

Cheese Yield: Moving on from Van Slyke

Cheese yield modelling

- Basic yield model & Van Slyke version
- Van Slyke : Moving on
- Yield model role in yield improvement



Yield modelling: Importance

- Budgeting & forecasting
- Compositional payment
- Target setting
- Process efficiency monitoring
- Flagging measurement errors



Basic Yield Model: Sum of Components

The cheese yield (Y kg) from 100 kg milk is made up from:

fat + protein + minerals + lactose + salt + water

Cheese solids = $Y (1 - m) = \text{fat} + \text{protein} + \text{minerals} + \text{lactose} + \text{salt}$

$$Y = \frac{(\text{fat} + \text{protein} + \text{minerals} + \text{lactose} + \text{salt})}{(1-m)}$$

Van Slyke

$$Y = \frac{(0.93 \times f_m + C_m - 0.1) \times 1.09}{(1 - m)}$$

f_m	Fat content of milk, e.g. 3.7%
C_m	Casein content of milk, e.g. 2.5%
0.1	Casein lost in whey: rennet effect/fines
0.09	Non-fat/protein solids (l, m, s) as a proportion of combined fat & protein
m	Moisture fraction of cheese, e.g. 0.37
0.93	Fat recovery into cheese



* From 100 kg milk

Van Slyke: Pros & Cons

PROS

- Good basis in practice & theory
- Simple, convenient
- Focuses attention on the 3 controllable yield factors
- Standard for plant comparison

CONS

- Different fat, casein recovery factors in practice
- Factor for salt, minerals, lactose doesn't account for variability in practice
- Under-estimates yield in higher moisture cheese

Key process parameters affecting recovery factors

- Protein fat ratio (PFR/CFR)
- Whey protein denaturation
- Gel firmness @ cutting
- Cutting intensity & stirring speed
- Post vat curd handling

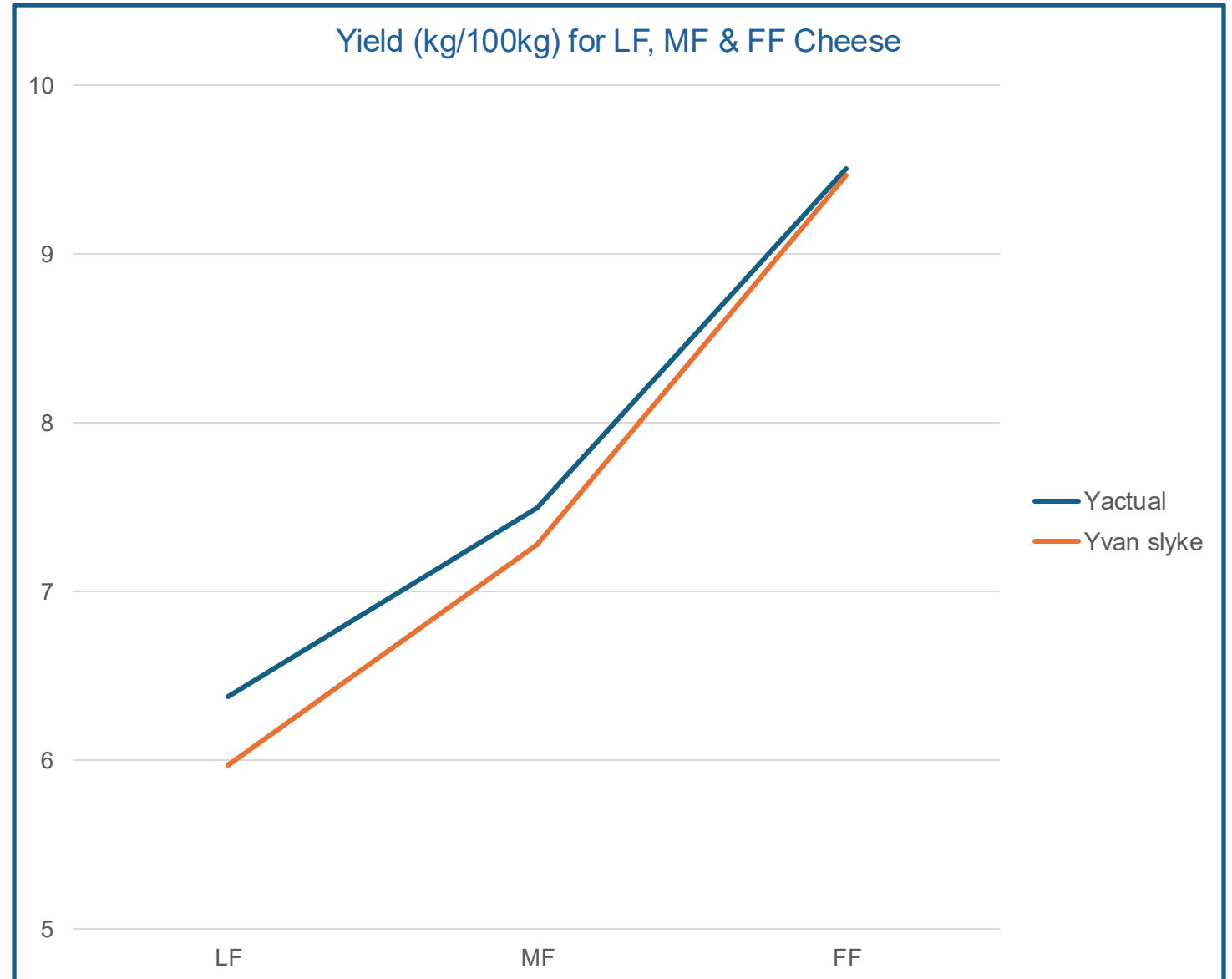
Fat recovery, R_f 84 to 92%

Casein recovery, R_c 94 to 98%

0.09 factor*, k 0.08 to 0.10

Case Study: Higher moisture/ lower fat cheese

Original data from Fenelon &
Guinee, 1999



Higher moisture cheese

- Higher moisture means more whey solids
- Higher moisture means lower (fat + protein)
- Salt, minerals, lactose now a higher proportion of (fat + protein)
- Factor for salt, minerals, lactose (1.09) too small



Moving on: Modified Van Slyke

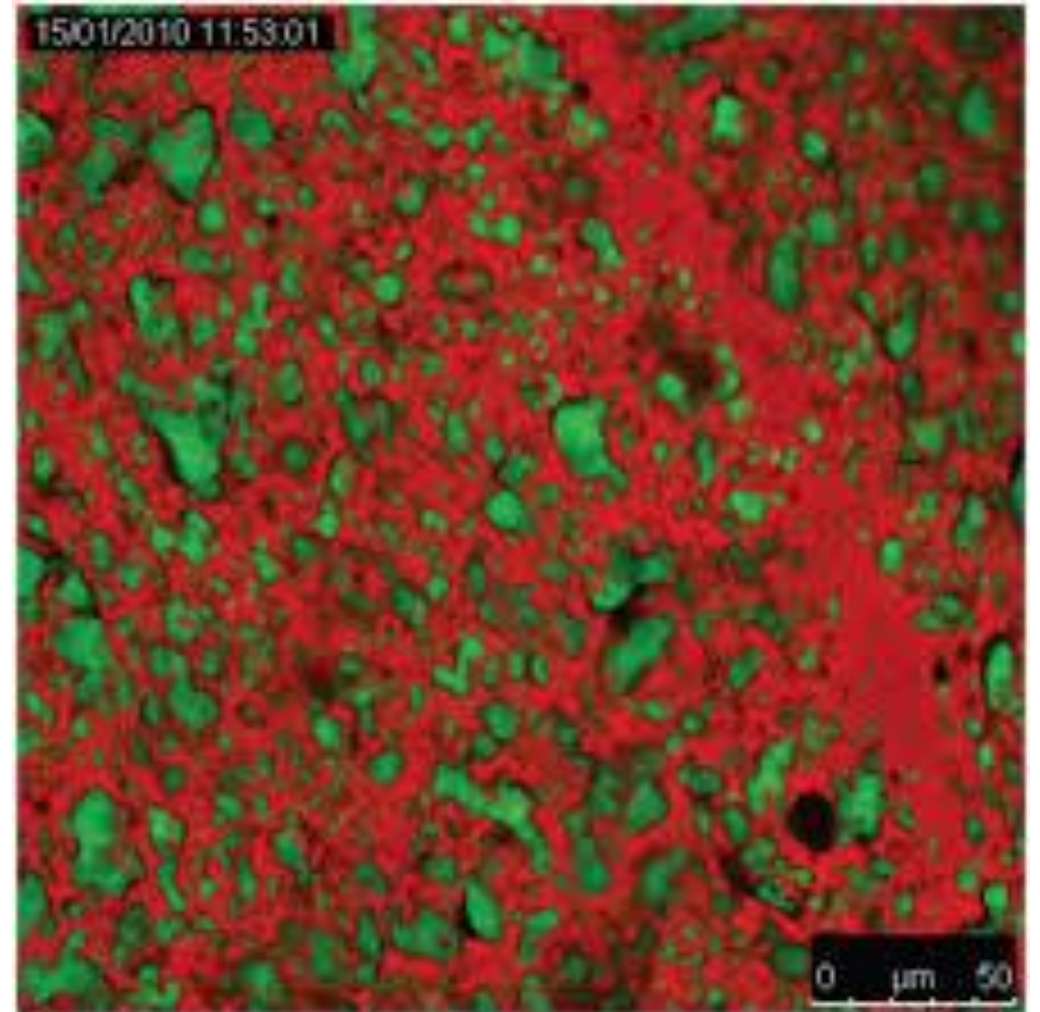
1. Use site fat recovery figure
2. Use site casein/protein recovery figure:
 - Incorporate casein recovery
 - Incorporate denatured whey protein
3. Use site specific value for solids non-fat non-protein (k)

$$Y = \frac{(f_m \times R_f + c_m \times R_c) \times (1 + k)}{(1 - m)}$$



A different perspective: Cheese Microstructure

- Protein gel network (protein, water & dissolved solids)
- Interdispersed fat globules



From Cheese: Chemistry, Physics & Microbiology, 2017

Relating lactose, minerals, salt to protein in cheese*

SNF = solids not fat

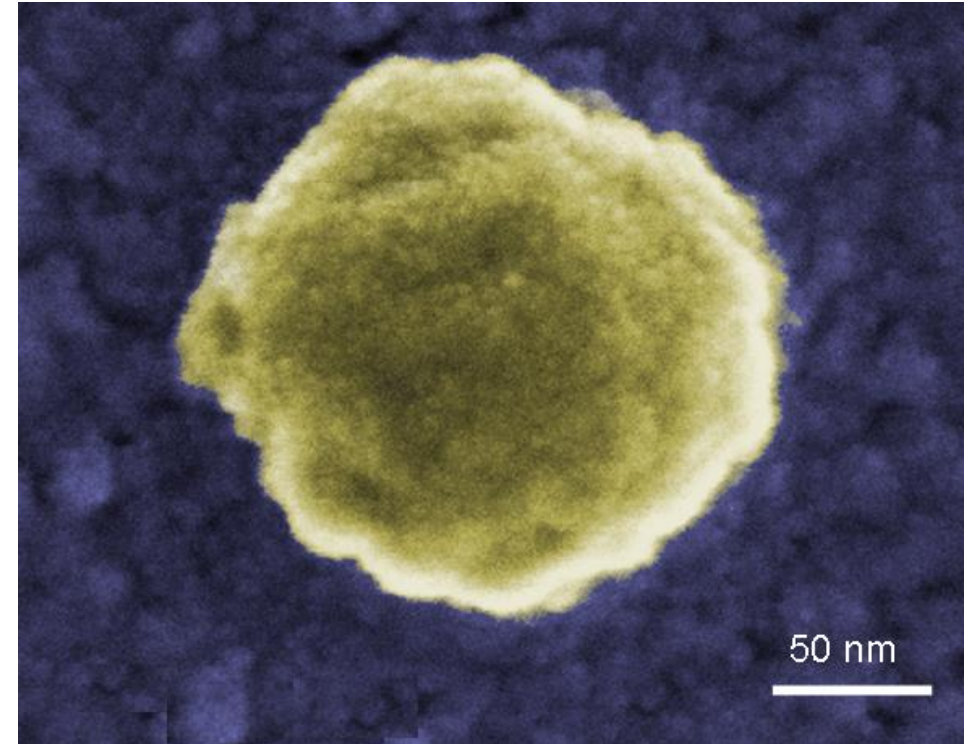
= protein + minerals + lactose + salt

SNF : protein \approx 1.22

MSNF = milk solids not fat

= protein + minerals + lactose

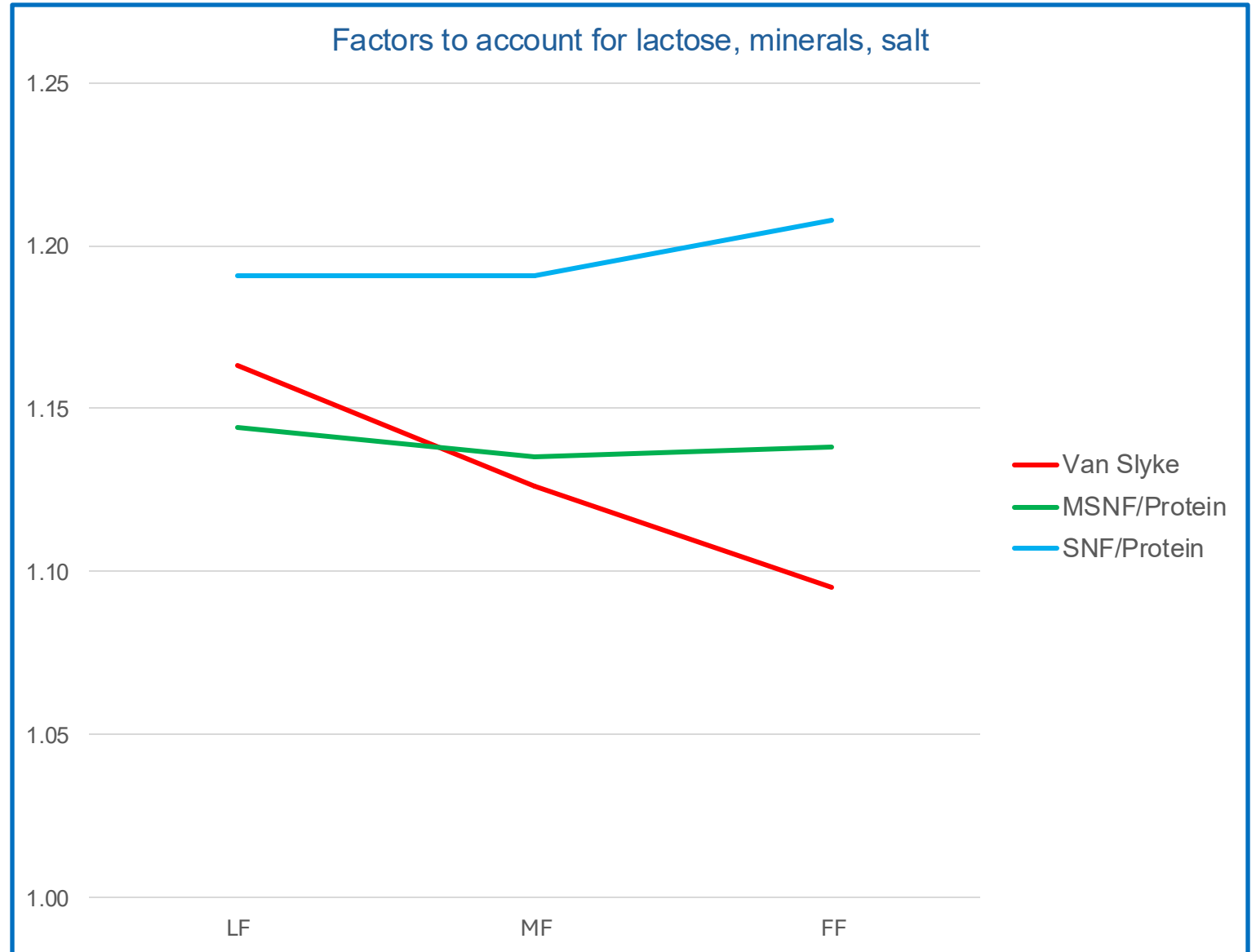
MSNF : protein \approx 1.14



* Cheddar types: calculated from Neocleous et al, Barbano & Sherbon. Fenelon & Guinee, Guinee et al

Factors to account for lactose, minerals, salt

Original data from Fenelon & Guinee, 1999



Modifying the basic model to use MSNF: protein ratio

$$Y (1 - m) = f_m \times R_f + c_m \times R_c + \text{minerals} + \text{lactose} + \text{salt}$$

Now salt = Y x s, where s is the cheese salt content

$$Y (1 - m - s) = f_m \times R_f + c_m \times R_c + \text{minerals} + \text{lactose}$$

$$Y = \frac{f_m \times R_f + c_m \times R_c \times 1.142^*}{(1 - m - s)}$$

* Note: The factor 1.142 is for milk pasteurized at 72 – 73°C using bulk starter culture

Modifying the basic model to use SNF: protein ratio

$$Y = f_m \times R_f + \text{SNF} + M$$

Can show that $\text{SNF} + M = \text{SNF}/(1 - \text{MFFC})$

Also, $\text{SNF} = 1.22 \times \text{protein}$

$$\text{SNF} + M = 1.22 \times \text{protein}/(1 - \text{MFFC})$$

$$Y = f_m \times R_f + \frac{C_m \times R_c \times 1.22*}{(1 - \text{MFFC})}$$

*Note: The factor 1.22 is for milk pasteurized at 72 – 73°C using bulk starter culture

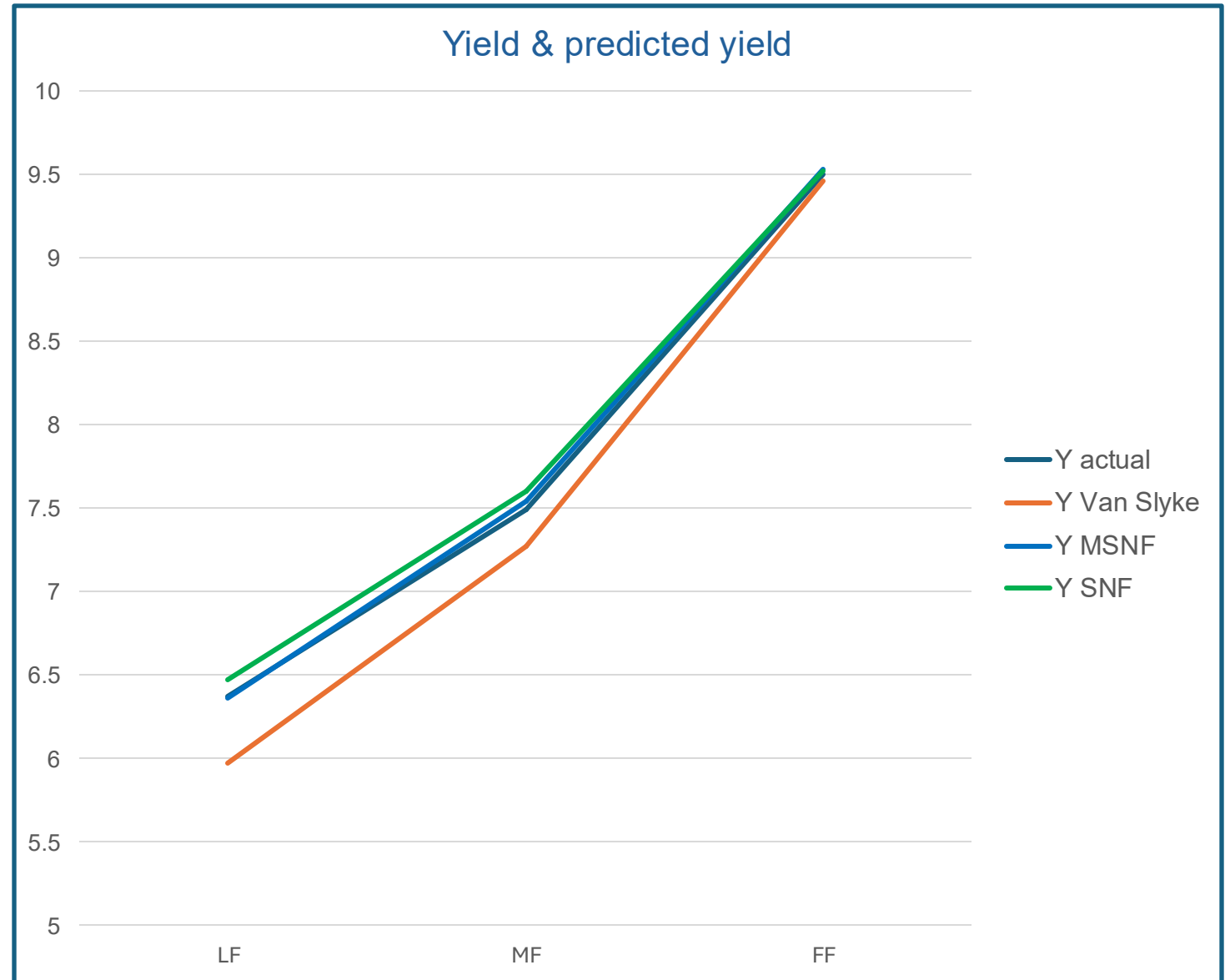
How applicable are the revised models

- High moisture
- Protein standardised



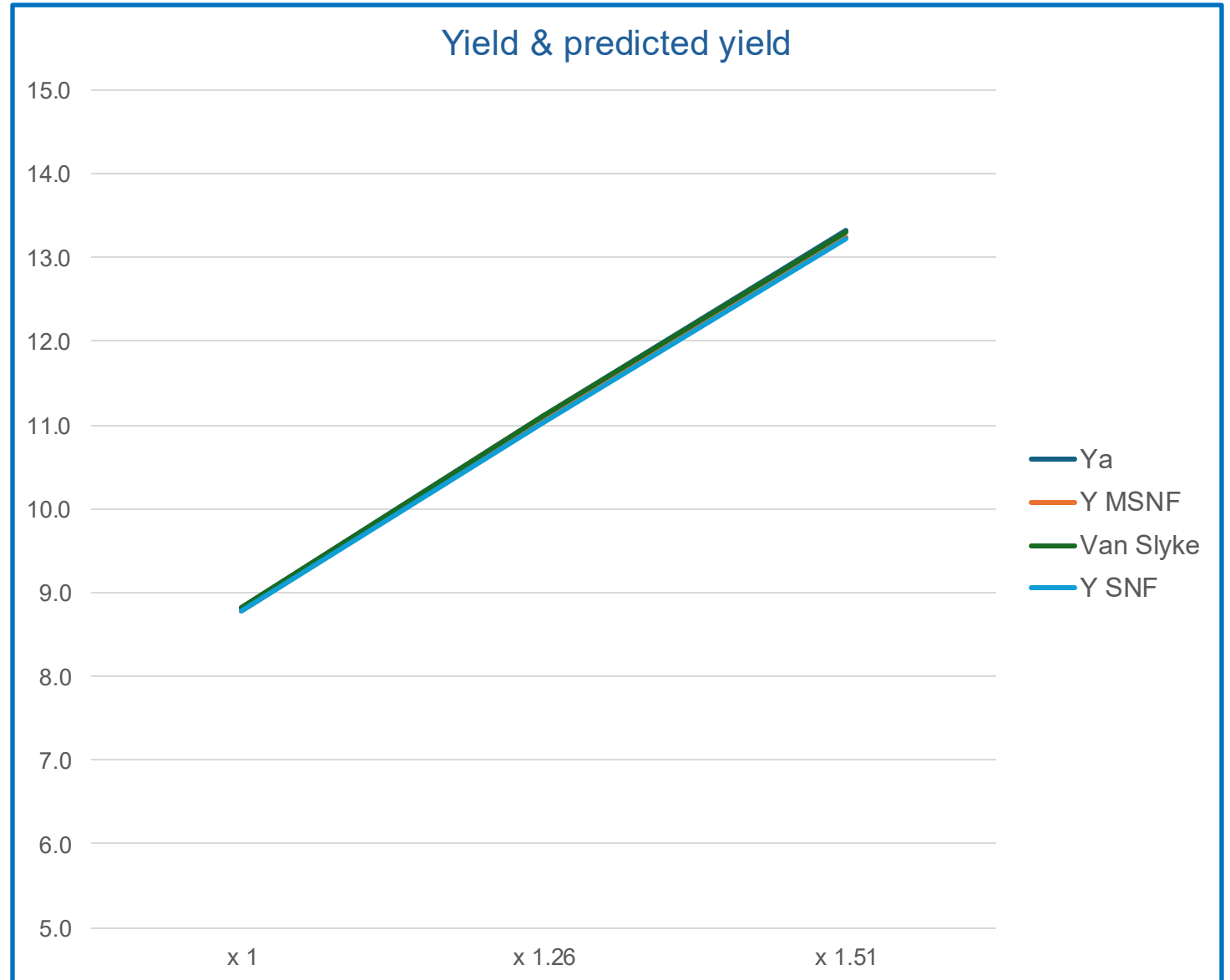
Higher moisture/ lower fat cheese

Milk & cheese data from
Fenelon & Guinee, 1999

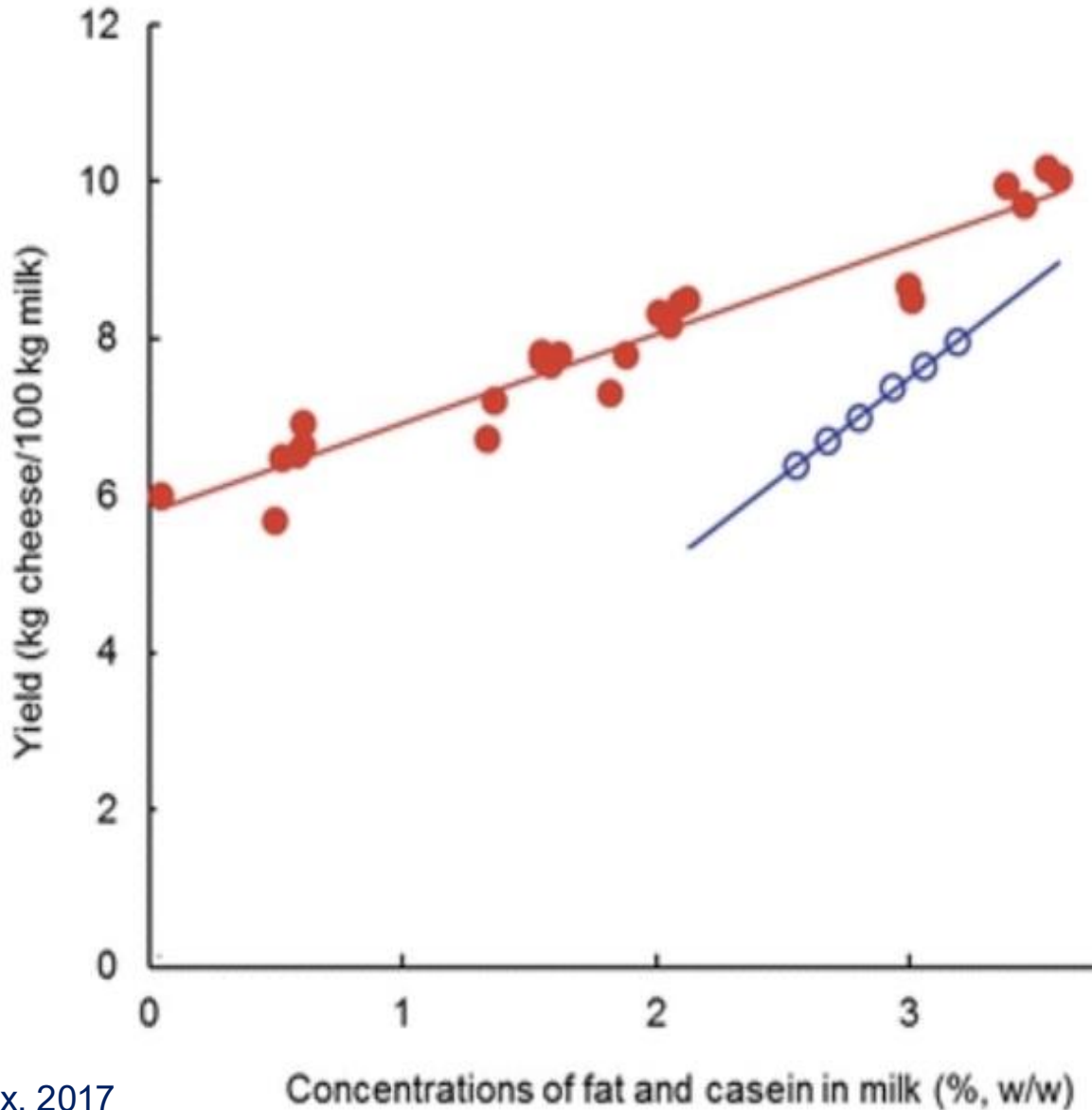


Protein standardised cheese: MF

Milk & cheese data from
Neocleous et al, 2002



Contribution of fat & casein to yield*



Van Slyke:

$$Y = 1.6 \times f_m + 1.7 \times c_m$$

MSNF:

$$Y = 1.5 \times f_m + 1.8 \times c_m$$

SNF:

$$Y = 0.9 \times f_m + 2.6 \times c_m$$

* For Cheddar with standard factors

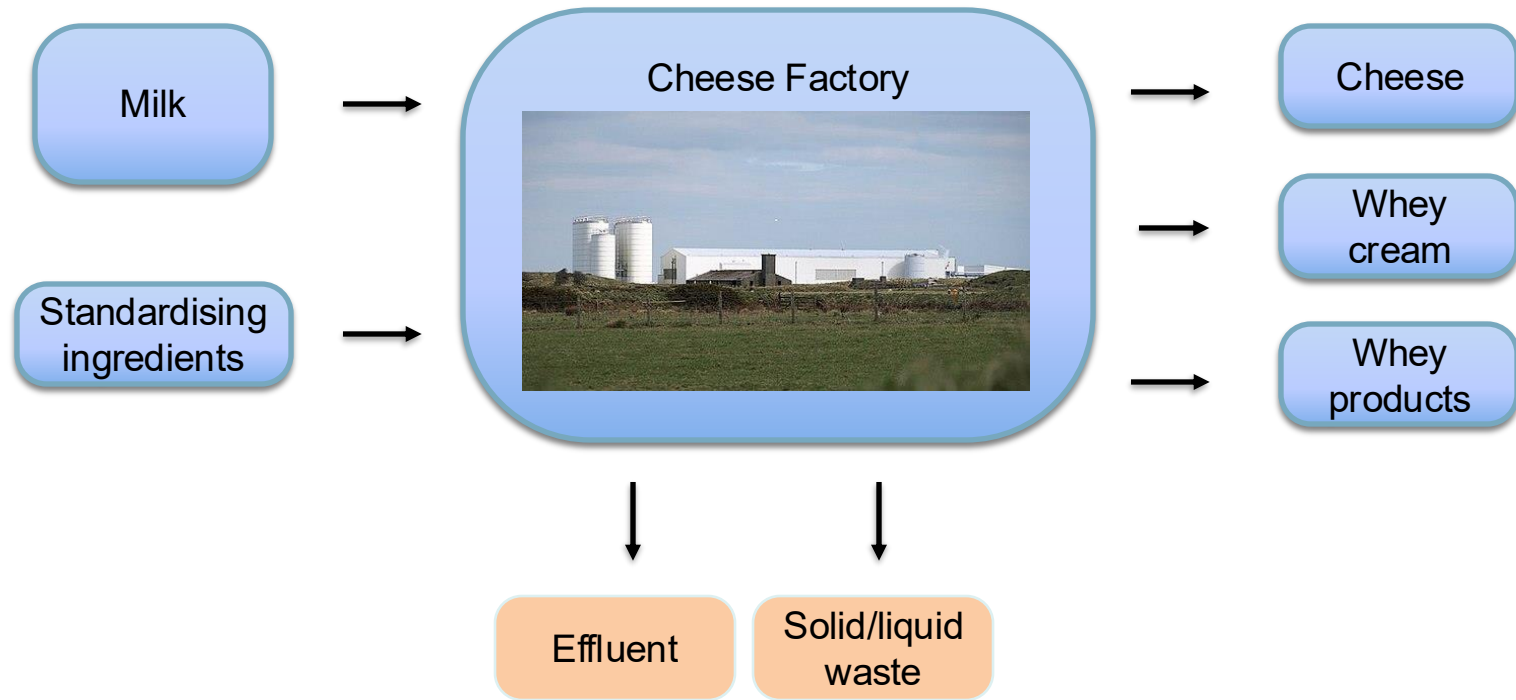
Yield modelling as a tool in yield improvement

- Yield model
- Mass balance
- Metrology
- Targets & monitoring



CHEESE
YIELD &
FACTORS

Mass Balance



Metrology

- Weights, volumes
- Sampling
- Analysis



Chapter 13: Targets and Monitoring

Targets & monitoring

- Y_{actual} as % of Y_{pred}
- Y_{actual} variance from Y_{pred}
- R_f , R_p , M variances from site and/or benchmark standards
- Financial variance of fat, protein usage against standard recipe



SUMMARY

- Basic yield model
- Van Slyke
- Two alternative models:
 - High moisture
 - Relative value of casein & fat
- Yield modelling value as tool in yield improvement

