Cheese Yield Evaluations: Improving the Quality of Cheese Composition Data

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Outline

- **Introduction**
- **Metrics of Cheese Yield Performance**
- **Improving Cheese Yield Performance**
- **A Cheese Yield Performance Evaluation System**
- **Sensitivity of Performance Evaluation to Input Data Quality**
- **Methods of Cheese Composition Analysis**
- **Conclusions**

Introduction – Important Information on Factors Influencing Cheese Yield

1890's – VanSlyke Cheese Yields in NYS

1978 Cheese Yield Studies in New York State

1984 National Milk Composition Study

IDF – Cheese Yield and Factors Affecting Its Control

Conference 1993 – Cork Ireland

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- Introduction
- **Metrics of Cheese Yield Performance**

Metrics of Cheese Yield Performance

Barbano Theoretical Generalized Cheese Yield Formula

$$\text{Yield} = \frac{(A+B+C)}{1 - ((\text{target cheese moisture} + \text{target cheese salt}) /100)}$$

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B=(percent casein in milk – 0.1) x (calcium phosphate retention factor)

C=[[((A+B)/(1-actual cheese moisture percent/100)) – (A+B)] x (separated whey solids percent/100)] x (solute exclusion factor)

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A = 3.674 x .93 = 3.417

B = (2.501 – 0.1) x 1.092 = 2.622

C = [[((A+B)/(1-37.5/100)) – (A+ B)] x 6.45/100] x 0.70)

Metrics of Cheese Yield Performance

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$$\text{Yield} = \frac{(A+B+C)}{1 - ((\text{target cheese moisture} + \text{target cheese salt})/100)}$$

A = 3.674 x .93 = 3.417

B = (2.501 – 0.1) x 1.092 = 2.622

C=[[((3.417+2.622)/(1-37.5/100)) – (3.417+ 2.622)] x (6.45/100))] x 0.70) = 0.163

$$\text{Yield} = \frac{3.417 + 2.622 + 0.163}{1-(37.5 +1.75)/100} = 10.21$$

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- **Improving Cheese Yield Performance**

Improving Cheese Yield Performance

Factors to Focus On:

1) Milk supply – composition and quality

- **Fat and Protein**
- **Bacteria count**
- **Somatic cell count**

Improving Cheese Yield Performance

Factors to Focus On:

2) Accuracy of parameters measured in the cheese factory

- **Cheese weight (type and specification on load cells)**
- **Milk weight (meter type and specifictions)**
- **Milk and whey composition**
    - **Mid-infrared analyzer**
- **Cheese Composition**
    - **Classical chemistry methods**
    - **Near-infrared**
    - **Mid-infrared??**

Improving Cheese Yield Performance

Factors to Focus On:

3) Control of cheese composition (accuracy and variability)

- **Process control**
- **Vat-to-vat, day-to-day variation**

Improving Cheese Yield Performance

Factors to Focus On:

4) Reduction in loss of fat and protein during the process

- **Measuring whey composition**

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Daily Output Data

Composition Control			Past Cheddar
Target fat on dry basis (%)			53.29
Actual fat on a dry basis (%)			53.29
Fat on a dry basis standard deviation (vat-to-vat variation) (%)			0.00
Fat gain or loss due to deviation from target (lbs)			0.00
Target moisture (%)			37.50
Actual moisture (%)			37.50
Moisture standard deviation (vat-to-vat variation) (%)			0.00
Moisture gain or loss due deviation from target (lbs)			0.00

Daily Output Data

Composition Control			Past Cheddar
Target salt (%)			1.75
Actual salt (%)			1.75
Actual salt-in-moisture (%)			4.67
Salt standard deviation (vat-to-vat variation) (%)			0.00
Salt gain or loss due deviation from target (lbs)			0.00
Target fat on a wet basis (%)			33.31
Actual fat on a wet basis (%)			33.31
Fat on a wet basis standard deviation (vat-to-vat variation) (%)			0.00
Target 4 day cheese pH (-)			5.05
Actual 4 day cheese pH (-)			5.05
pH standard deviation (vat-to-vat variation) (-)			0.00
Total cheese yield gain or loss per day (lbs)			0.00

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- **Sensitivity of Performance Evaluation to Input Data Quality**

Sensitivity of Performance Evaluation to Input Data Quality – Testing Accuracy

Accuracy of Cheese Analysis – What is the impact?

Moisture – there is a moisture target for each cheese type, if the moisture for the day is lower than the target you miss an opportunity for higher yield and if the moisture is higher than you target you can gain yield but may risk have a negative impact on cheese quality. This is straight forward assuming the moisture test results are correct.

In a plant converts about 2 million pounds of milk to cheese in a day, the impact running 0.5% low on moisture is about 1050 pounds of cheese for the day, assuming the moisture test is correct. What if the test is not correct?

Sensitivity of Performance Evaluation to Input Data Quality – Testing Accuracy

Accuracy of Cheese Analysis – What is the impact?

What if the moisture test is not correct for Cheddar?

Cheese	Reference Test Actual Moisture					QC - Moisture
Moisture	37	37.1	37.2	37.3	37.4	37.5
Yield Loss (lbs/day)	1066	853	640	426	213	0
Yield Loss (lbs/year)	389127	311301	233476	155651	77825	0

Sensitivity of Performance Evaluation to Input Data Quality – Testing Accuracy

Accuracy of Cheese Analysis – What is the impact?

What if the salt test is not correct for Cheddar?

Cheese	Reference Test Actual Salt					QC Salt
Salt	1.50	1.55	1.60	1.65	1.70	1.75
Yield Loss (lbs/day)	533	426	320	213	108	0
Yield Loss (lbs/year)	194545	155490	116800	77745	39420	0

Sensitivity of Performance Evaluation to Input Data Quality – Testing Accuracy

Accuracy of Cheese Analysis – What is the impact?

What if the fat test is not correct for Cheddar?

Cheese	Reference Test Actual Fat					QC - Fat
Fat	32.8	32.9	33	33.1	33.2	33.3
Yield Loss (lbs/day)	1066	853	640	426	213	0
Yield Loss (lbs/year)	389127	311301	233476	155651	77825	0
Fat Recovery(%)	91.60	91.88	92.16	92.44	92.72	93.00

Sensitivity of Performance Evaluation to Input Data Quality – Testing Accuracy

What about Low Moisture Part Skim Mozzarella?
What if the tests are not correct?

Cheese	Reference Test Actual					QC - Moisture
Moisture	47.5	47.6	47.7	47.8	47.9	48.0
Yield Loss (lbs/year)	243820	194910	146365	97455	48910	0
Fat	19.7	19.8	19.9	20.0	20.1	20.2
Yield Loss (lbs/year)	243820	194910	146365	97455	48910	0
Salt	1.50	1.55	1.60	1.65	1.70	1.75
Yield Loss (lbs/year)	121910	97455	73000	48910	24455	0

Sensitivity of Performance Evaluation to Input Data Quality

Sensitivity Analysis

1. **The sensitivity of management decisions to the accuracy of all measured parameters can be determined systematically. The impact increases as plant capacity increases.**

2. **The most important measured parameters are: a) milk and cheese analysis and b) milk and cheese weight determination**

3. **The economic impact can be calculated and can be used as guide on how much to invest in enabling the management system to have sound data on which to make decisions.**

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Cheese Composition: testing options

Classical chemistry methods (slow but accurate when done correctly)

- **Fat - Babcock, Gerber, ether extraction**
- **Protein – Kjeldahl**
- **Moisture – forced air oven or vacuum oven**
- **Salt – Volhard silver nitrate titration or chloridometer type salt meter**

Cheese Composition: testing options

NIR Cheese Analysis (rapid and simple sample preparation)

- **Parameters measured – fat, protein, moisture, and salt**
- **Local NIR calibration (very difficult and extensive calibration required for each cheese type)**
- **Global NIR calibrations (less calibration cost)**
- **Standard Error of Prediction for NIR of cheese components are in the range of 0.2 to 0.4% (Holroyd, 2011. NIR News. 22 (6) p 9-11)**

Cheese Composition: testing options

MIR Cheese Analysis (new research)

Goal to improve accuracy (i.e., lower Standard Error of Prediction and develop a more simple global calibration for Cheddar cheese)

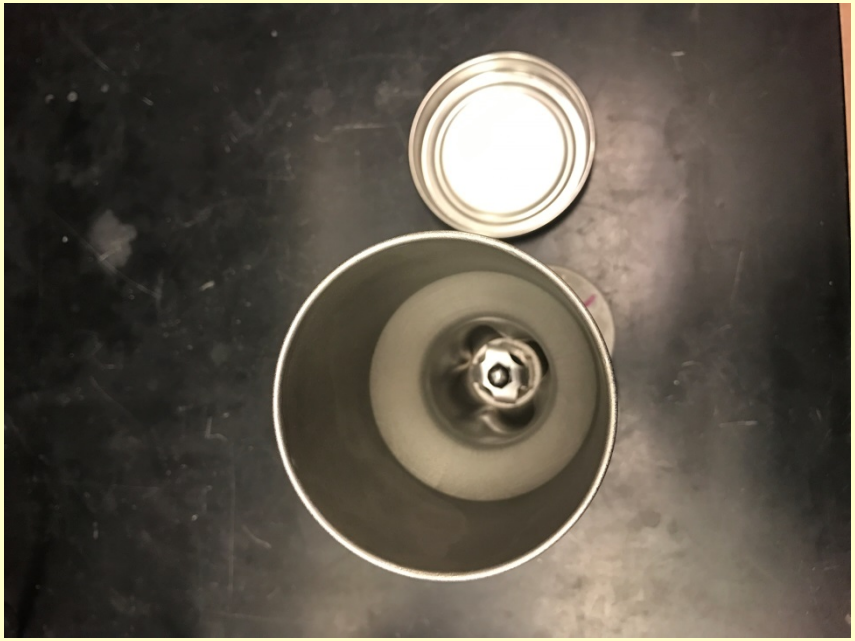
- **Parameters measured – fat, protein, moisture, and salt.**
- **Instrument: Delta FTA**
- **Sample Preparation: Blend the cheese with a buffer and analyze the cheese on the same MIR analyzer used for milk and whey analysis.**
- **Calibration with a set of liquid cheese standards**

Cheese Composition: Sample Preparation

MIR Cheese Analysis (new research)

Method:

1) **Warm cheese solver solution to 65°C**
2) **Weigh 81 g of 65°C solver and add to stainless steel Eberbach blender jar**



Cheese Composition: Sample Preparation

MIR Cheese Analysis (new research)

Method:

1) Warm cheese solver solution to 65°C
2) Weigh 81 g of 65°C solver and add to stainless steel Eberbach blender jar
3) Weigh 9 g of cheese and added to the blender jar containing the solver
4) Add 3 drops of antifoam
5) Blend at low speed for 15 seconds and the increase to high speed for 45 seconds.
6) Pour the liquid into a 4 oz plastic snap lid and place into 40°C water bath.
7) After 20 to 30 minutes test on the Delta FTA like a milk sample.

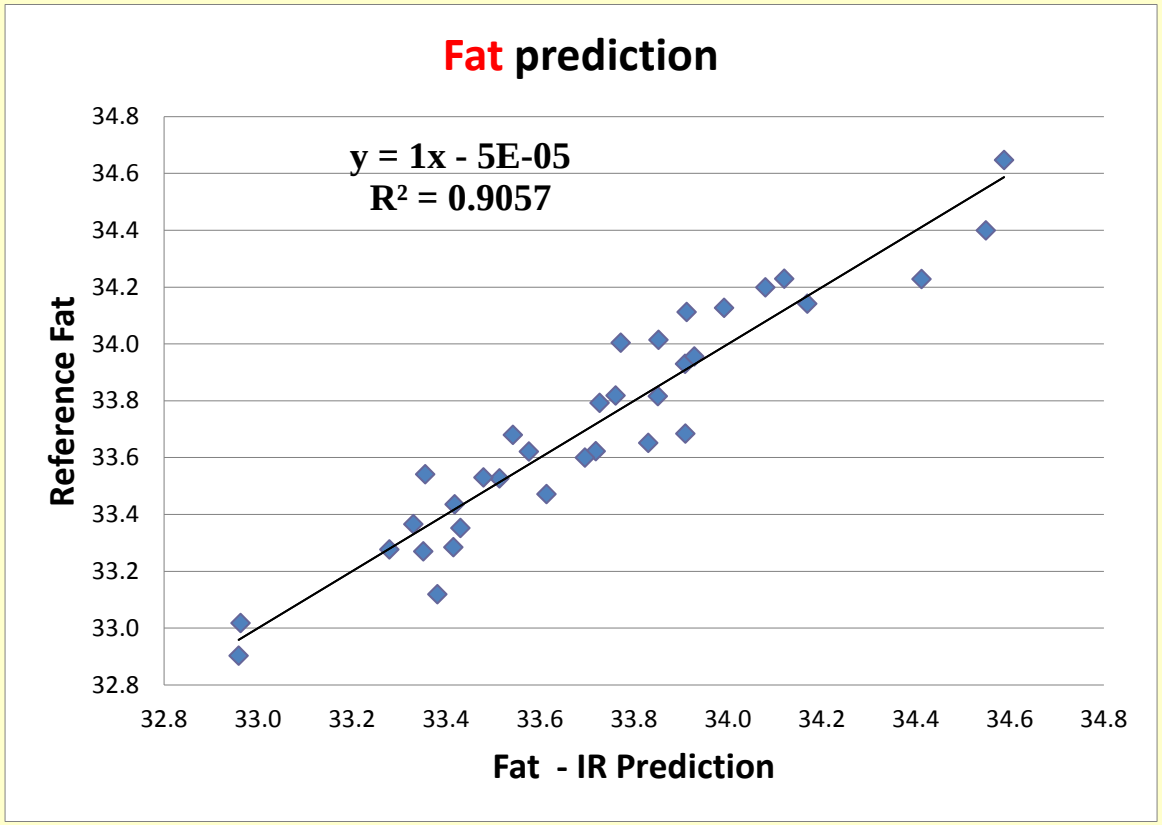
Cheese Composition: MIR testing

MIR Cheese Analysis (new research) – Delta FTA

1) **For fat and protein used the optimized sample and reference wavelengths used to measure fat and protein content of milk with the same intercorrection factors used for milk.**
2) **For salt we used a combination of the infrared spectra and an in-line conductivity sensor in the MIR milk analyzer.**
3) **For total solids the we added the fat, protein, and salt calibrated results and did a final slope and intercept using oven drying total solids reference value on cheese samples.**

Cheese Composition: MIR Results

MIR Cheese Analysis (new research) – Delta FTA



0.001 MD

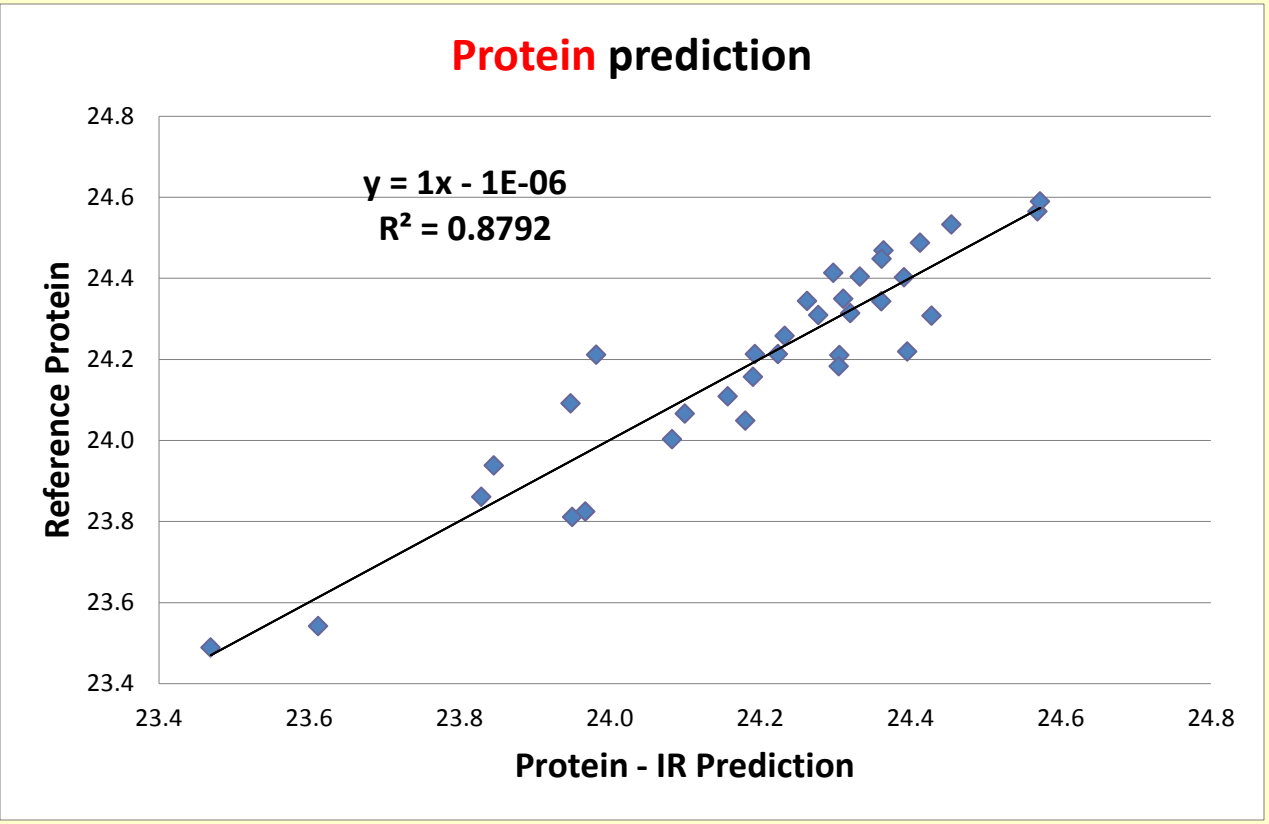
0.124 SDD

0.367 CV

0.128 Standard Error of Prediction

Cheese Composition: MIR Results

MIR Cheese Analysis (new research) – Delta FTA



-0.001

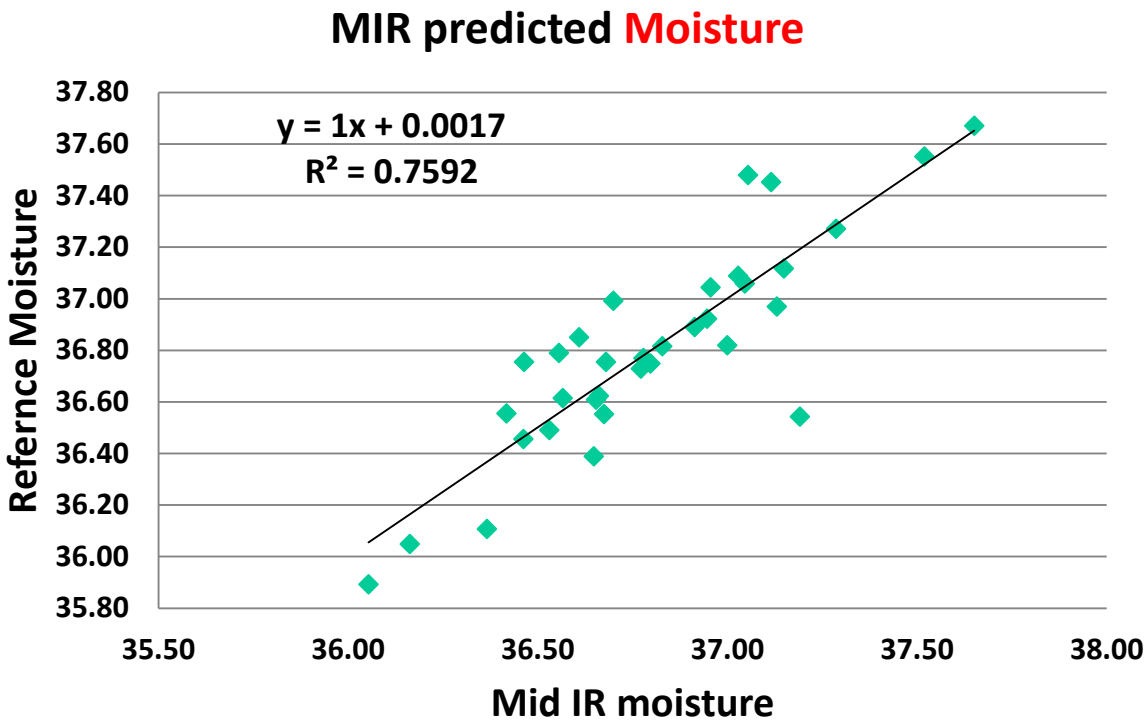
0.092 SDD

0.379 CV

0.094 Standard Error of Prediction

Cheese Composition: MIR Results

MIR Cheese Analysis (new research) – Delta FTA



-0.001

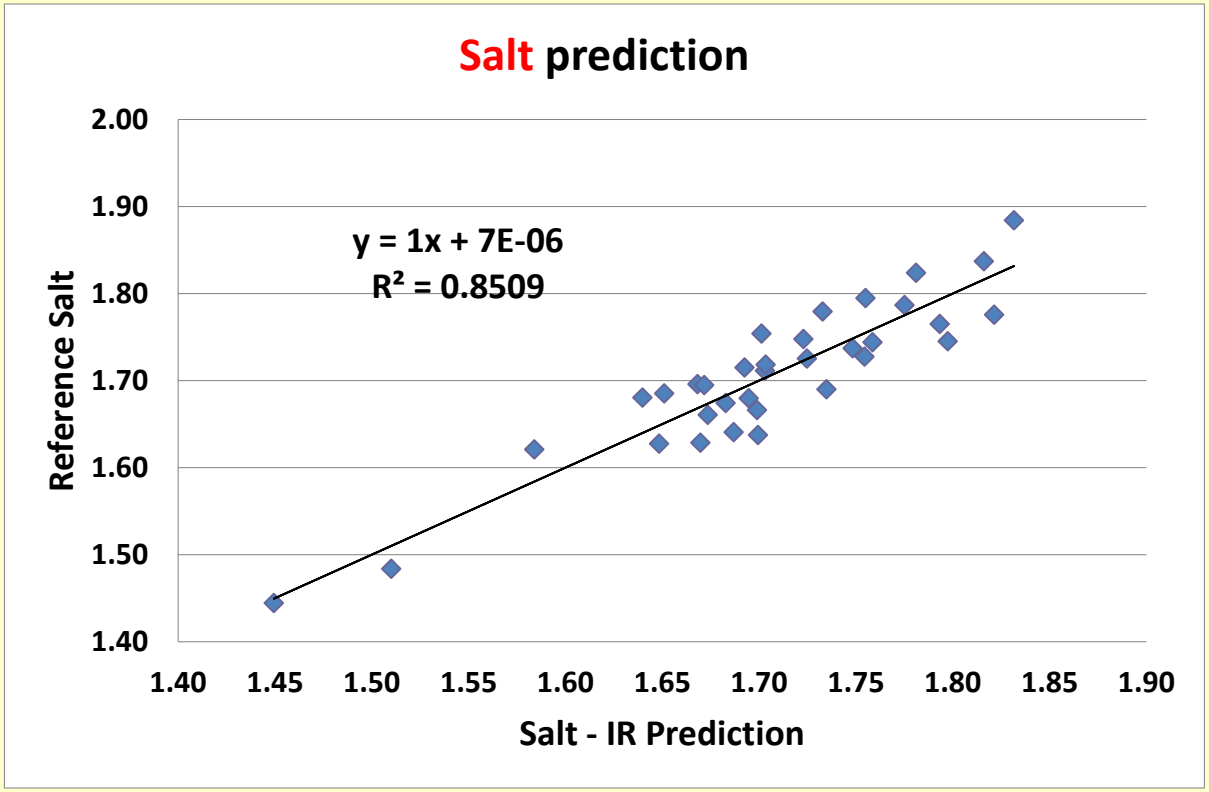
0.195 SDD

0.531 CV

0.201 Standard Error of Prediction

Cheese Composition: MIR Results

MIR Cheese Analysis (new research) – Delta FTA



0.000

0.033 SDD

1.953 CV

0.034 Standard Error of Prediction

Conclusions

1. **Standard Error of Prediction on moisture was equal to best performance by NIR analysis of cheese.**
2. **Standard Error of Prediction for fat, protein and salt were better than those reported for NIR analysis of cheese.**
3. **Further work is need to determine if the calibration for Cheddar cheese is valid across manufacturing plants.**

Future Work

- **The approach for Cheddar cheese analysis will be tested on Mozzarella cheese, cottage cheese, cream cheese, and sour cream.**
- **Once we get good at measuring composition of Cheddar cheeses, we would like to determine if we could predict parameters that relate to flavor quality development during cheese aging.**