Lowering Sodium in Cheese: Challenges and Solutions

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Through National Dairy Council, dairy farmers and the dairy industry have been committed to health and wellness for nearly a century, providing one of the original, wholesome foods – milk and milk products.
Innovation Center for U.S. Dairy combines industry resources precompetitively to foster innovation

Healthy People

Healthy Products

Healthy Planet

The Innovation Center works to combine the collective resources of the industry, on a precompetitive basis, to provide nutritious dairy products and foster industry innovation for healthy people, healthy products and a healthy planet.
Commitment to innovation is broad and growing

<table>
<thead>
<tr>
<th>32</th>
<th>CEOs &amp; Chairmen</th>
</tr>
</thead>
<tbody>
<tr>
<td>450</td>
<td>Companies</td>
</tr>
<tr>
<td>1,000</td>
<td>Individuals</td>
</tr>
<tr>
<td>48,000</td>
<td>Avg. annual man hours</td>
</tr>
<tr>
<td>$5.7M</td>
<td>Avg. annual staff value</td>
</tr>
</tbody>
</table>
Today’s agenda

► Why cheese industry is taking action to reduce sodium
► Situation assessment
► Sodium management and reduction
► Key learnings for broader food industry
Disclaimer

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Why cheese industry is taking action to reduce sodium
About five years ago, sodium was identified as a primary Health & Wellness issue in the food industry.

Cut the Salt. Get the Facts.
The National Salt Reduction Initiative

Americans Consume Too Much Salt
Lower sodium recommendation applies to almost 70 percent of American adults

PREVENT 150,000 Deaths Each Year
AVOID 11 million cases of high blood pressure
SAVE $1.5 trillion healthcare costs over 20 years

Sources: Harvard School of Public Health; CSPI
Sodium consumption among Americans is higher than recommended

2010 Dietary Guidelines for Americans recommendation:

- General Population - 2300 mg/day or less
- Those who are 51 and older and those of any age who are African American or have hypertension, diabetes, or chronic kidney disease - 1500 mg/day or less
  - Applies to about half of the U.S. population, including children

Current consumption:

- Current average intake by Americans is 3400 mg/day
Many consumers are concerned about their sodium intake

- 54% of U.S. consumers say they limit their use of packaged snacks/foods because they think they are too high in sodium/salt

- 53% express concern of too much sodium/salt in their diets

Source: Mintel, 2012
The 2010 Dietary Guidelines included 3 servings of dairy foods as a core part of healthy dietary patterns

► Supply 3 of 4 “nutrients of concern”
► Associated with multiple health benefits
  ▪ Bone health
  ▪ Cardiovascular disease
  ▪ Type 2 diabetes
  ▪ Blood pressure
► Important for children’s diets
► Important for those with lactose intolerance
Most Americans are not meeting DGA dairy recommendations

Average intake of milk, cheese and yogurt is **1.8 servings/day**

- **2.4** servings/day for 2-3 yrs
- **2.0** servings/day for 4-8 yrs
- **2.1** servings/day for 9-18 yrs
- **1.6** servings/day for 19-50 yrs
- **1.4** servings/day for 51+ yrs

*NHANES 2007-2008*
Dairy foods (milk, cheese, yogurt) make important nutrient contributions to U.S. diets at current intakes

- **White Milk**: 0.71 servings
- **Flavored Milk**: 0.09 servings
- **Cheese**: 0.32 servings
- **Cottage/Ricotta cheese**: 0.01 servings
- **Yogurt**: 0.04 servings
- **Milk or Cheese in Food Mixtures**: 0.60 servings

Average Dairy Consumption
1.8 servings*/day:
- 1 cup milk
- 0.7 serving cheese
- 0.1 cup yogurt per day

Milk, cheese, and yogurt contribute:
- 51% calcium
- 58% vitamin D
- 10% calories
- 14% fat

*NMyPyramid serving: 1 cup milk or yogurt, 1.5 oz natural cheese, 2 oz processed cheese. Low-fat or fat-free recommended.

NHANES 2003-2006, 2 years and older
Cheese contributes 8% of the sodium in the U.S. diet

*Hentges E. Sources of sodium in the food supply. Paper presented at: Institute of Medicine Committee on Strategies to Reduce Sodium Intake, Information-Gathering Workshop; 2009; Washington D.C.; Note: Data from day 1 of the NHANES 24-hour dietary recall (n=7,966). Individual food items. Individual food items in mixed dishes are included within their respective food groups (e.g., for pizza, the crust is categorized as grain, the cheese as cheese, tomato sauce as vegetables, etc.). **Dairy Research Institute™, NHANES (2003-2006). Ages 2+ years. Data Source: Centers for Disease Control and Prevention, National Center for Health Statistics, National Health and Nutrition Examination Survey. Hyattsville, MD: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, [2003-2004; 2005-2006]. [http://www.cdc.gov/nchs/nhanes.htm]
Dairy industry took a proactive approach to address sodium in cheese

► In early 2010, a planning meeting was held to determine how to collaboratively and precompetitively address sodium in cheese
  ▪ Attendance from 27 organizations including American Heart Association, American Academy of Pediatrics, American Medical Association, American Dietetic Association, USDA, several universities, cheese makers

► Meeting outcomes:
  ▪ Three different scenarios were built with rich dialogue and debate
  ▪ Some key themes were identified
    ▪ Education is critical on role of dairy in diet and role of sodium in cheese
    ▪ Sodium reductions must not compromise safety, quality, or consumer acceptance
  ▪ Whole system must be involved to build robust perspective and broad commitment to action
Dairy industry wanted and needed to take action to address sodium in cheese

Become part of solution, not part of problem
Cheese & Sodium Best Practices Task Force was formed to collaboratively address sodium in cheese.
Collaboration is unprecedented and investment has been significant

- Nearly 80% of cheese volume nationally is represented on Cheese & Sodium Task Force
- All initiatives are pre-competitive so will benefit entire industry
- Significant resources are being invested to support research to help overcome barriers to sodium reduction
  - $3 million from dairy farmers
  - $1 million from cheese makers against key sodium reduction initiatives over past 2 years
  - University-led research has also been significant
- Dairy industry is working cooperatively with USDA, FDA, CDC, NSRI, AHA, etc. to share research and uncover solutions to address sodium
Situation Assessment

- Critical role of salt in cheese making
- Approaches and challenges to sodium reduction
- Retail cheese and consumer sensory studies
Situation Assessment

► Critical role of salt in cheese making
► Approaches and challenges to sodium reduction
► Retail cheese and consumer sensory studies
“Cheese” seems straightforward…

… but is rather complex

Natural Cheese Is Made Of Four Basic Ingredients:
- Milk
- Salt
- Starter Culture
- Enzymes

72 “standard of identity” cheeses

More than 300 types of cheese

Cheese types have different amounts of sodium

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Innovation Center for U.S. Dairy

Healthy People • Healthy Products • Healthy Planet

NATIONAL DAIRY COUNCIL
There are over 300 types of cheese in the U.S.

- Unique tastes
- Different textures
- Diverse meltability
- Individual nutritional profiles
- Different sodium contents
  - Some cheeses are naturally low in sodium (i.e. Swiss) while others are higher (i.e. processed)
Salt plays a critical role in cheese making

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>• Limits growth of pathogenic bacteria</td>
</tr>
<tr>
<td>Shelf Life &amp; Quality</td>
<td>• Significant factor in minimizing spoilage</td>
</tr>
<tr>
<td>Taste</td>
<td>• Influences flavor and flavor formation during ageing/ripening</td>
</tr>
<tr>
<td>Texture</td>
<td>• Influences cheese texture and performance (i.e., meltability)</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>• Salt addition to the curd draws moisture (whey) to the surface of the cheese</td>
</tr>
</tbody>
</table>
Situation Assessment

- Critical role of salt in cheese making
- Approaches and challenges to sodium reduction
- Retail cheese and consumer sensory studies
There are several approaches to reducing sodium in cheese making.

<table>
<thead>
<tr>
<th>Approaches</th>
<th>Reduce salt addition &amp; variability</th>
<th>Partial replacement of salt</th>
<th>Added flavor “enhancers”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antes</td>
<td>Determine lowest level of salt that can be used</td>
<td>Determine if salt substitutes can be used to reduce sodium</td>
<td>Determine flavor boosters to help compensate for reduced salt &amp;/or speed up flavor development</td>
</tr>
<tr>
<td></td>
<td>Reduce sodium variability</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Without compromising consumer acceptance, quality, or food safety.
“Standards of Identity” have implications for reducing the sodium in cheese

72 standards of identity for cheese and cheese products in the Code of Federal Regulations

Using salt substitutes may result in a product that can no longer be called cheese (“cheese product”)

To qualify for a “reduced sodium” claim, a cheese must have 25% less sodium than the regular product

Impacting Consumer Acceptance
All sodium reduction approaches involve hurdles

**Consumer Acceptance**
- Consumers can detect small changes in sodium in cheese; therefore, reductions must be gradual and not too low to avoid dissatisfaction.
- Decreases in sodium may lead to decreased consumer liking; must be done gradually and avoid going too low to avoid unintended consequences (i.e., reduced dairy consumption).

**Safety**
- Sodium is a significant factor in preventing the growth of pathogens…keep good bugs in, bad bugs out.

**Cost**
- Potassium chloride costs over 10 times as much to use than sodium; it will take innovation and collaboration to find economical solutions.
- Product development and manufacturing changes utilize extensive resources; it will take innovation to find efficient solutions.
Reformulation is an iterative process and can take a long time, even years with cheese aging.

**Rules:**
Must follow the rules in the Code of Federal Regulations

**Standards Of Identity:**

**Microbial Management:**
Create desired microflora, control pathogens

**Function:**

**Taste:**
Liking acceptable or at parity for flavor

**Go/No-go:**
Liking acceptable or at parity for flavor

**Must haves:**
Texture, cheese curd formation

Minimize risk:
Create desired microflora, control pathogens
Situation Assessment

► Critical role of salt in cheese making
► Approaches and challenges to sodium reduction
► Retail cheese and consumer sensory studies
Two key studies and industry feedback lead to identification of priorities for sodium reduction

- Retail Cheese Study
- Industry Feedback (18 mths)
- Consumer Sensory Study

Cheese & Sodium Task Force

- Rapid, Direct Sodium Measurement
- Research & Development
- Expanded Food Safety Curves
- Education & Outreach
Retail Cheese Study: Most comprehensive cheese study ever

Study Objectives:

► Determine sodium levels across major cheese types and forms
  - Cheddar: chunk, shredded
  - Mozzarella*: chunk, shredded, string
  - Process: process singles

► Review variability in sodium levels across national brands, retailer brands, and regions… 1,665 samples in total

► Identify areas of opportunity for the industry

*Low moisture part-skim mozzarella cheese

Retail Cheese Study Key Learning: Substantial sodium variability currently exists

- Wide variation in sodium levels across different types of cheese, brands, forms, and/or sample-to-sample variation
  - Variation across types of cheese:
    - Cheddar: 600 to 800 mg/100g
    - Mozzarella: 526 to 893 mg/100g
    - Process Singles: 1185 to 1740 mg/100g

- Variation within mozzarella brands, for example:

  Least Variable: Mean 814 mg, Range 695 to 1010 mg
  Most Variable: Mean 619 mg, Range 318 to 976 mg

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Retail Cheese Study Key Learning: Tightening variability is an opportunity to improve label accuracy

- With all this variability, there’s less sodium in the cheese than on the label
  - Label accuracy can be improved with reduced variability

<table>
<thead>
<tr>
<th>Sodium levels in cheeses (mg/100g)</th>
<th>Analytical Average</th>
<th>Label Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheddar</td>
<td>615 mg</td>
<td>648 mg</td>
</tr>
<tr>
<td>Mozzarella</td>
<td>666 mg</td>
<td>685 mg</td>
</tr>
<tr>
<td>Process Singles</td>
<td>1242 mg</td>
<td>1313 mg</td>
</tr>
</tbody>
</table>

Consumer Sensory Study: Understand consumer acceptance of reducing sodium

Study Objectives:

► Understand consumer reaction once reduced sodium levels are imposed

► Determine consumer acceptance threshold for sodium reduction

► Identify areas of opportunity for the industry
Consumer Sensory Study Key Learning: Reducing sodium in small increments is best approach

- Reducing sodium below control level, especially for mozzarella and process cheese, negatively impacts liking and purchase intent.
- There is an opportunity to improve consumer satisfaction by reducing sodium variability.
- Reducing sodium in small increments is best approach; making larger changes may have negative impact on overall acceptance.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Control Level</th>
<th>Range Offering Highest Satisfaction</th>
<th>Level at Which Risk will Increase if Sodium Level Decreases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheddar</td>
<td>650 mg</td>
<td>630 – 670 mg</td>
<td>600 mg</td>
</tr>
<tr>
<td>Mozzarella</td>
<td>650 mg</td>
<td>630 – 690 mg</td>
<td>650 mg</td>
</tr>
<tr>
<td>American</td>
<td>1200 mg</td>
<td>1150 – 1250 mg</td>
<td>1150 mg</td>
</tr>
</tbody>
</table>
The industry has had some success with a “gradual” approach, but it has been challenging

Successes include:

- Kraft Grated Parmesan: 10% reduction
- Kraft Singles American Slices: 18% reduction
- Velveeta: 10% reduction
- Mozzarella for Schools: 25% reduction
- Most Process American & Blended Cheese USDA sends to Schools: 25% reduction

Note: Reductions not highlighted on package or in marketing initiatives (“gradual” approach)

- Reducing sodium in cheese is extremely challenging without sacrificing taste, quality, or food safety
  - Simply reducing salt is unsuccessful; other factors have to be changed
- The industry will not compromise on food safety and the public will not compromise on taste
- Extensive consumer testing is required as sodium reductions impact taste, texture, and melt
Sodium management and reduction

- Rapid direct sodium measurement
- Research and development on sodium reduction
- Food safety curves development
Cheese industry is committed to further reducing sodium; priorities were identified from research studies.

- **Retail Cheese Study**
- **Industry Feedback (18 mths)**
- **Consumer Sensory Study**

Cheese & Sodium Task Force

- Rapid, Direct Sodium Measurement
- Research & Development
- Expanded Food Safety Curves
- Education & Outreach

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[Logo: NATIONAL DAIRY COUNCIL]
Sodium management and reduction

► Rapid direct sodium measurement
► Research and development on sodium reduction
► Food safety curves development
Rapid Sodium Testing (RST) enables quick, accurate sodium measurement

- **Objective of RST:** Enable sodium adjustments during cheese-making to reduce variability

- **Existing methods either:**
  - Don’t directly measure sodium
  - Take too long to be actionable

**Chloride Testing**

- Results in 30 minutes
- Measures chloride and backs into sodium

**ICP Testing**

- Results in 5 minutes
- Measures sodium directly

- 1 day in-house or 3-5 days sent out
- Measures sodium directly

*Less accurate*
RST was identified utilizing an open innovation approach; new technology takes time to prove out.

**Project Identification**
- 2009-2011: Phase 1
  - Determined need to reduce sodium variability from large retail cheese study
  - Success criteria: rapid & direct sodium measurement

**Proof of Concept**
- 2011-2012: Phase 2
  - Two potential technologies identified from outside food industry
  - One technology met success criteria

**Proof during Production**
- 2013-2014: Phase 3
  - Testing in lab and pilot plants
  - Activate industry adoption
RST utilizes Oxford Instruments’ XRF technology to directly and accurately measure elements.

The energy of the X-rays indicates which elements are present.

The number of X-rays indicates how much of the element is present.

The energy of the X-rays indicates which elements are present.
Equipment is designed for use during production to enable real-time sodium adjustments.

First: Prepare sample and place on carousel.

Second: Press Start key.

Third: Obtain results.

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zn</td>
<td>0.000 Wt %</td>
</tr>
<tr>
<td>Ca</td>
<td>0.054 Wt %</td>
</tr>
<tr>
<td>S</td>
<td>0.688 Wt %</td>
</tr>
<tr>
<td>P</td>
<td>0.041 Wt %</td>
</tr>
</tbody>
</table>

The Business of Science®
Testing results to date of new technology look promising

<table>
<thead>
<tr>
<th>Rapid Results</th>
<th>• Delivers data in a timely manner to better manage or control processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accurate Measurement</td>
<td>• Directly measures sodium to tighten sodium specifications</td>
</tr>
<tr>
<td>Ease Of Use</td>
<td>• Operators can use during production</td>
</tr>
<tr>
<td>Added Benefit</td>
<td>• Measures other elements (e.g. potassium, calcium, etc.)</td>
</tr>
</tbody>
</table>
Sodium management and reduction

- Rapid direct sodium measurement
- Research and development on sodium reduction
- Food safety curves development
Overarching goals for sodium reduction research are consumer acceptance and food safety

**Consumer Acceptance**

- Most importantly, cheese has to taste good
- Performance must be similar to “traditional” full sodium counterparts

**Food Safety**

- Ensure hurdles are high enough to limit pathogenic growth and spoilage
There are three primary approaches that cheese makers can use for sodium reduction:

1. **Reduce Salt Addition**
   - Determine lowest level of salt that can be used

2. **Sodium Replacement**
   - Assess salt substitutes

3. **Flavor “Enhancers”**
   - Assess flavor boosters to help compensate for reduced salt &/or speed up flavor development
Key learnings on reducing salt additions

- Cheese flavor develops due to biochemical process that is controlled by salt

- Reducing salt alters the flavor chemistry
  - Leads to increased off flavors and bitterness

- Manufacturing changes are needed to control moisture, acidity and flavor

Research by: Dr. MaryAnne Drake, North Carolina State University; Dr. Don McMahon, Utah State University
Application for lowering sodium in cheese for pizzas available to schools

- **Creative Application**: Mixing of cheeses with varying salt content to deliver consumer acceptable cheese

- **Example**: Wisconsin Center worked on formulating tastier lower-sodium cheese for pizza served in schools by blending “aged” traditional with “young” low-sodium cheese

Research by: Dr. Mark Johnson, University of Wisconsin-Madison
Advances on sodium replacement

Studies showed potassium chloride has the most promise as a salt replacement
  - Magnesium, calcium salts were not successful
  - Studies showed that a 25% replacement of sodium chloride can be achieved with potassium
  - Further reductions required a combination of potassium chloride and bitterness blockers

Non-mineral emulsifiers are being explored for process cheese applications

Research by:
Dr. MaryAnne Drake, North Carolina State University; Dr. N. Farkye, Cal Poly; Dr. J. Lucey, University of Wisconsin-Madison; Dr. Don McMahon, Utah State University; Dr. L. Metzger, University of Minnesota; Dr. T. Schoentuss, University of Minnesota
## Advances on flavor “enhancers”

<table>
<thead>
<tr>
<th>Addition of flavor enhancers</th>
<th>Use of enzymes</th>
<th>Use of selected starter cultures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide savory notes since reduced sodium / low sodium cheeses are often bland</td>
<td>Offsets bitterness that can be common in lower sodium cheese</td>
<td>Helps provide more cheese flavor</td>
</tr>
</tbody>
</table>

Research by:
Dr. MaryAnne Drake, North Carolina State University; Dr. N. Farkye, Cal Poly; Dr. J. Lucey, University of Wisconsin-Madison; Dr. Don McMahon, Utah State University; Dr. L. Metzger, University of Minnesota; Dr. T. Schoenfuss, University of Minnesota; Dr. J. Steele, University of Wisconsin-Madison
The safety of cheese is based on several vital factors including salt content. Working together, these factors limit the growth of bacteria.

- **Salt content**
- **Compounds that inhibit bacteria growth**
- **Acidity**
- **Moisture**
**What are we up against?**

- Substantial progress has been made to understand the microbiological risks associated with reducing the sodium in cheese

**How can we overcome the risks?**

- Develop a knowledge base and explore technologies to mitigate the risk of pathogen and spoilage microbes

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*Applied Knowledge Is Powerful!*
Sodium management and reduction

- Rapid direct sodium measurement
- Research and development on sodium reduction
- Food safety curves development
Developing food safety curves enables more rapid formulation of safe, reduced-sodium products

- Testing includes a mix of both “expected safe” and “expected sensitive” samples
- Testing conducted over shelf-life of product
- Objectives of developing food safety curves:
  - Enable more rapid formulation of lower sodium products
  - Significantly reduce industry investment in proprietary product testing

Tanaka et al, 1986 JFP
Testing is currently in progress for process cheese

- Central composite statistical design with 7 parameters
- 80 samples in total being tested, including a mix of both “expected safe” and “expected sensitive” samples

<table>
<thead>
<tr>
<th>Factor</th>
<th>Test Variables</th>
<th>Low</th>
<th>Interm.</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>% fat</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>% moisture</td>
<td>50</td>
<td>55</td>
<td>60</td>
</tr>
<tr>
<td>3</td>
<td>pH</td>
<td>5.4</td>
<td>5.8</td>
<td>6.2</td>
</tr>
<tr>
<td>4</td>
<td>% K replacement</td>
<td>0</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>% sorbic acid</td>
<td>0</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>6</td>
<td>% NaCl</td>
<td>1.7</td>
<td>2.05</td>
<td>2.4</td>
</tr>
<tr>
<td>7</td>
<td>% DSP solids equiv</td>
<td>0.8</td>
<td>1.2</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>total salts</td>
<td>2.5</td>
<td>3.25</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>mg Na / 100 g</td>
<td>928</td>
<td>1195</td>
<td>1462</td>
</tr>
<tr>
<td></td>
<td>mg Na if 50% repl</td>
<td>464</td>
<td>598</td>
<td>731</td>
</tr>
</tbody>
</table>
Scientific publication of findings are expected in Q4 2015

- Expected timing:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testing completion</td>
<td>June 2014</td>
</tr>
<tr>
<td>Statistical analysis completion</td>
<td>Aug. 2014</td>
</tr>
<tr>
<td>Proprietary report to funding partners</td>
<td>Sept. 2014</td>
</tr>
<tr>
<td>Scientific report publication</td>
<td>Q4 2015</td>
</tr>
</tbody>
</table>

- Testing was funded by five cheese makers as testing is expensive; for their investment, the funding partners get to utilize results for one year before scientific publication and usage by entire industry
Key learnings for broader food industry
Collaboration is critical for success

► Cheese & Sodium Task Force represents approximately 80% of cheese volume
  ▪ Task Force meetings are well attended with very interactive discussions and debates

► Cheese makers, Dairy Research Institute, and other experts (i.e. equipment suppliers, universities) are project partners and are resolving issues together

► Dairy industry is also working cooperatively with USDA, FDA, CDC, NSRI, AHA, etc. to share research and uncover solutions to address sodium
Key initiatives are research-based and benefit entire industry

- Determining key initiatives requires detailed research analysis and significant discussions with all stakeholders

- Focusing on pre-competitive, collaborative projects benefits entire industry
  - Key projects are large in scope and unlikely could be completed and/or funded by a single company
  - While cross-industry collaboration can take longer, the benefits to the industry are immense
While not discussed in this presentation, Education & Outreach has also been important

- Providing education to health professionals, thought leaders, and consumers on importance of dairy in the diet and critical role of sodium in cheese for food safety, consumer acceptance, and quality
- Dispelling myths and misinformation about cheese and sodium
- Communicating new information to broader dairy and food industry
- Sample resources: www.nationaldairycouncil.org/cheeseeducation
Thank you!