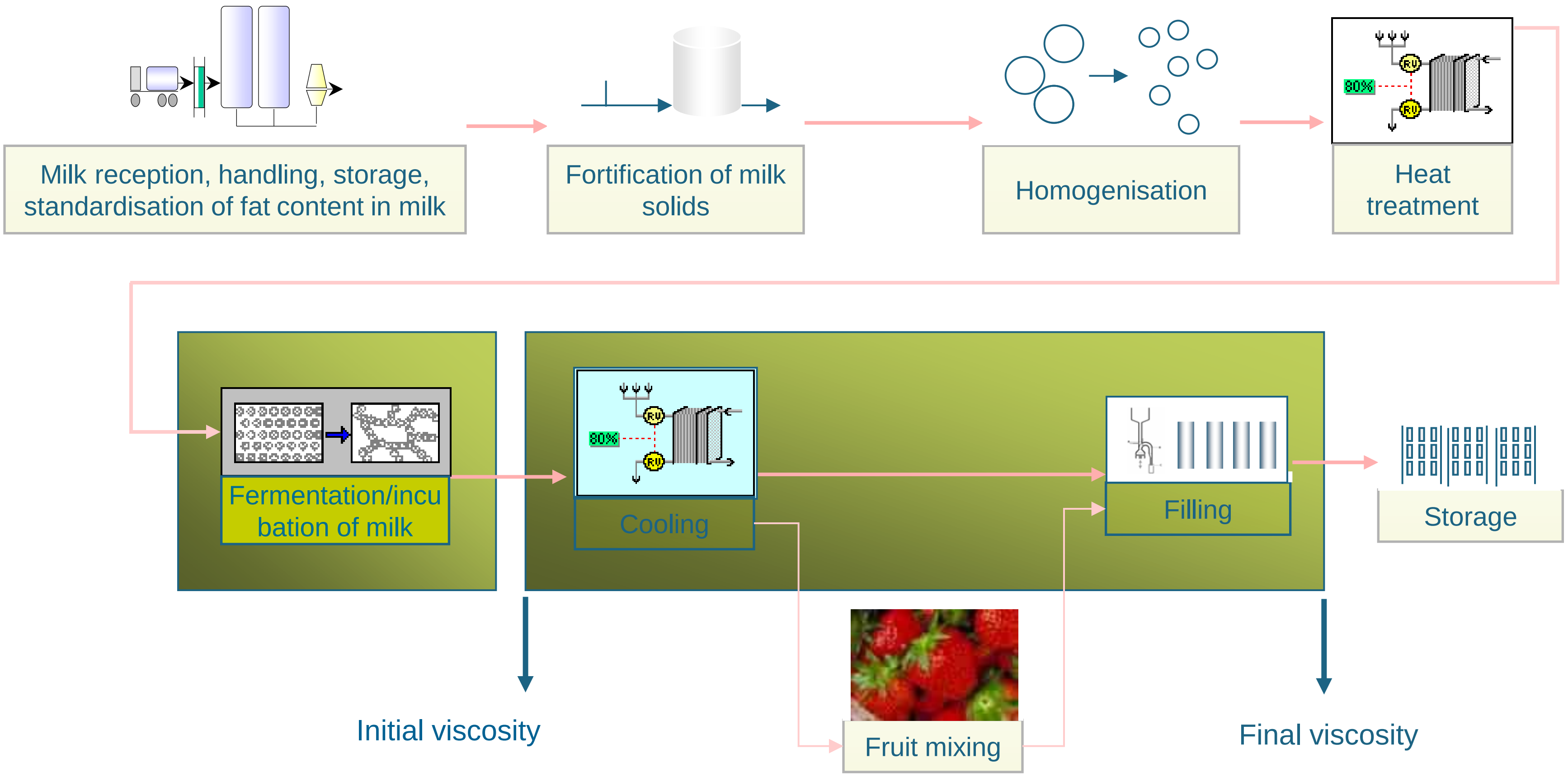
Processing

General



By understanding the effect of the applied shear and the functionality of milk proteins these factors can be optimised resulting in an increased viscosity of Greek-style yogurt while maintaining a smooth and creamy texture.

Processing routes



Structure and shear sensitivity of fermented milks

Use of powders in fermented products

Protein type / formulation approach

- MPC powder
- MPC/WPC mixture
- Milk concentrate (UF)
  - Liquid condensed milk

Choice affect functionality and flavour
- Solubility
- Clean flavour
- No graininess or chalky mouthfeel

SMP (high MSNF) in a formulation can lead to a very sweet taste and high solids formulation

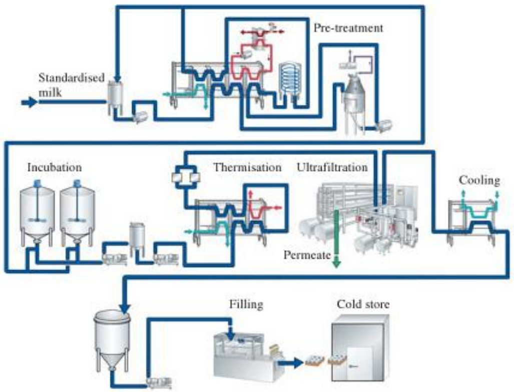


Fig. 7.5 Flow chart for the manufacture of concentrated yoghurt by ultrafiltration (Reproduced by permission of Tetra Pak, Lund Sweden).

32 commercial MPC's

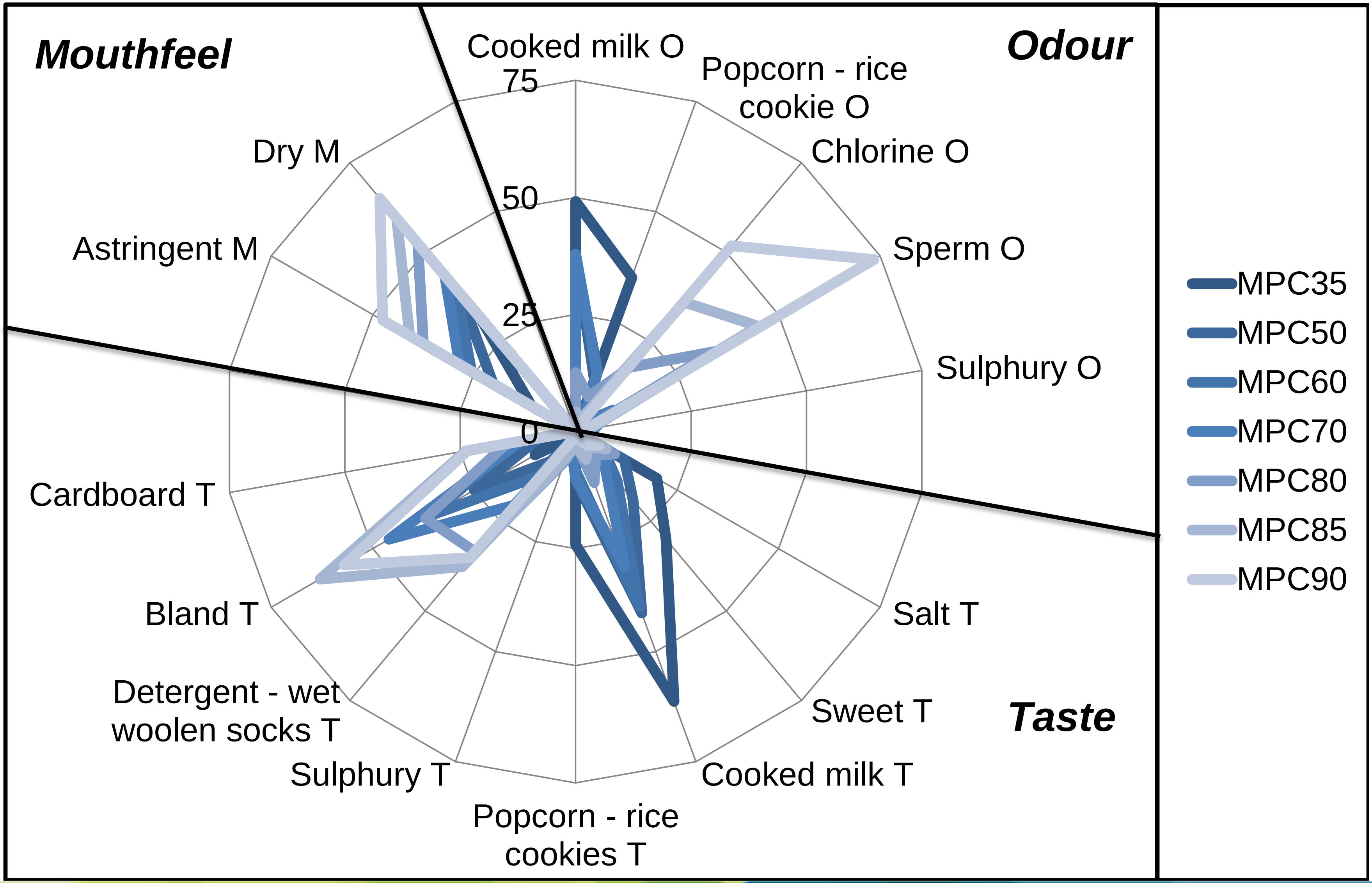
The extremes

Low		High
55	Protein (%, m/m)	85
3.5	Moisture (%, m/m)	6.6
14	Calcium (mg/g)	24
0.3	Sodium (mg/g)	14
17	Lactosylated β-lactoglobulin (%)	83
20	Denatured β-lactoglobulin (%)	80
38	Dispersibility (%)	100
27	Nitrogen solubility index (%)	87
0	Heat stability (min)	42
15	Gel strength (g)	266
178	Foam overrun (%)	390

- Extremely large differences in composition and properties between MPCs
- Differences attributable to:
  - Desired composition
  - Tailored processing
  - Sub-optimal processing
- Control of composition and process will allow optimized and tailored functionality

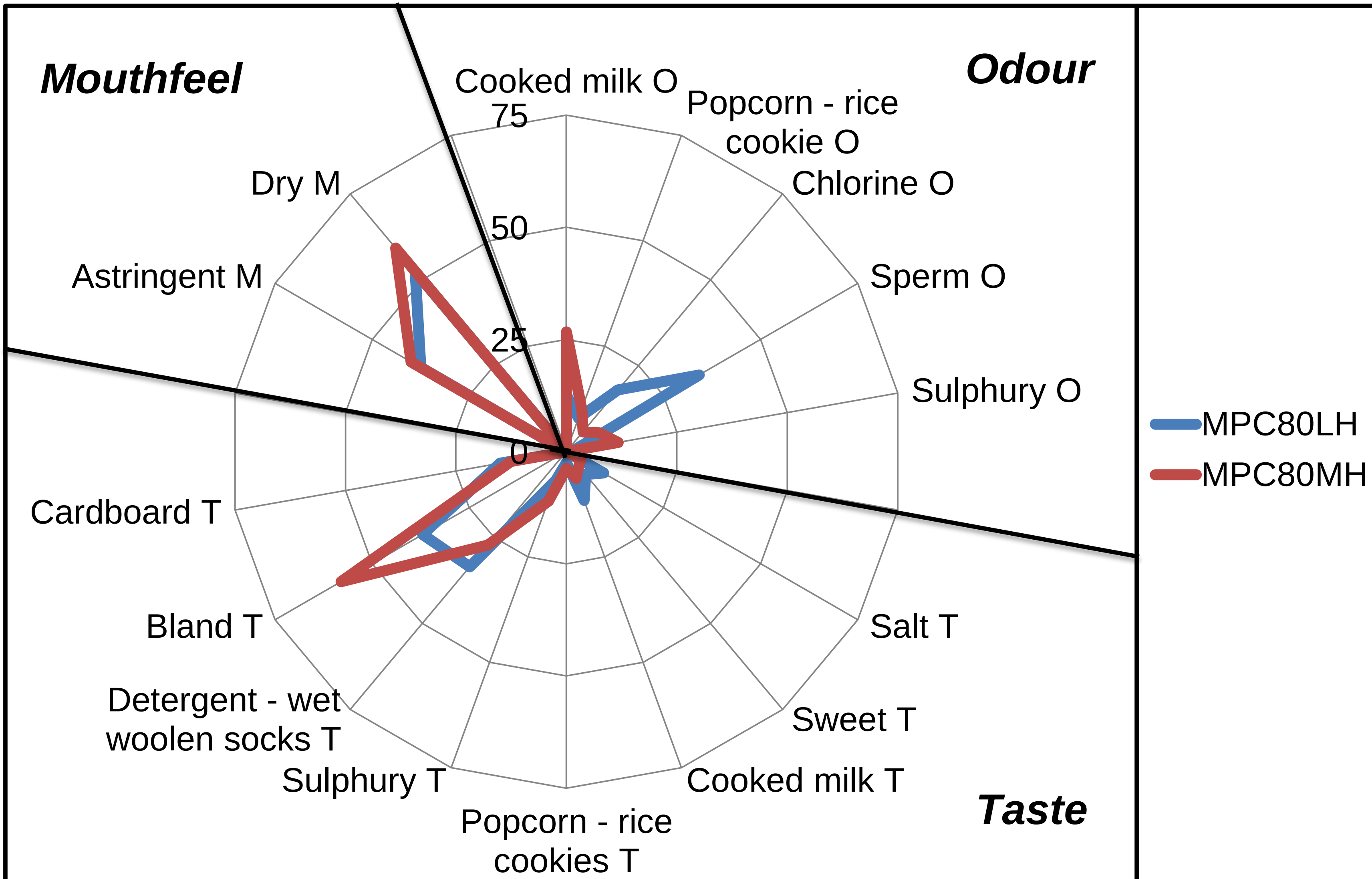
Sensory analysis

Low heat MPC



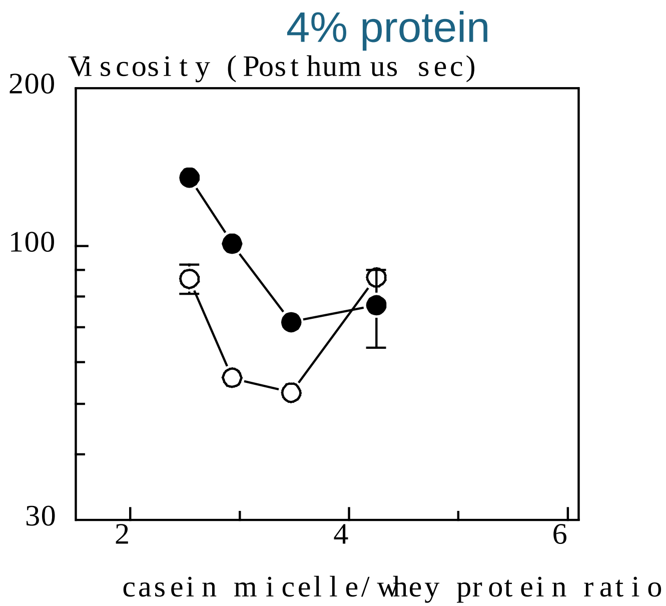
Sensory analysis

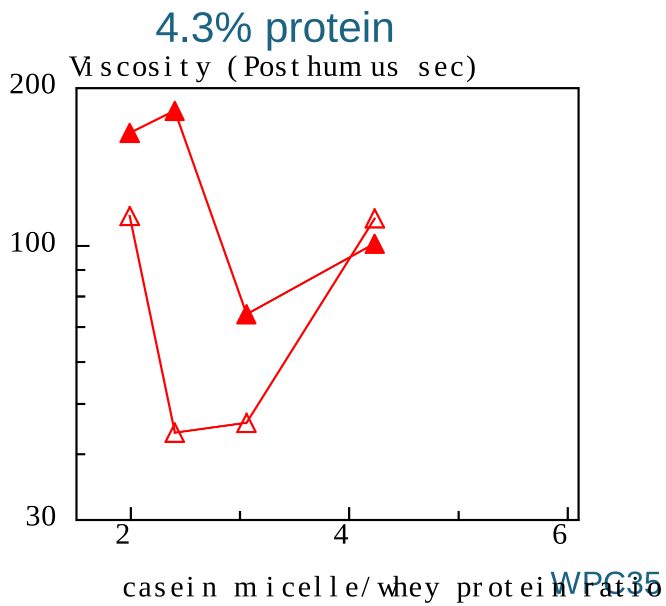
Effect of heat treatment



Role of WPC on yoghurt texture

Effect of casein micelle to whey protein ratio on viscosity and particle size of stirred yoghurt





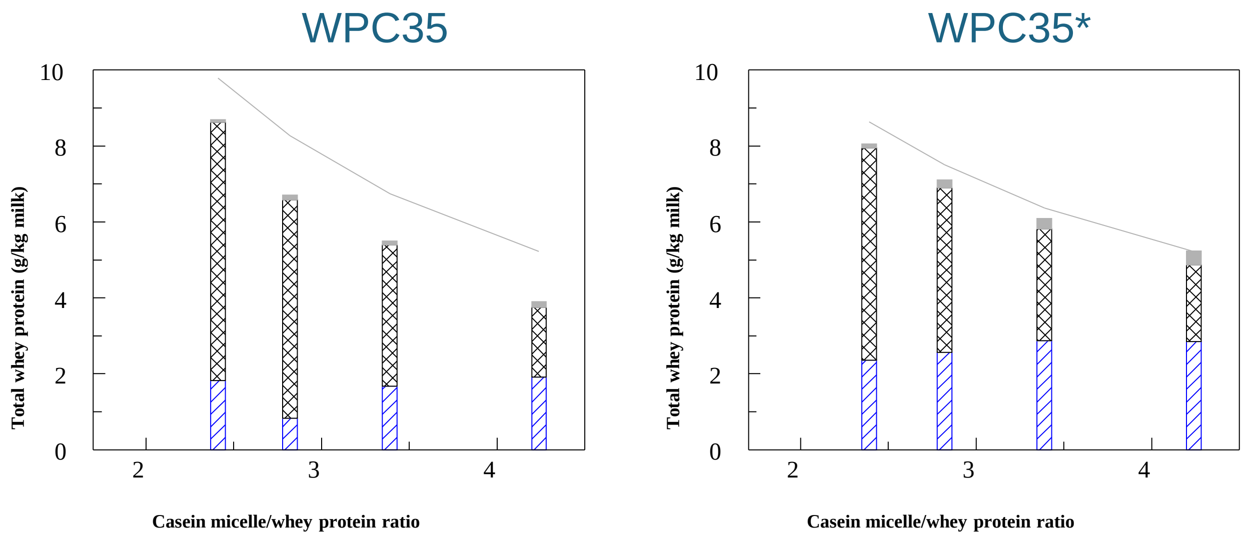
WPC35 (closed symbol)
WPC35* (open symbol)

Conclusion:
To obtain a viscosity enhancing effect, an optimal amount of whey proteins should be present, as a non-optimal amount decreased the viscosity.
The required amount was dependent on the protein composition of the final milk.

Kanning (2014). Routes to tailor the structure of mildly acidified stirred yoghurt using whey protein denaturation and interactions. IDF Microstructure

Yoghurt milk characterisation

Effect of casein micelle to whey protein ratio on total whey distribution in yoghurt milk after pasteurisation (4% protein)



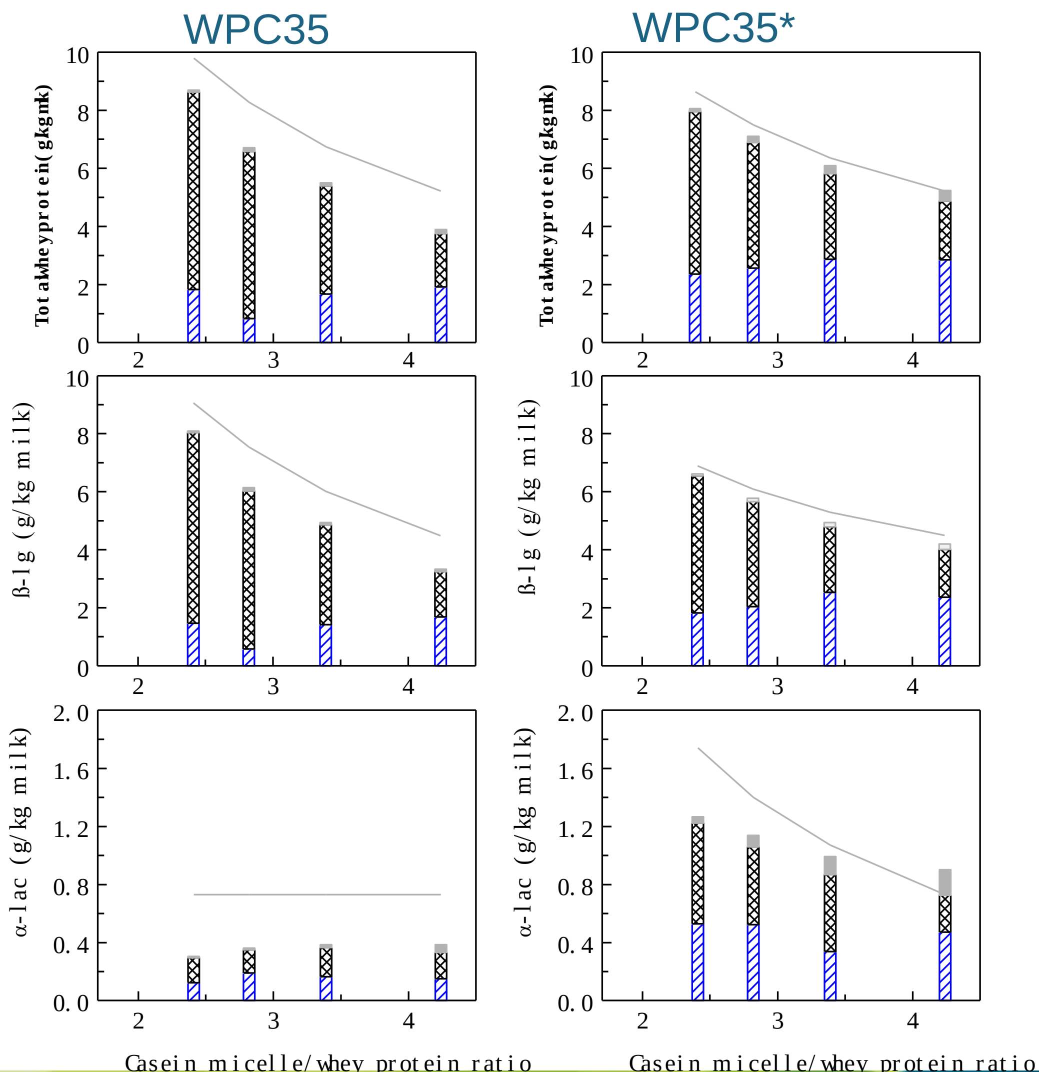
native (grey)
aggregates (black)
micelle-associated (blue)

Conclusion:

Increased formation of soluble whey protein aggregates

Yoghurt milk characterisation

Effect of casein micelle to whey protein ratio on distribution of ß-lg and α-lac in yoghurt milk after pasteurisation (4% protein)



native (grey)
aggregates (black)
micelle-associated (blue)

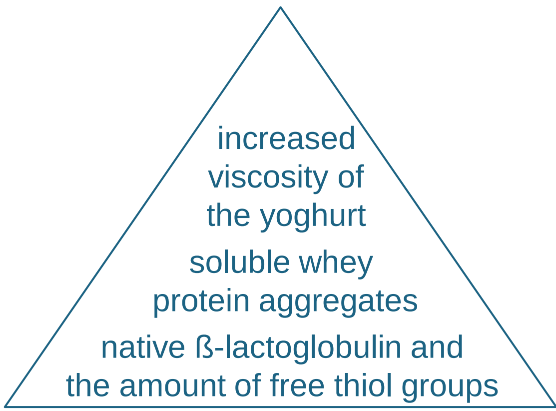
Conclusion:

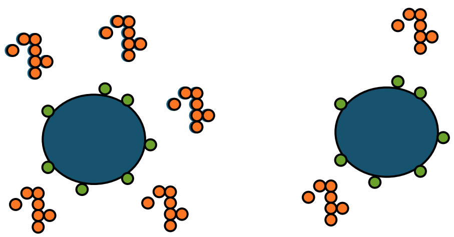
Heterogeneous aggregates were formed

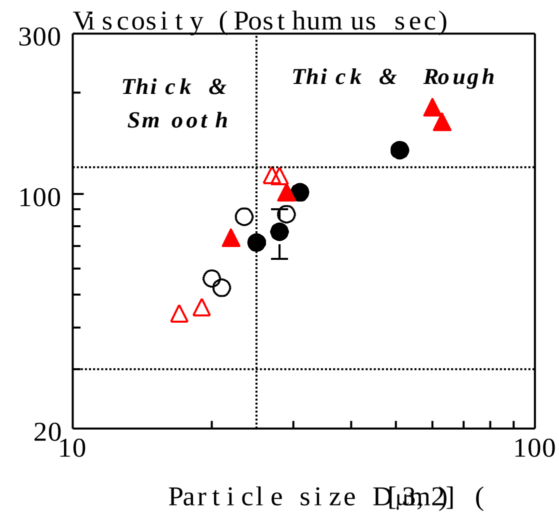
ß-lg was more easily involved in the incorporation of aggregates than it was involved in the coating of micelles, particularly at higher whey protein levels.

Role of WPC on yoghurt texture

- Role of whey proteins in yoghurt texture





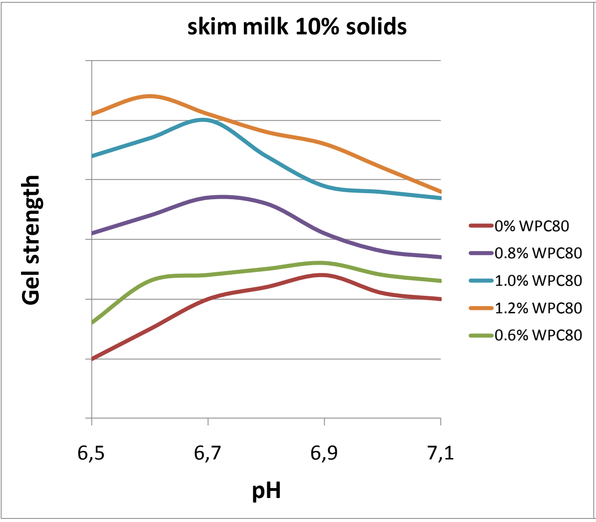


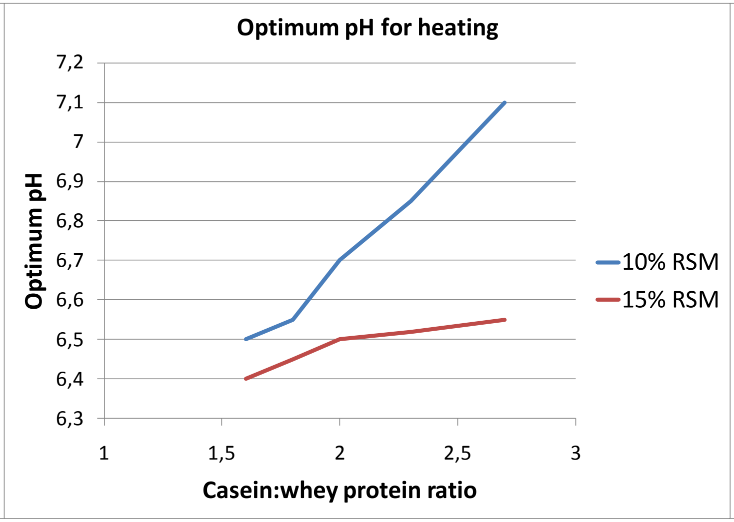
- Type of whey protein powder
  - Degree of denaturation. Minimizing the heat treatment during whey processing maximized the functional properties of WPC to be used in yoghurt.
  - Composition (ratio ß-lactoglobulin/α-lactalbumin)

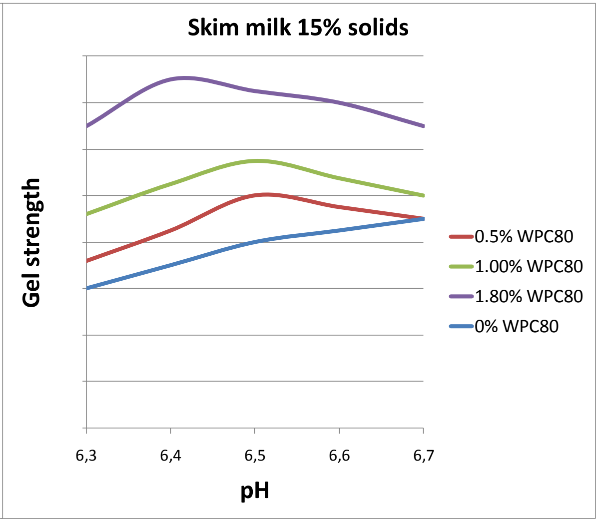
Kanning (2014). Routes to tailor the structure of mildly acidified stirred yoghurt using whey protein denaturation and interactions. IDF Microstructure

Concentration before fermentation

Effect of MPC/WPC mixture (functional blend)







- Optimum pH for pre-heating strongly dependent on:
- Milk solids concentration
- Casein:whey protein ratio
- Minerals

Concentration after fermentation

Greek-style yoghurt

- Cloth straining
- Ultrafiltration (UF)
  - Spiral wound
  - Ceramic
- Centrifugation

Choice affect texture and flavour
- Shear
- Process temperature

All remove acid

Tetra Pak

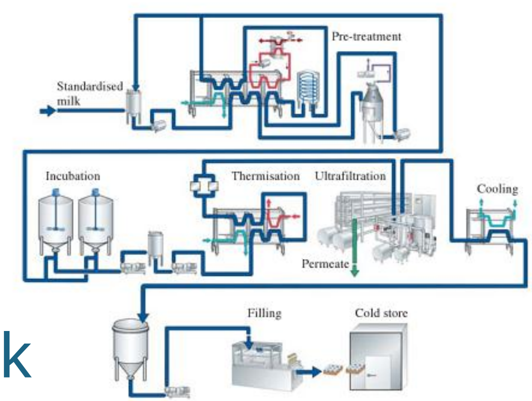
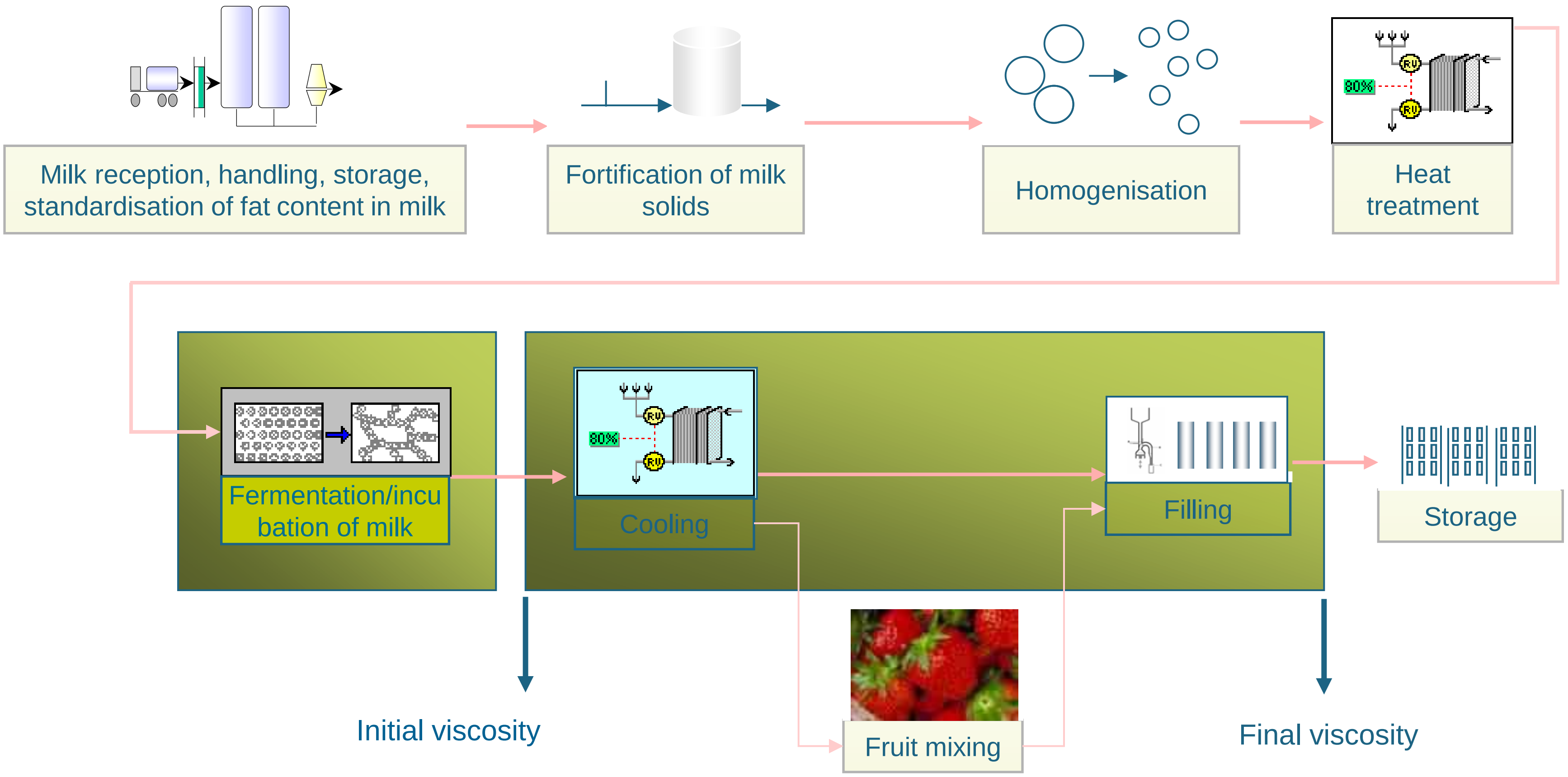


Fig. 7.5 Flow chart for the manufacture of concentrated yoghurt by ultrafiltration (Reproduced by permission of Tetra Pak, Lund Sweden).

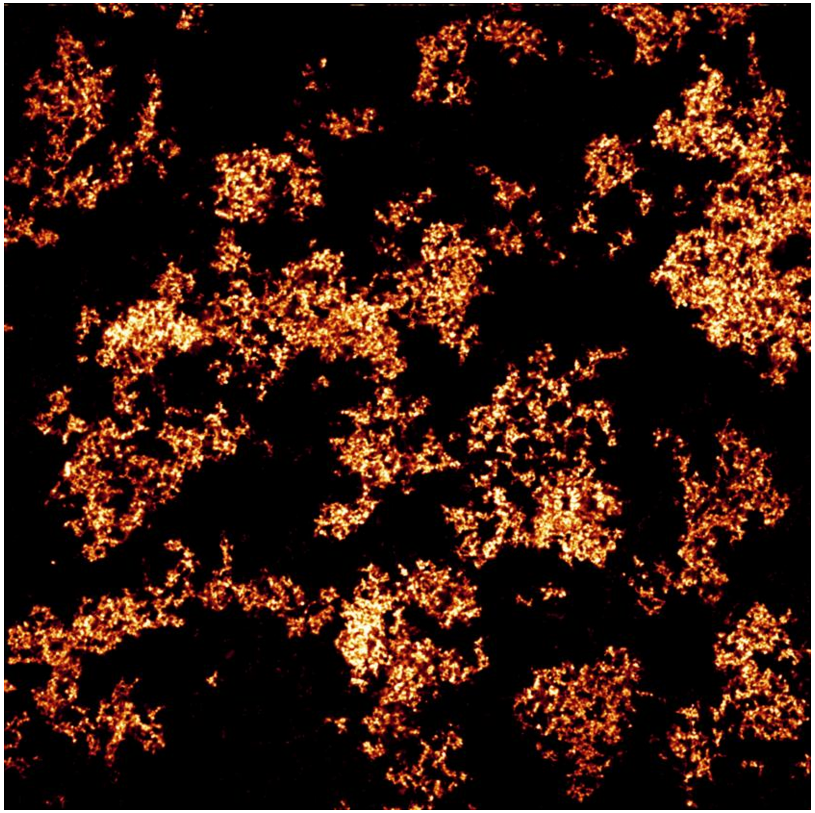
Processing routes



Structure and shear sensitivity of fermented milks

Yoghurt texture

Functionality of ingredients



Stirred yoghurt

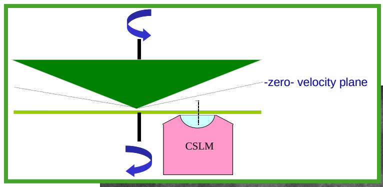
Picture size 160 μm × 160 μm

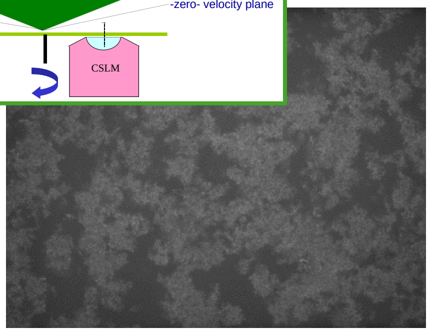
Yoghurt can be regarded as a concentrated dispersion of particles in serum

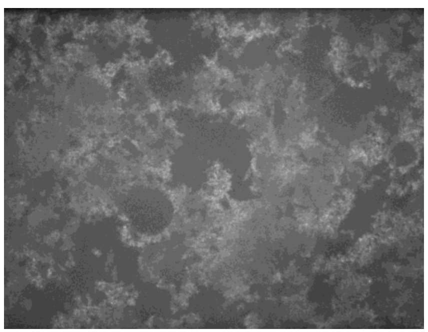
Viscosity yoghurt =
Viscosity serum phase x particles
(volume, properties and interactions)

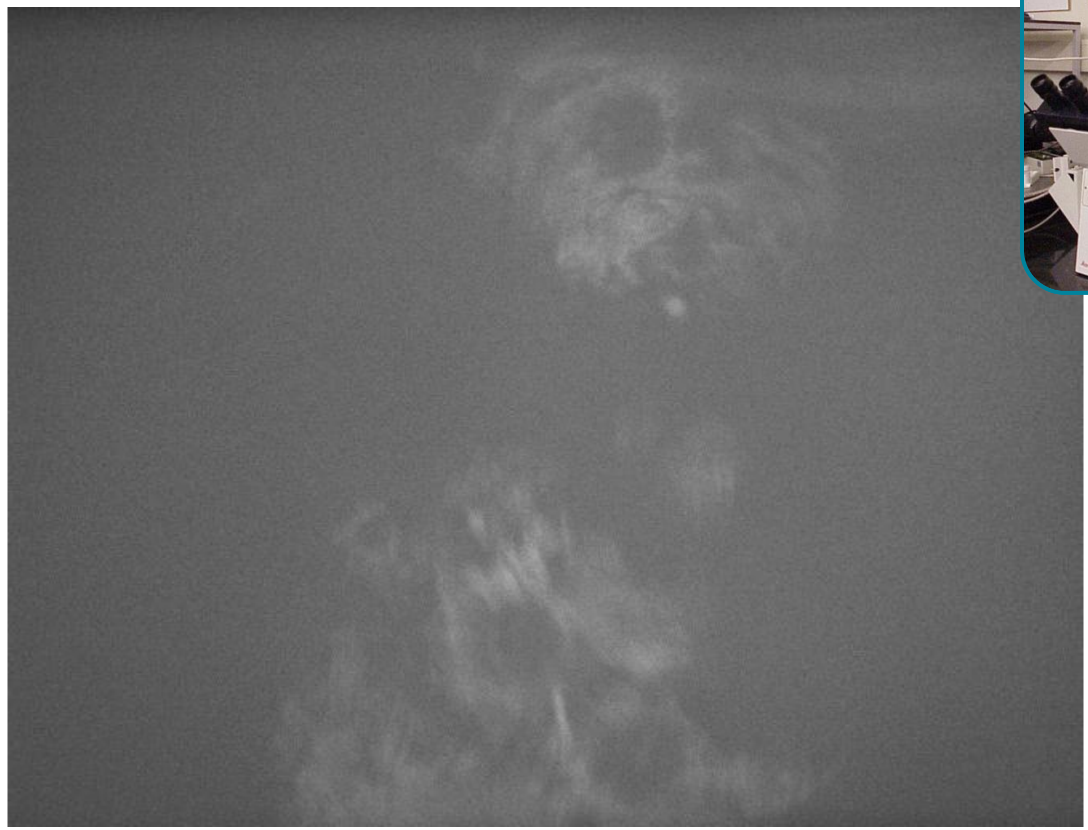
$$\eta = \eta_s \times f(\phi)$$

Structure breakdown of starch-containing yoghurt



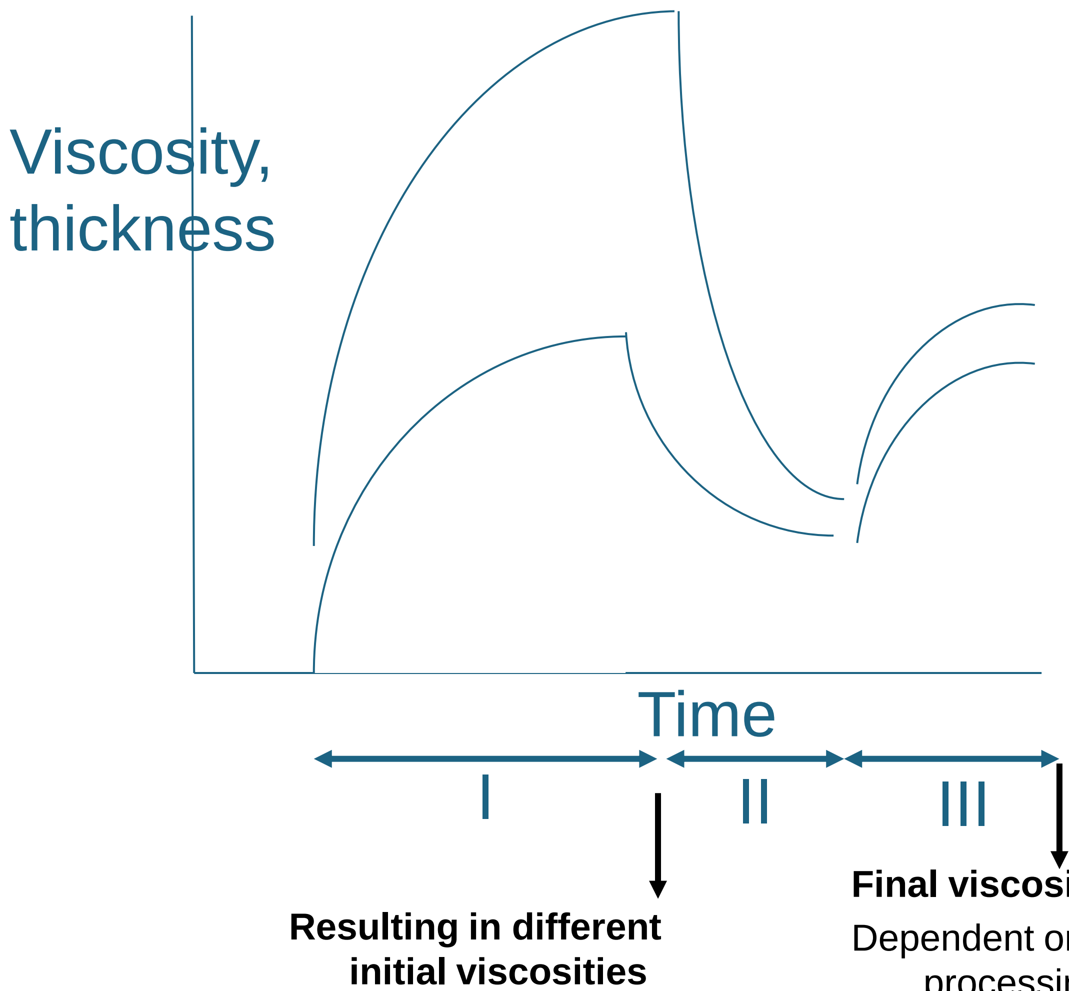






The shear rate at which aggregates breakup varies with yogurt composition (ref at 0.75 s^{-1}; tapioca at 1.5 s^{-1} and rice at 2.25 s^{-1}). This suggests a variation in the breakup of the protein network as a function of the presence and size of starch granules.

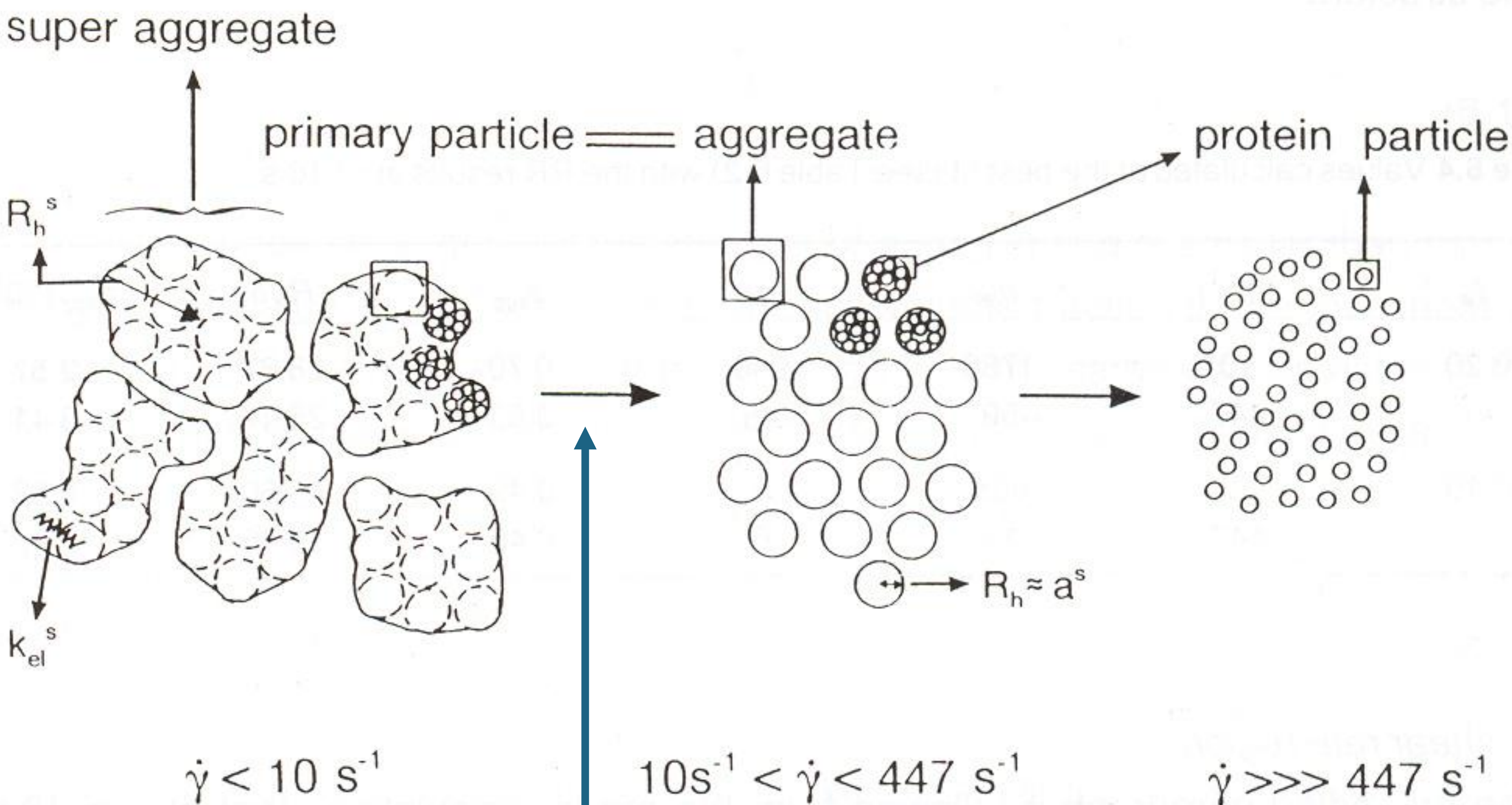
Thickness of product



Dependent on the applied shear rate during processing (Cooling, Buffer tank, Filling machine)

1. Gel build-up during fermentation
2. Structure break-down (concentration, cooling, structuring, filling)
3. Structure build-up (rebodying)

Shearing/smoothening



This occurs during pumping/filling

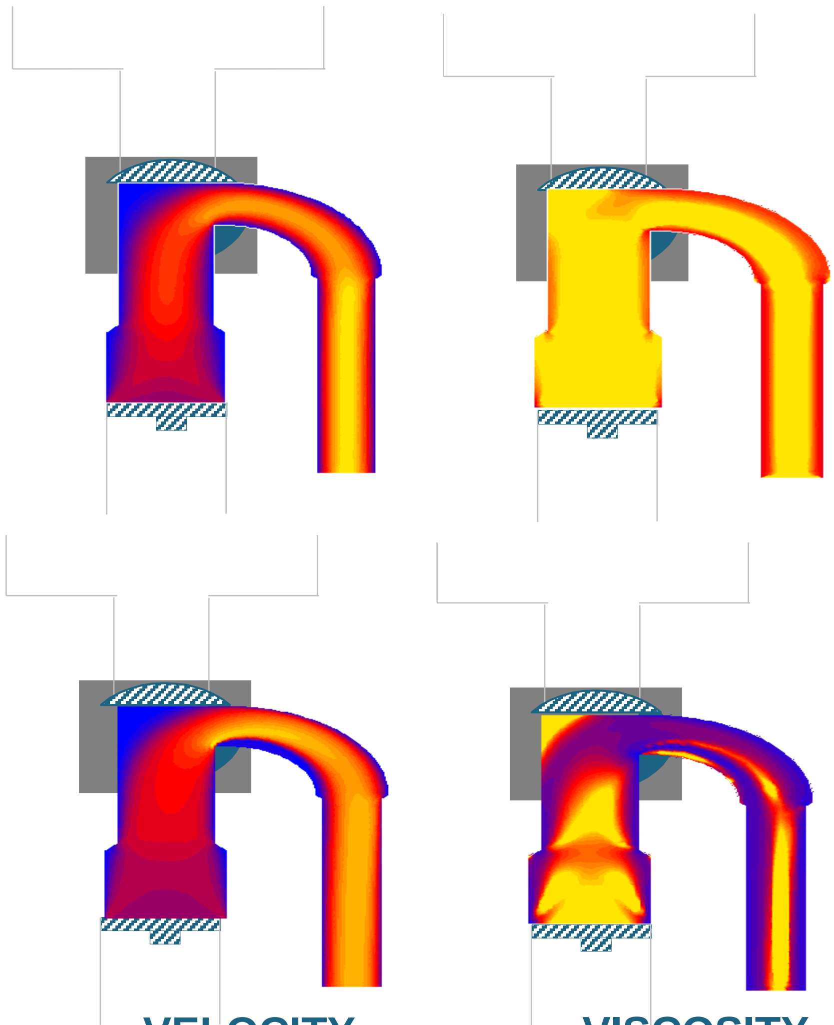
- M. E. van Marle *et al.*

Shearing/smoothening devices

- Smoothening valve (back-pressure valve)
- Sieves
- Smoothening homogenisers or pumps
- High-shear devices

- Low velocity in system

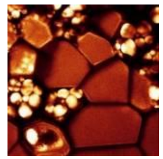
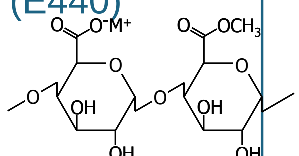
- High velocity in system



VELOCITY
(Yellow is highest velocity)

VISCOSITY
(Yellow is highest viscosity)

Ingredient functionality – multiple functions

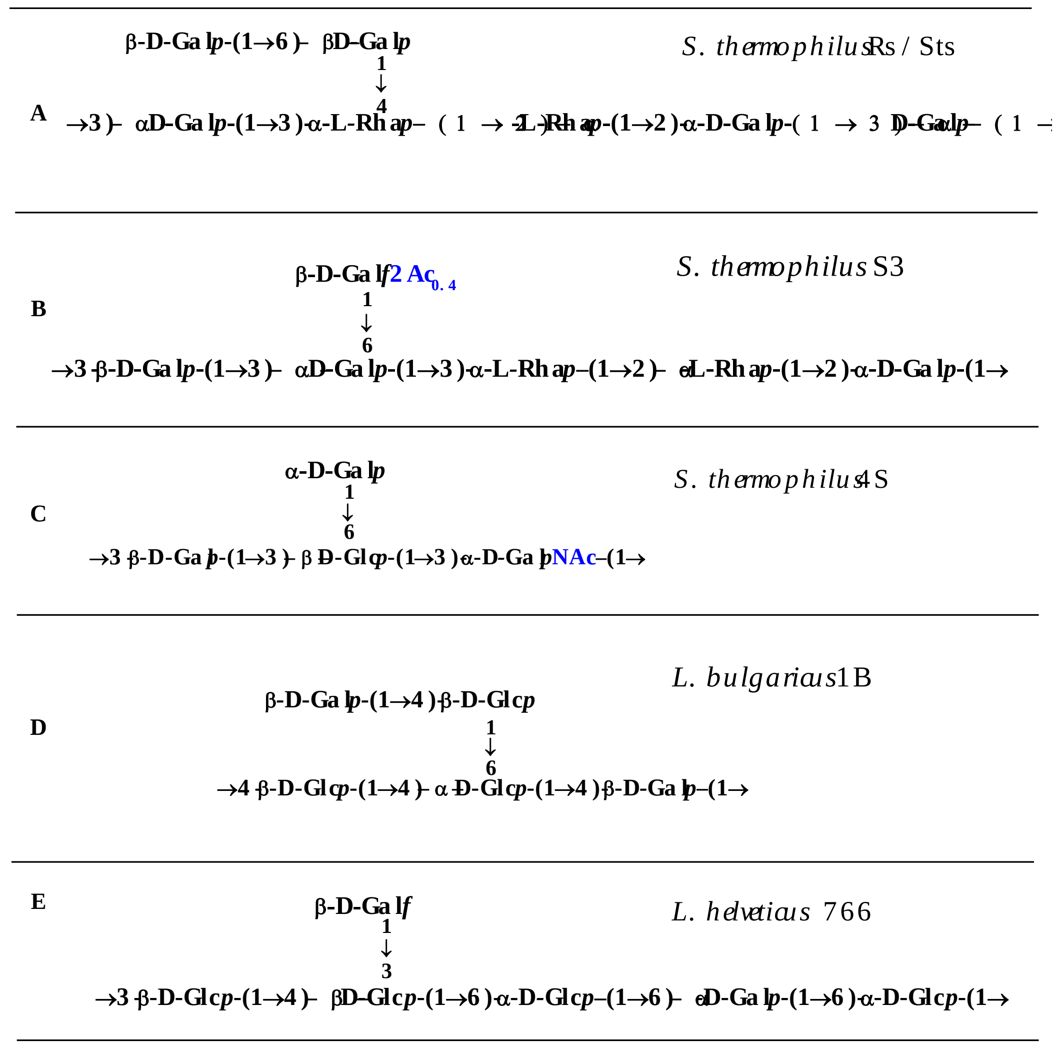
Function	Plants	Seaweeds	Micro-organisms	Proteins
Increase bulk volume	Starch 			Milk proteins and their derivates (MWP, WPC)
Viscosifier continuous phase / viscosity builders	Inulin Maltodextrin Galactomannans (guar gum E412, lbg E410) Gum tragacanth	λ-Carrageenan (E407) Agar Alginate 	Xanthan gum (E415), EPS from LAB	
Particle interactions	Pectins (E440) 		*EPS from LAB*	Milk proteins and their derivates (MWP, WPC)
Syneresis prevention / gelation / gelling agents	*Pectins (LM)* (E440) – *calcium induced gel*	κ- / ι-Carrageenan (E407) Agar, Alginate		Gelatin

Ingredients in green = used as fat replacer

MWP = microparticulated whey protein

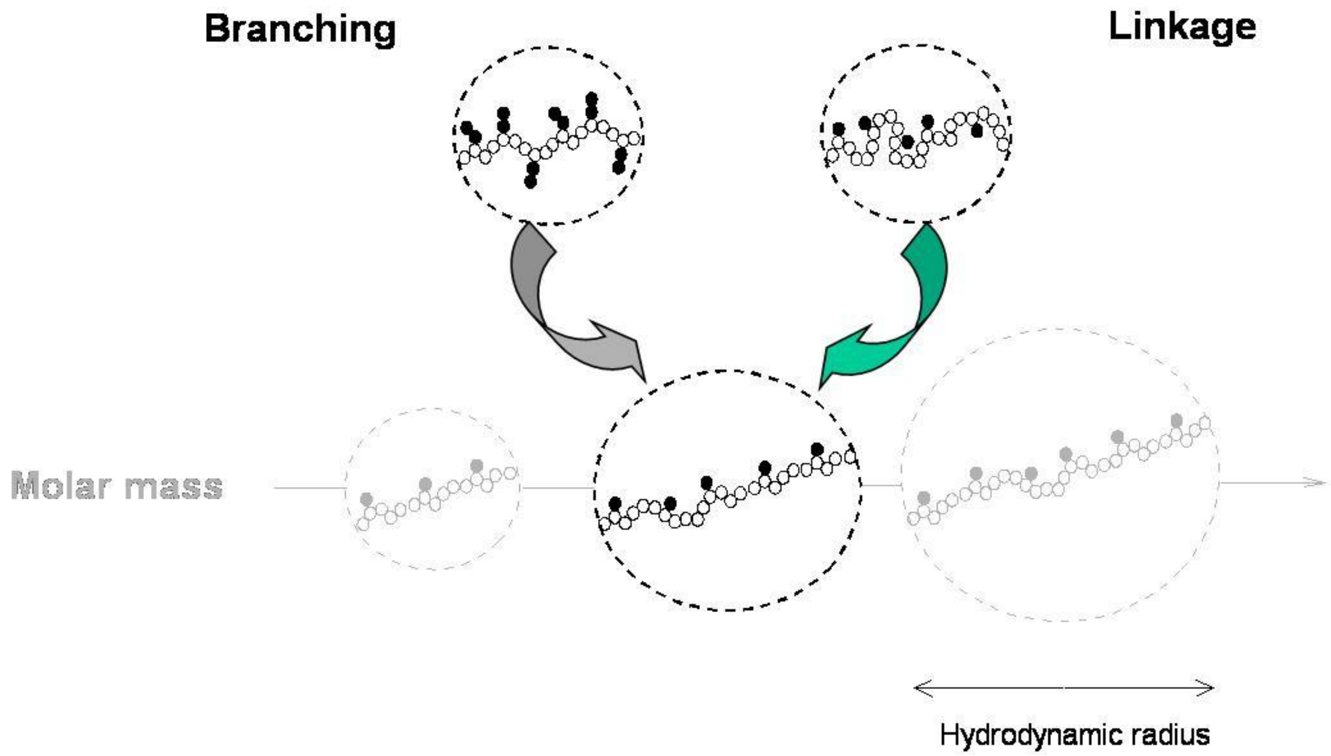
Structure and shear sensitivity of fermented milks – set-up

- The influence of EPS properties and their location in the protein network on shear sensitivity of fermented milks was investigated.
- Six LAB strains with known chemical structure of the repeating unit of EPS were used to acidify milk at 32°C and 42°C.
- The role of EPS on milk gel structure breakdown was analyzed using
  - Rheological measurements
  - Localization of EPS in the gel structure during acidification



Flexibility of EPS polymer

The relation between molar mass and radius of gyration provides information of the flexibility of a polymer.



EPS flexibility

L. lactis subsp. *cremoris* in fermented milks

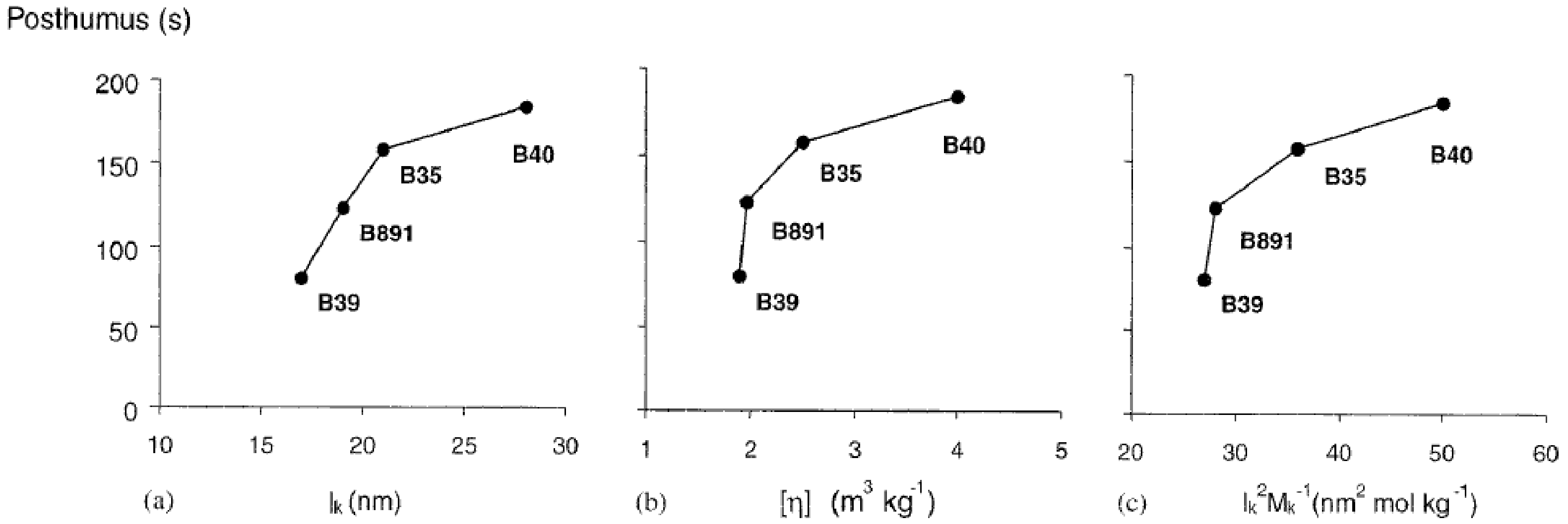
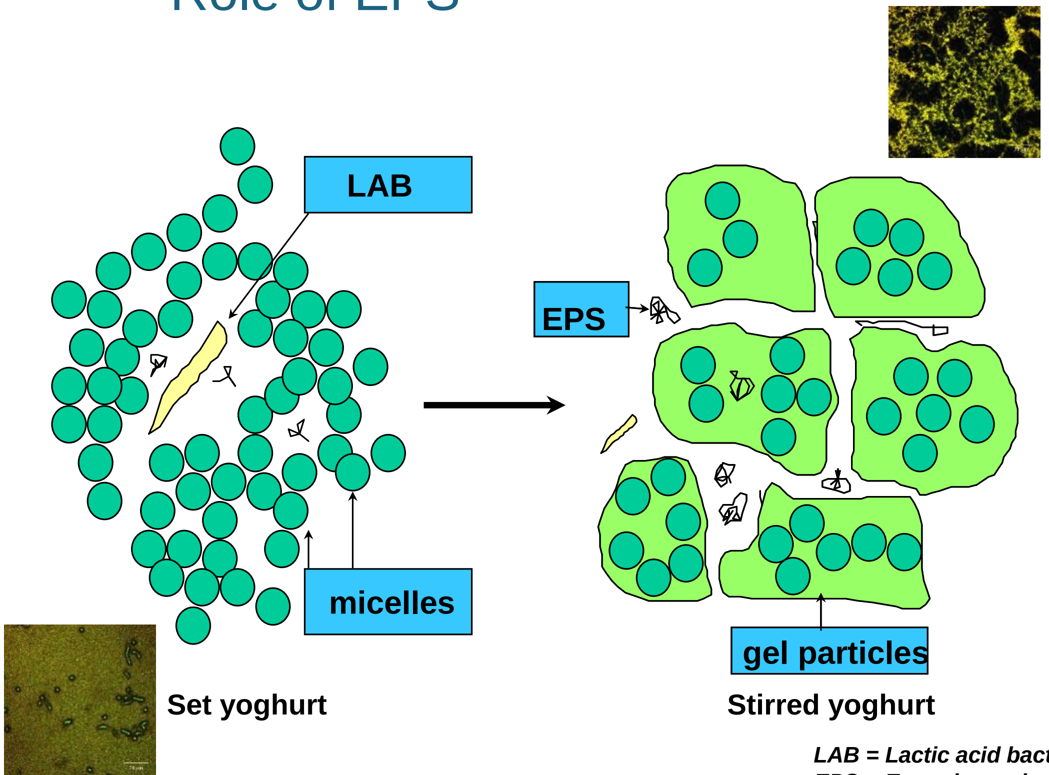


Fig. 3. Relation between Posthumus viscosity of stirred fermented milks made at 25°C and some molecular characteristics of EPS produced by strains of *L. lactis* subsp. *cremoris*: Posthumus vs. EPS Kuhn length (a), Posthumus vs. EPS intrinsic viscosity (b) and Posthumus vs. EPS thickening efficiency (c).

P. Ruas-Madiedo, R. Tuinier, M. Kanning, P. Zoon (2002). International Dairy Journal 689-695.

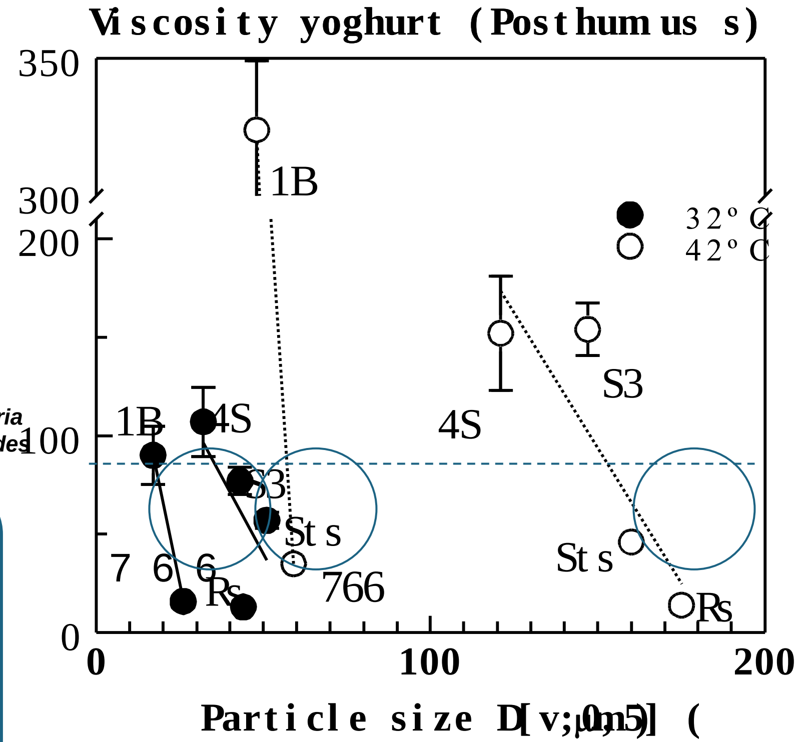
Effect culture

Role of EPS



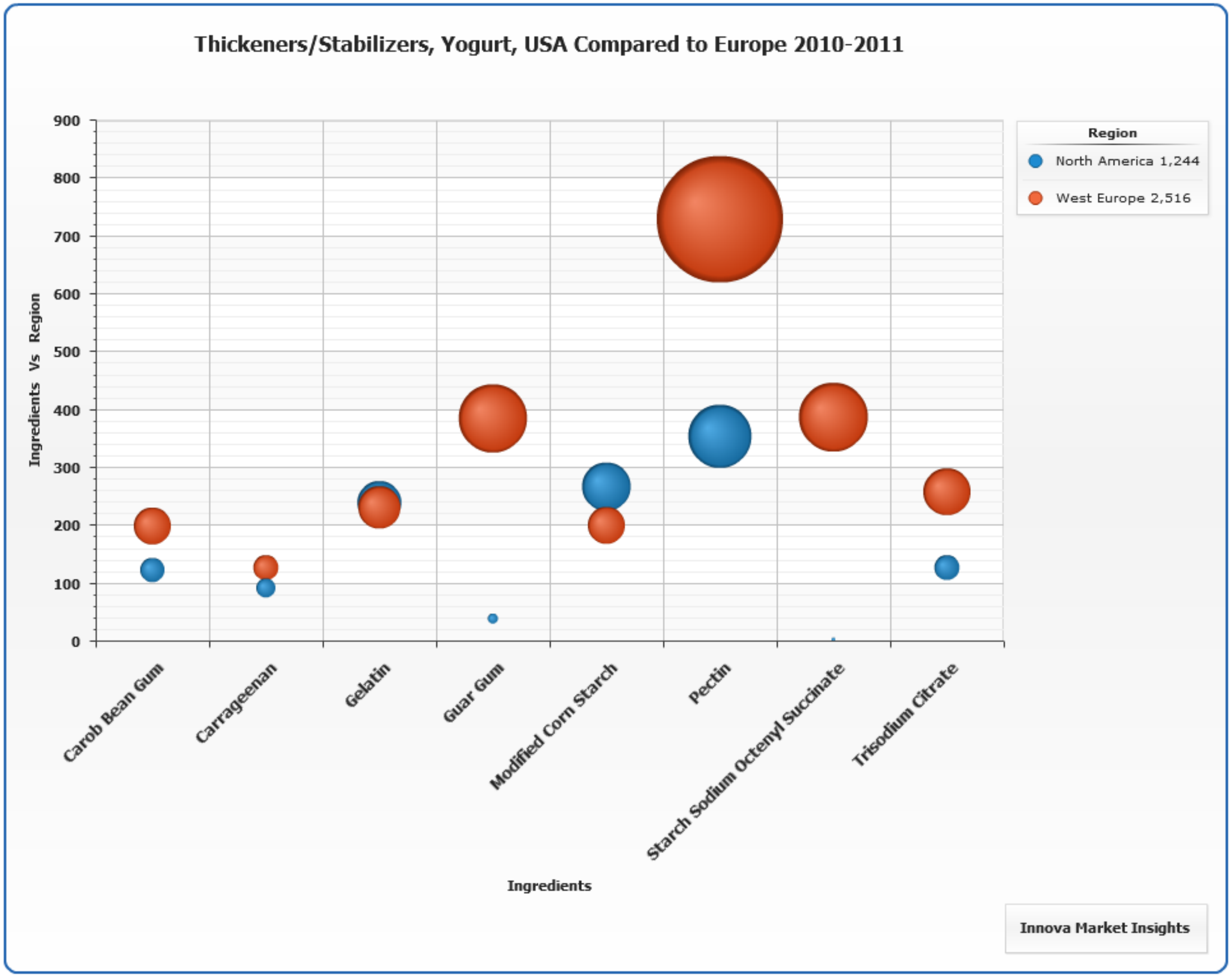
LAB = Lactic acid bacteria
EPS = Exopolysaccharides

Smoothness of yoghurt is affected by EPS



EPS functionality is determined by
- **EPS amount, characteristics (Mw, Rg)**
- **Distribution in the yoghurt**

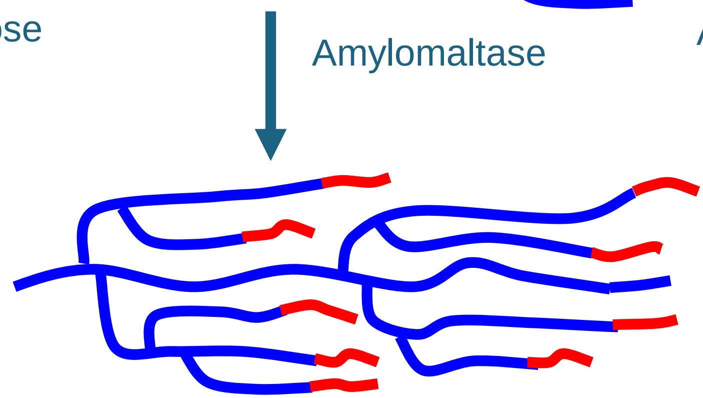
Use of stabilisers



Amylomaltase treated starch (ATS)

Mechanism

Potato starch:



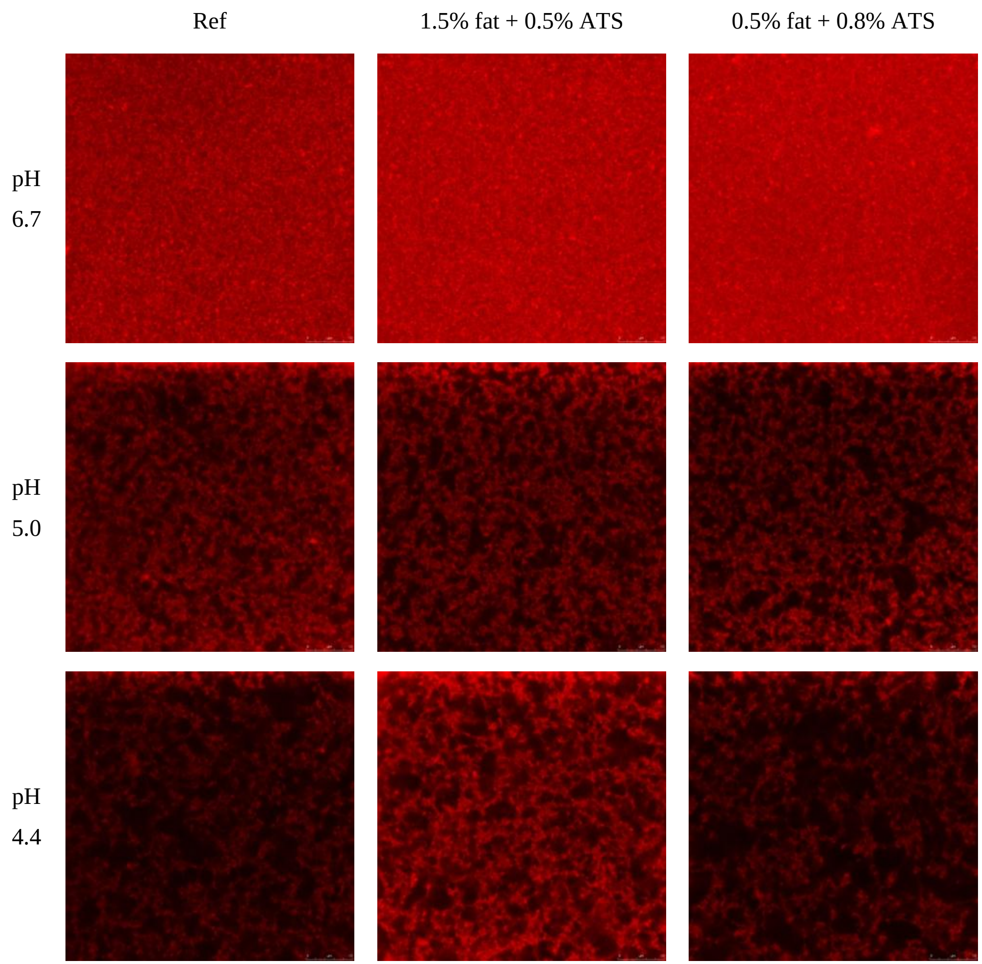
DP (branch): 35
No amylose

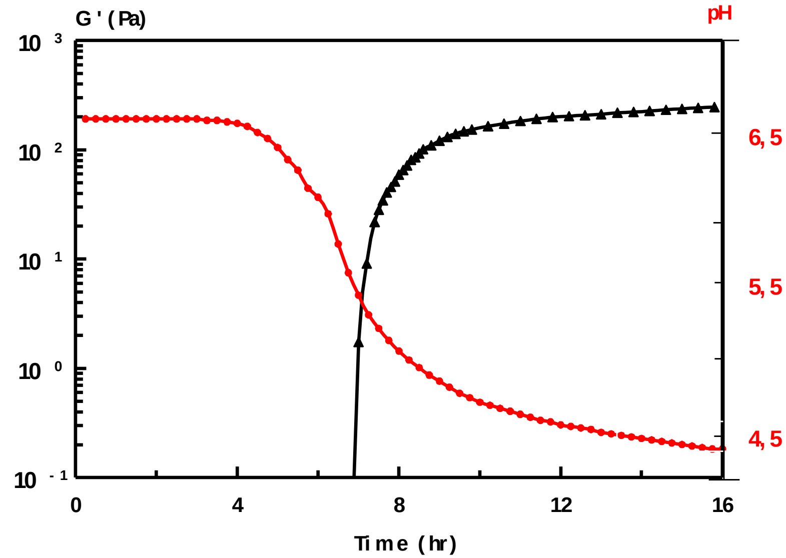
Enzyme is an amylomaltase or (α1,4)-(α1,4) glucosyltransferase, E.C. 2.4.1.25

- Declared as starch or potato starch in Europe
- Sold under trade name ETENIA™, by AVEBE

Amylomaltase treated starch (ATS)

Mechanism





ATS did not affect the fermentation process (pH and microstructure)

Amylomaltase treated starch (ATS)

Mechanism

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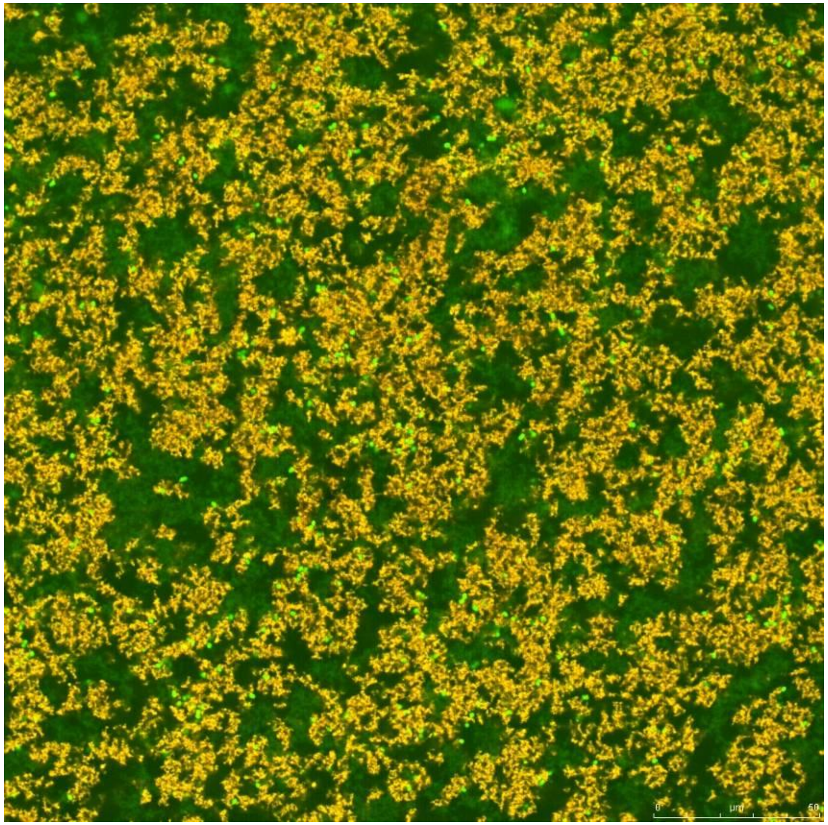
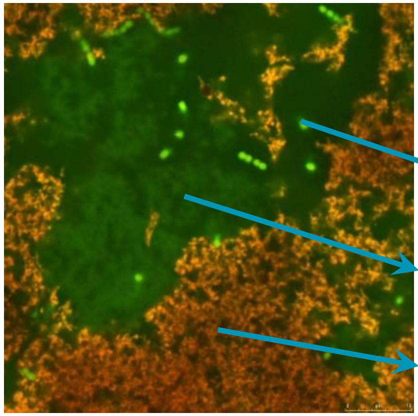
Fig. CLSM image of stirred yoghurt (3.5% protein; 0.5% fat) with 0.8% ATS. Image size 62 µm × 62 µm. Orange/red are protein aggregates; micro-organisms are bright green and ATS domains are green.

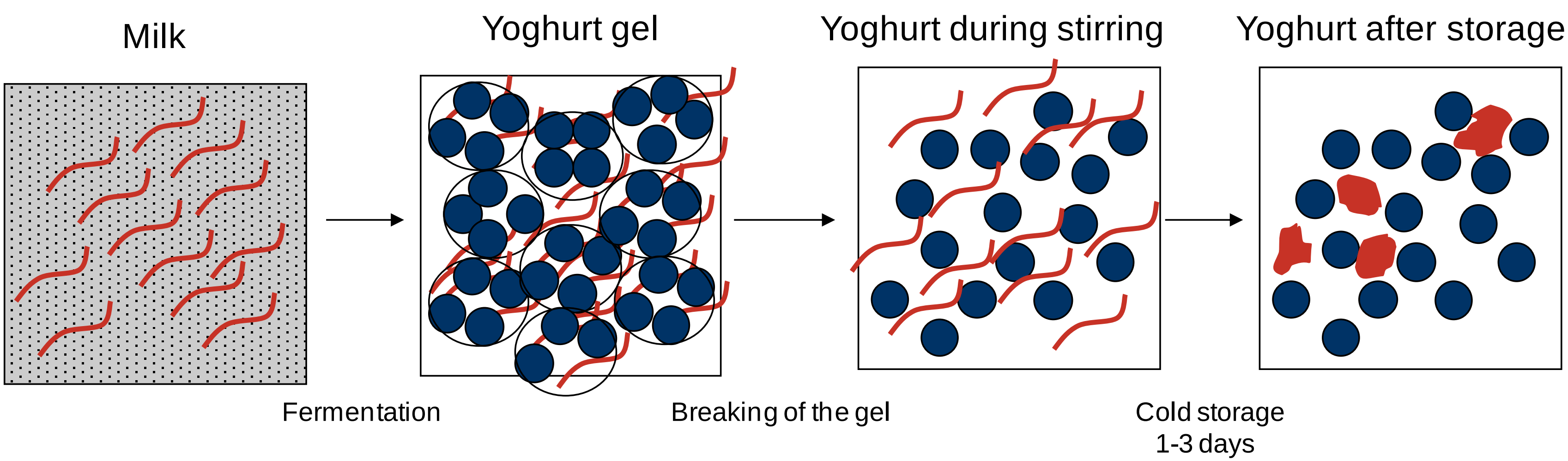




ATS formed domains in the pores of the protein network

Amylomaltase-treated starch (ATS)

Mechanism



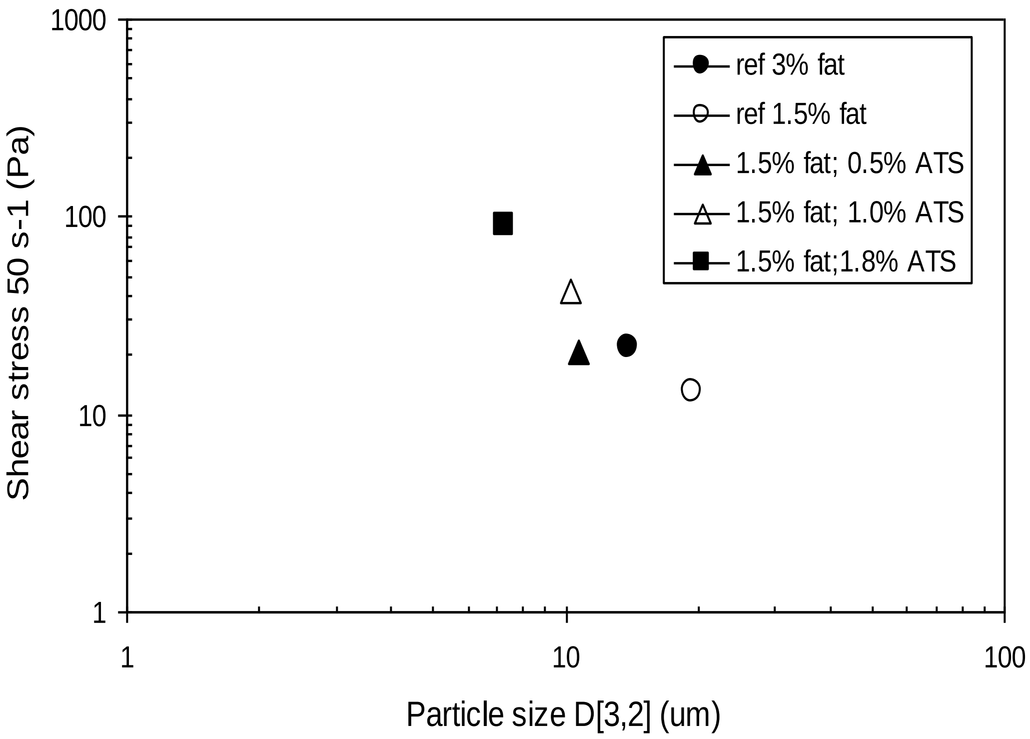
= Dispersed / dissolved ATS

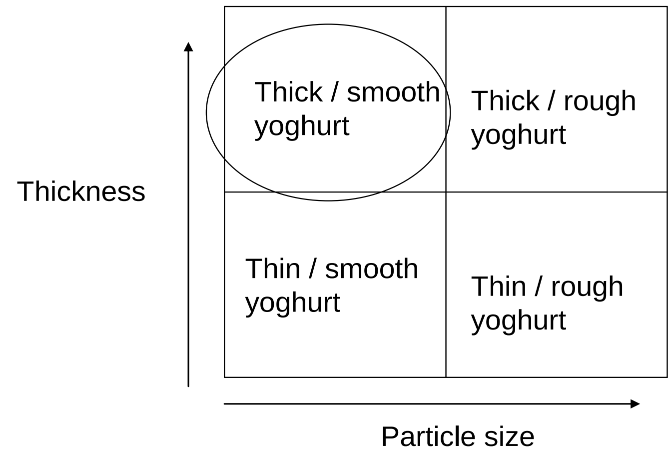
= Gelled ATS domains

= Protein aggregate

Amylomaltase-treated starch (ATS)

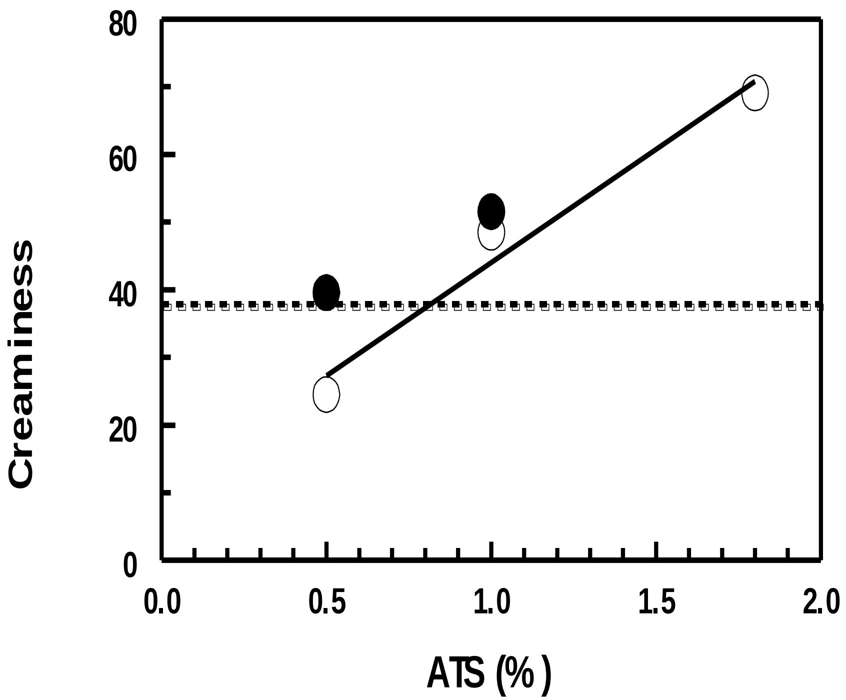
Effect on yoghurt properties





ATS in low-fat, stirred-style yoghurt results in thick, smooth product.

Excellent creaminess enhancer



O = yoghurt with 0.5% fat

● = yoghurt with 1.5% fat

Low-fat, stirred-style yoghurt (0.5%) having the perception of full-fat yoghurt (3%)

ATS domains in complex foods, behaving like fat globules

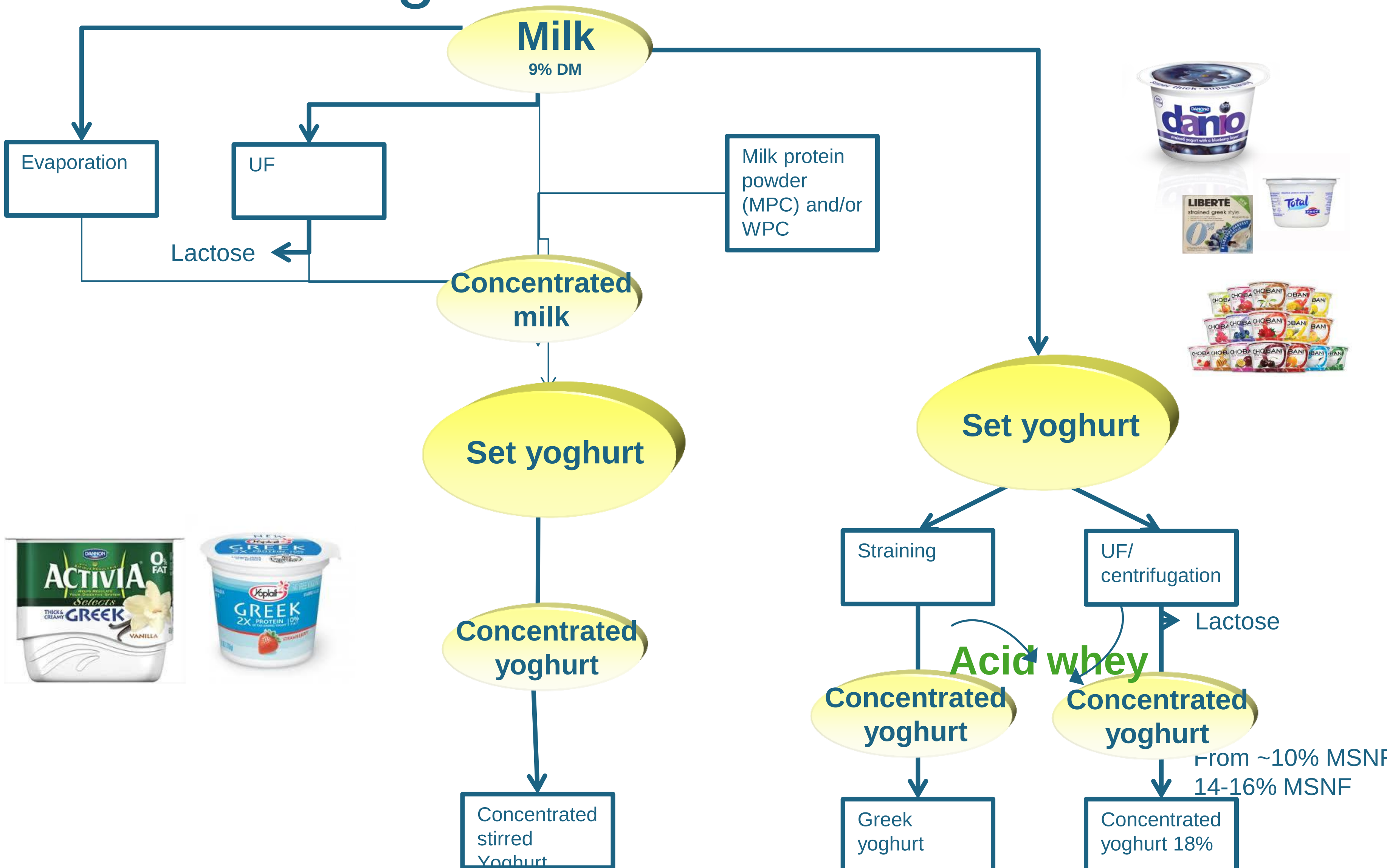
Reduction in fat-related energy value from 27 to 4.5 kcal/100 g product.

etenia

Alting, van de Velde, Kanning et al. (2009) *Food Hydrocolloids* 23 980

Kanning et al. (2012) *International Dairy Journal*.

Processing routes



Acid whey

Whey Too Much: Greek Yogurt's Dark Side

Greek yogurt is a booming $2 billion a year industry — and it's producing millions of pounds of waste that industry insiders are scrambling to figure out what to do with.

By Justin Elliott on May 22, 2013

Twice a day, seven days a week, a tractor trailer carrying 8,000 gallons of watery, cloudy slop rolls past th bucolic countryside, finally arriving at Neil Rejman's dairy farm in upstate New York. The trucks are coming from the Chobani plant two hours east of Rejman's Sunnyside Farms, and they're hauling a distinctive byproduct of the Greek yogurt making process—acid whey.

http://modernfarmer.com/2013/05/whey-too-much-greek-yogurts-dark-side/

environmental LEADER
Environmental & Energy Management News

July 2, 2013

Yogurt Companies Face Whey Disposal Problem

Greek yogurt is a booming $2 billion a year industry with popular brands including Chobani and Dannon. But it produces millions of pounds of waste that industry insiders are scrambling to figure out what to do with, Modern Farmer reports.

Greek yogurt is strained, unlike other varieties of yogurt, and the byproduct is a thin, runny, acid whey that cannot be dumped because it becomes toxic as it decomposes, robbing rivers and streams of oxygen, author Justin Elliott writes.

New York's Greek yogurt industry tripled in size over the last five years with companies in the state producing a total of 150 million gallons of acid whey last year, Modern Farmer says.

Companies like Chobani typically make 1 ounce of creamy yogurt out of 3 to 4 ounces of milk. The rest becomes acid

RELATED STORIES

Kraft Cuts Natural Gas Purchases With Waste-To-Energy Projects

Cheese Waste Turned into

Routes to apply acid whey

- Composition
  - High in lactose, Ca and P

Component	Unit	Sweet whey (rennet precipitation)	Sour whey (biol. precipitation)	Technical whey* (HCL precipitation)
Water	%	93–94	94–95	93–94
Lactose	%	4.5–5.0	3.8–4.2	4.4–4.6
Protein (N x 6.38)	%	0.8–1.0	0.8–1.0	0.8–0.9
Fat	%	0.2–0.8	Traces	Traces
Ash	%	0.5–0.8	0.7–0.9	0.7–0.8
pH value		6.2–6.6	4.5–4.7	4.4–4.55
Cheese fines**	Vol.-%	0.05–0.3	0.05–0.3	0.05–0.3

* Aggregated figures are independent of the type of protein precipitant used
** The percentage figures refer to "removable" cheese fines

http://us.westfalia-separator.com/fileadmin/GEA_WS_US/Documents/Brochures/Dairy/Processing_Lines_for_Whey_Brochure.pdf

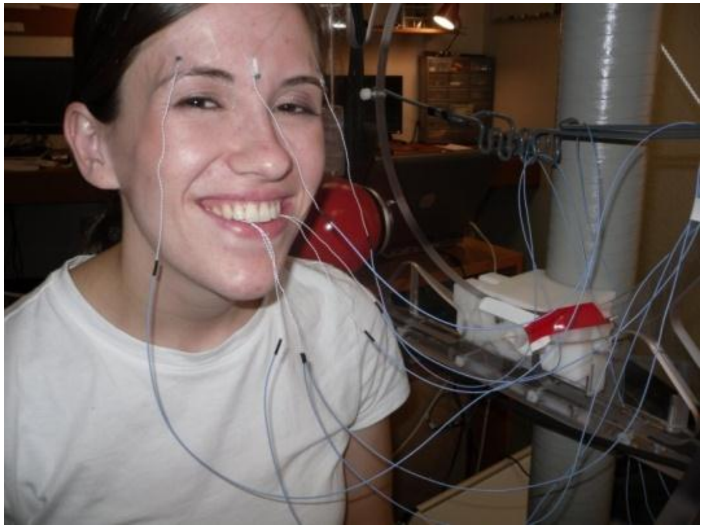
- Flavour profile
- Protein functionality

High protein fermented beverages
Whey smoothies
Fermented desserts

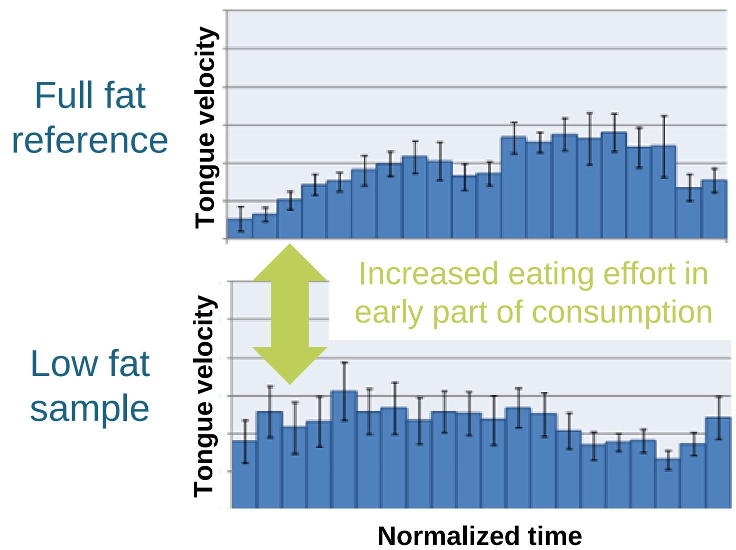
Tracking oral behaviour

- The “amount of work” to orally process a food product is an important quality marker
- EMA is a new technique to track the oral behaviour during consumption

Measure consumer response to your products

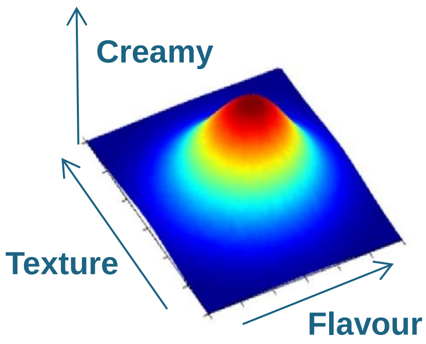


- ElectroMagnetic Articulography (EMA) has been used for many years in speech therapy
- Up to 8 sensors are attached to oral surfaces
- Position of the sensors is tracked in time and time-linked to consumption
- NIZO developed proprietary software for data analysis



Creamy low fat yoghurt

Conclusions



- Increase in protein content provides an improved texture
- Route to formulate the product affects the flavour and texture
- Consumer decides!

Improving creaminess of yoghurt and fermented products by understanding the role of ingredients and processing routes

M.W. Kanning

Acknowledgements

Tuesday, March 04, 2014

Together to the next level

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