Report
of
Michigan
Fresh Unprocessed Whole Milk
Workgroup

December 2012
Report

Michigan
Fresh Unprocessed Whole Milk Workgroup

Presented to Director Jamie Clover Adams
Michigan Department of Agriculture and Rural Development

December 11, 2012
General considerations of the Fresh Unprocessed Whole Milk Workgroup’s recommendations:

- During the workgroup’s deliberations, herd share programs were considered to include only Fresh Unprocessed Whole (FUW) Milk intended to be consumed by people.
- Products such as butter, yogurt, cheeses, etc. made from fresh unprocessed milk were not included in the workgroup’s discussions and are not included in these recommendations.
- The workgroup recommends that herd share programs not be regulated and that legislation is not needed to implement these recommendations.
- State and local health agencies should maintain their current ability to investigate food and health issues.
- There is a need for further education on herd shares and FUW milk.
- Representatives from the workgroup would remain available as a resource.
- The herd share farmers and shareholders should be made aware of the FUW milk workgroup’s recommendations and report.

The workgroup recommends that herd share operations include the following elements:

- There is a signed and dated written contract between a single herd share farmer and shareholder.
- There must be a workable means of communication between the farmer and all of the households receiving milk.
- Milk should be from a single farm and not co-mingled with another farm’s milk.

The workgroup recommends the following scope of herd share arrangements:

- FUW milk is not for sale or resale.
- Shareholders should be encouraged to periodically pick up the FUW milk from the farm.
- The herd share farmer should provide educational material about the farm including farm operations, benefits, risks, and responsibilities. This should be in the contract.
- FUW milk cannot be distributed from a licensed food establishment.
- Advertising of herd shares is not regulated.

Why the workgroup is comfortable with these recommendations:

- There is a defined consumer pool.
- Rapid trace-back is possible.
- The farmer and shareholder are both responsible for maintaining the quality of the milk.
- The workgroup wants the shareholder to be knowledgeable about the operation of the herd share.
- The Michigan Fresh Unprocessed Whole Milk Workgroup report will be available to the farmers and shareholders.

Recommended Next Steps:

- Meet with the MDARD Director to discuss the FUW milk workgroup recommendations and next steps.
- Request that the Food and Dairy Division develop a guidance document built on these recommendations for the Food and Dairy Division staff. This guidance document will be shared with the Michigan FUW milk stakeholders.
- The Michigan Fresh Unprocessed Whole Milk Workgroup requests that representatives of the workgroup be included in any discussion of change on MDARD’s stance regarding FUW milk.
About the Michigan Fresh Unprocessed Whole Milk Workgroup

Purpose

The workgroup is addressing the question: “Where do we want to be in 3 to 5 years on access to fresh unprocessed whole milk?”

Goal

The group desires clear direction with clear public policy regarding access to fresh unprocessed whole milk and adjusting the law accordingly, if needed.

Background

In October 2006, the question of access to raw milk came to a head in Michigan when the Michigan Department of Agriculture (now known as the Michigan Department of Agriculture and Rural Development (MDARD)) initiated an investigation and legal action against a food cooperative for, among other things, the distribution of unpasteurized milk and milk products. As a result, Michigan Food and Farming Systems (MIFFS) and Michigan State University (MSU) met with MDARD leadership to talk about the action and how to address a desire among some Michigan consumers for access to raw milk while minimizing health risks.

It was decided that a workgroup would be formed and the first meeting was held in January 2007. Workgroup members represent an array of perspectives, relative to the issue at hand and the group’s purpose: consumers who seek to ensure access to raw milk, producers who want to provide a healthy source of raw milk, a Grade “A” milk industry representative and food safety regulators who are looking to balance access and choice issues with protection of the food supply. MIFFS and MSU served as facilitators and resource providers to guide the dialog and deliberations of the workgroup.

The group agreed to use the term Fresh Unprocessed Whole Milk to describe the product intended for direct human consumption since “raw milk” is used to describe milk intended for pasteurization. The group agreed to address the question “Where do we want to be in 3 to 5 years on access to fresh unprocessed whole milk?”

The Michigan Fresh Unprocessed Whole Milk Workgroup met to identify the issues and questions it had regarding access to this milk. The workgroup reached consensus on the goal: “The group desires clear direction with clear public policy regarding access to fresh unprocessed whole milk and adjusting the law accordingly, if needed.” The group decided to reach this goal using a question and answer format. Over 60 questions covering 10 topic areas were initially identified by the workgroup. Since early 2007, the group has met almost monthly in face-to-face, usually three-hour sessions to discuss the questions, share resources and expertise, and develop answers to the questions. An additional five-hour meeting was held with herd-share farmers to solicit their views, needs and ideas. The group invited guest speakers to share information and expertise which aided the development of answers to the questions. The Michigan Fresh Unprocessed Whole Milk Workgroup’s answers to the questions were developed after thorough discussion, deliberation and consensus among the group’s members. As time went on, some of the topics and questions originally developed were removed from the workgroup’s consideration because they were no longer relevant to the goal.

By agreement, the group’s discussions have been kept confidential. However, as each topic was completed, the consensus summary was posted on a website made available by MIFFS. The workgroup’s discussions and resulting recommendations are focused on the state of Michigan. The questions, answers, recommendations and additional reference information are included in this report.

Since 2007, some members of the workgroup have retired while other members have joined the group. Over this time, workgroup members have celebrated milestone birthdays, wedding anniversaries, graduations and births of children and grandchildren. The workgroup members have especially enjoyed the opportunity to get to know each other and understand differing perspectives on the subject of consumer access to fresh unprocessed whole milk.
Michigan Fresh Unprocessed Whole Milk Workgroup
Members

(Moderator)

Ted Beals, MD, Retired pathologist, faculty U of Mich. Med. School; Director, Farm-to-Consumer
Foundation; and MI Fresh Milk Council, January 2007 - present

Peggy Beals, RN, Teacher, lecturer, and author: Traditional Food Preparation and Food Safety; Leader,
South Central Michigan Chapter, Weston A. Price Foundation; Nonpaid Administrator and member,
MI Fresh Milk Council; and Director, Farm-to-Consumer Foundation, January 2007 - present

Susan Esser, Food and Dairy Division Deputy Director, Michigan Department of Agriculture and Rural
Development, January 2007 – present

Frank Fear, Sr., PhD, Associate Dean, MSU College of Agriculture and Natural Resources and Kettering
Project Principal, January 2007 – Dec 2011

Katherine Fedder, Director, Food and Dairy Division, Michigan Department of Agriculture, January
2007 - December 2010

Jesse and Betsy Meerman, Cow Share Dairy Farmers, March 2011- present

Jennifer Nord, Environmental Sanitarian, University of Michigan, September 2011- present

John Partridge, PhD, Michigan State University, Department of Food Science and Human Nutrition, May
2011 – present

Rosanne Ponkowski, Executive Director, Healthy Traditions Network, Metro Detroit Chapter, Weston A.
Price Foundation and Member of MI Fresh Milk Council, January 2007 - present

Joe Scrimger, Principle, Bio-Systems; Life Time Foods; Scrimger Farm and Member MI Fresh Milk
Council; Member of Healthy Traditions Network; and Chair of Michigan Thumb Organics (MTO),
January 2007 – present

Gary Trimner, Director of Member Services, Michigan Milk Producers Association, January 2007 –
December 2011

John and Patti Warnke, Cow Share Dairy Farmers and Members MI Fresh Milk Council, January 2007 to
June 2011

Invited Subject Matter Experts

George Bird, PhD, Professor, Michigan State University, Department of Entomology

Edwin Blosser, Owner, Midwest Bio-Systems

Tilak Dhiman, PhD, Animal Nutrition, Environmental Health and Natural Foods

Angela Renee Katafiasz, DVM, private veterinary practitioner

Paul Bartlett, MPH, DVM, PhD, Michigan State University, Department of Large Animal Clinical Science,
College of Veterinary Medicine

Mark McAfee, California Certified Raw Milk Organic Dairy Farmer

Greg Miller, PhD, Vice-President, National Dairy Council

Sally Fallon Morell, President and Treasurer, Weston A. Price Foundation

Elliot Ryser, PhD, Michigan State University, Department of Food Science and Human Nutrition

Melinda Wilkins, PhD, Director, Communicable Disease Division, Michigan Department of Community
Health

Warnke Family, Warnke’s Emerald Acres Farm
# Table of Contents

## Recommendations
- Recommendations and Recommended Next Steps ........................................ iii

## About the Michigan Fresh Unprocessed Whole Milk Workgroup
- Purpose, Goal and Background ................................................................. iv
- Lists: Members and Invited Subject Matter Experts ...................................... v

### Topic One — History of Fresh Unprocessed Whole Milk
1. Historically, why is milk an important component of our diet? .................... 3
2. What is the history of milk regulation? ..................................................... 3
3. Why is milk one of the most regulated foods in the U.S.? ............................ 5
4. Is there something uniquely hazardous about milk? ................................. 6
5. Initially, what were the conditions that prompted pasteurization for milk — have those conditions and knowledge/understanding changed today? ......................................................... 6
- References ................................................................................................. 7

### Topic Two — Benefits and Values
1. What is the nutritional value of milk? ..................................................... 11
- Nutritional Components Listed on Nutriton Facts Label .............................. 13
2. Going beyond the Nutrition Facts label what other nutritional values should we be considering? ................................................................. 14
3. What are the additional benefits of milk fresh from the cow? ..................... 17
4. What is the impact of pasteurization on FUW milk's value? ....................... 22
   Table-Impact of Heat, Temperature and Time ........................................... 24
5. What is the impact of homogenization on FUW milk's value? .................... 26
6. Assuming that all milk is not the same, what do production and management practice have to do with FUW milk's nutritional value, pathogens, color, taste, etc.? ........................................... 26
7. What is the impact of consumer preferences on production and management practices of FUW milk? ................................................................. 27
- References ................................................................................................. 28

### Topic Three — Risks
- Introduction
  1. What are the risks for fresh unprocessed whole milk, including all types of risks, such as adverse consequences, intolerance and allergens? ......................................................... 33
  2. Where do these risks originate? ............................................................... 33
- Milkborne Bacterial Human Pathogen Summaries ....................................... 34
  - *Campylobacter jejuni* ................................................................. 34
  - *Listeria monocytogenes* ............................................................ 37
Topic Three – Risks continued

Salmonella .................................................. 41
Escherichia coli ............................................. 43
Sidebar – Lateral Transfer of Genetic Material ........... 45
Sidebar – Differing Perspectives ......................... 45
References .................................................. 48
Scenarios for Transmission ................................ 49
Campylobacter jejuni ....................................... 49
Listeria monocytogenes .................................... 52
Salmonella .................................................. 54
Escherichia coli ............................................. 56
Discussion of Infectious Dose ............................... 60
Other pathogens of historical milk-related public health concerns .......................... 61
Categories of risk other than infectious disease for people consuming fresh unprocessed whole milk .................................................. 64
Adverse Consequences Unique to Fresh Unprocessed Whole Milk Consumption .......... 66
Table of Terms ............................................. 67

Topic Four – Risk and Benefit Management

Introduction 1. What steps are necessary to minimize the health risk for consumers of fresh unprocessed whole milk?
2. Who is responsible for minimizing risk, as it relates to fresh unprocessed whole milk? ....................... 75

Table of Risk Management ................................ 76
Hygiene ....................................................... 76
Consumer Preferences .................................... 77
Dairy Animals .............................................. 77
Milk ............................................................ 79
Monitoring, Laboratory Testing, and Record-keeping .................................................. 80
Sources of Pathogens Virulent in People .................. 81
Water .......................................................... 82

3. What steps can be taken to mitigate or prevent adverse impacts on the entire dairy industry in the event of a milkborne outbreak originating from milk consumption? ....................... 83
4. What management practices enhance benefits? .................................................. 85

Table of Benefit Management .............................. 85

Topic Five – Consumer Choice Options

1. How might consumer access to fresh unprocessed whole milk be achieved? .......................... 89
2. How might people who are considering choosing to drink fresh unprocessed whole milk be properly educated and informed on their choice? .......................... 89
Discussion Summaries

Michigan Fresh Unprocessed Whole Milk Workgroup
Topic One

History
of
Fresh Unprocessed Whole Milk

1. Historically, why is milk an important component of our diet?

2. What is the history of milk regulation?

3. Why is milk one of the most regulated foods in the U.S.?

4. Is there something uniquely hazardous about milk?

5. Initially, what were the conditions that prompted pasteurization for milk – have those conditions and knowledge/understanding changed today?
Summary
Approved June 8, 2009

Topic One – History of Fresh Unprocessed Milk

1. Historically, why is milk an important component of our diet?

"It has been said truly that milk is the only material in the whole range of animal matter that is designed and prepared by nature expressly as food." (From the preface to the 6th Annual Meeting of the American Association of Medical Milk Commissions, 1916)

As far back as we have recorded evidence, milk and milk products have been a mainstay of infant, child and adult diets. Earliest records document the domestication of animals as a source of fluid milk and other dairy products, and religious texts contain many references to milk.

Historians have repeatedly cited ways in which the use of milk was a competitive advantage for people. It was a rich source of nutrients and water. Domesticated lactating animals accompanied migrating people and moved with armies as they marched across great distances. Many of the early settlers to this country brought dairy animals with them to provide milk during their transatlantic crossings and in their new communities. Traditionally, nearly all milk was obtained directly from the animal, consumed fresh and was not refrigerated.

Milk producing animals were prevalent throughout the world and intentionally bred to produce more milk than was needed for their newborn for human consumption. Fresh milk proved palatable and nutritionally beneficial. It was also cultured into many foods, such as yogurt and kefir (a fermented milk drink), and preserved as butter, ghee (butter fat separated from milk) and a variety of cheeses. This practice increased the nutrient content and portability of these products and extended their storage life, which helped sustain people during harsh times and when animals weren’t producing milk. Milk-producing animals were considered – and still are – a sign of personal wealth and security. In some cultures, the cow is considered sacred.

Historically, milk consumption was common and unregulated. Recorded history does not show that milk caused widespread disease. Items in traditional diets, which are developed over generations, remain if they are beneficial and do not have adverse consequences.

2. What is the history of milk regulation?

In the United States, milk and milk products were not regulated until the 20th century. Milk producing animals were prevalent and well integrated into the community, family life and local commerce.

Then several things happened:

- There was a huge increase in the population of metropolitan areas resulting from the influx of immigrants and people moving to urban areas for work.
- New dairies were located near these rapidly growing urban centers to provide these huge concentrations of people with the milk they wanted. The industrial model was seen by these urban dairies as the way to maximize profits by efficiencies of scale and the use of locally-available, cheap, alternative feed.
- Dairies developed extensive distribution systems to get their product to consumers. Some milk production facilities located in cities still obtained milk from rural dairies, which required transportation of farm milk over considerable distances. Farmers left cans of milk on platforms beside the railroad tracks and trains would stop and pick the cans up along the way. This is the origin of the term “milk run” – a train that made repeated stops to pick up cans of milk. This
expanded movement of milk resulted in longer times between milking and public consumption. None of this milk was refrigerated.

- As the need for more milk in these urban areas increased, a few dairies exploited this demand to increase profits. Examples included adding water to augment volume, using whiteners to hide discoloration and adding disinfectants to camouflage spoilage.

During this same period, a number of diseases developed into serious public health problems due to overcrowding, inadequate means to dispose of human waste, and rudimentary water and sewage treatment. Scientists began to understand that microorganisms were often the cause of these illnesses. Federal food safety regulation began when farmers called for a national approach to meat processing so they could compete in the foreign market, resulting in the Meat Inspection Act of 1891. At the time, their domestic and European markets were threatened by growing public concern over diseases such as trichinosis from pork.

The public became outraged when journalists reported the unsanitary conditions in “swill dairies” (so named because they were located near distilleries to take advantage of huge amounts of waste material – known as swill – left over from fermenting grains). The swill was used as a substitute for pasture/forage feeding. Newspapers showed pictures of milk transporters adding water to milk cans and other questionable practices to increase profits (now categorized as adulteration and mislabeling). Groups of physicians made the connection between unsanitary conditions at dairies and children developing diarrhea when consuming bottled milk.

In 1892 a New York physician, Dr. Henry Coit, introduced a system for designating milk from inspected dairy farms as “Certified Milk”. As a strong proponent of pasteurization, Nathan Straus contributed some of his personal wealth to building milk pasteurization plants and distribution centers in large cities as a way of providing subsidized “pure” milk to the poor, particularly for newborns of mothers that were not able to breastfeed. Soon 20 large cities had distribution centers, half required pasteurization, all only used Certified Milk. There was vigorous public and scientific debate about the “milk problem”. Some milk processors saw the advantages of pasteurization (e.g., extended time to transport milk, reduced spoilage, and marketing their milk as germ-free). The physician groups were concerned that pasteurization destroyed medical benefits of the milk. Physicians, veterinarians and health officials argued that the solution to the unsanitary conditions and public health issues was to encourage dairies to clean up in order to meet the Medical Milk Commissions’ certification standards. This was a prolonged and contentious debate.

During the first decade of the 20th century, there was an increase in the number of local governments that adopted strict sanitation standards. Many of the Medical Milk Commissions included a requirement for testing cows for tuberculosis using a new test. In Chicago, this resulted in municipal regulations requiring that milk from cows not tested for tuberculosis be pasteurized. Most of the local regulations and laws for sanitation standards were later expanded by initially recommending, then requiring pasteurization.

In 1906, the Federal Food and Drug Act was passed. Most large cities had pasteurization requirements by 1917. In 1924, the U.S. Public Health Service developed a model regulation known as the Standard Milk Ordinance for voluntary adoption by state and local agencies. This model regulation is now known as the Grade “A” Pasteurized Milk Ordinance (PMO) and has been adopted by nearly every state. In 1948, Michigan became the first state to require pasteurization of all sold milk. There were still Medical Milk Commissions in the 1970s and 1980s.
3. Why is milk one of the most regulated foods in the U.S.?

Food regulation in the United States has a complex history. Microorganisms were discovered that were linked to communicable diseases. There was a common school of thought during the late 19th and early 20th century that, by eradicating germs, we could eliminate disease. This idea was promoted by a variety of advocacy groups. Milk was one of the earliest foods to stimulate debate related to food safety because of its widespread consumption. Historically, milk regulations were linked to the “war on germs.” In addition, early milk regulations targeted areas such as the adulteration of milk and dairy products, the health of milk-producing animals and the health of people involved in handling milk and dairy products.

In 1924, the U.S. Public Health Service developed a model regulation known as the Standard Milk Ordinance for voluntary adoption by state and local agencies. With the addition of the pasteurization step in the processing of milk, a whole new set of regulations were needed to maintain the effectiveness of the pasteurization process. The public and manufacturers wanted controls covering mislabeling as imitation dairy products were made commercially available. Various state and local governments developed their own regulations governing milk and dairy products, sometimes with the intent of protecting their local dairies from competing dairies in others cities or states. Following World War II, the problem of regulatory barriers to the free flow of milk between markets increased, leading to the formation of the National Conference on Interstate Milk Shipments (NCIMS) in 1950.

The NCIMS provides cooperative input for the states, the dairy industry and the Food and Drug Administration regarding milk regulation. All proposed changes to the PMO filter through the committee structure of the NCIMS and are voted on by representatives of state regulatory agencies. The NCIMS meets every two years and, typically, over 100 proposals for changes to the PMO and other NCIMS documents are reviewed. These proposals are submitted by states, industry and the FDA. The NCIMS promotes regulatory uniformity across the United States because it allows milk regulatory issues to be thoroughly discussed by stakeholders and alleviates the need for individual states to enact their own dairy laws. In 2004, the Institute of Health, in their report, Scientific Criteria to Ensure Safe Food, made a point about the historical background of food regulation: “The need for such standards in the food industry goes to the heart of regulatory theory, which recognizes the necessity for the government to establish standards as a counterbalance to private economic incentives.” The PMO, along with the NCIMS program, are recognized by the FDA as a state and federal cooperative program providing milk regulatory oversight for the entire United States.

The PMO includes both technology-based and performance-based standards. For example, the construction standards for the floors, walls and ceilings of a dairy plant have been included in the PMO and changed very little over the past 55 years. Performance standards such as cooling temperatures, bacteria counts and coliform counts have been included in the PMO over the years as well. The NCIMS process allows for the adoption of new systems and technology. For example, in 2003, a voluntary Hazard Analysis Critical Control Point Program for dairy plants was adopted and, more recently, standards for automatic (robotic) milking systems have been added to the PMO. The document has evolved to be a complex and comprehensive set of regulations.

The PMO requirements are limited to Grade “A” milk and milk products intended for shipment across state lines. However, states have the authority to regulate milk and milk products that move within their borders. Some states adopt, and may even expand, the PMO requirements as state law to cover intrastate sales. Other dairy products, such as ice cream and cheese, are regulated by individual states.
4. Is there something uniquely hazardous about milk?

Milk is not inherently hazardous. Fresh milk from the mammary glands is one of the most nutritious and complete foods available to people. Although milk contains water and many other nutrients to sustain growth of bacteria -- whether beneficial or pathogenic -- many other foods have similar characteristics that can readily support the growth of disease-producing bacteria: fresh and processed meat, sea food and foods consumed fresh such as produce, coconut milk and fruit juices. To enhance safe products, animal-based products require good handling practices. Milk is a liquid that is harvested from animals at a body temperature conducive to bacterial contamination from the environment. No food, including milk, is completely safe.

5. Initially, what were the conditions that prompted pasteurization for milk – have those conditions and knowledge/understanding changed today?

At the turn of the 20th century, much of the public concern about disease and dissatisfaction with milk was caused by the swill dairies in large urban areas and the human illness caused by milk that was contaminated by sick cows, sick humans, insanitary handling, and adulteration. Doctors in orphanages noticed that children were becoming ill from drinking milk. Filthy dairy operations, with both sick animals and sick or unclean workers, led to heavily soiled and contaminated milk. The initial milk commission criteria for certification focused primarily on these conditions. Public outrage, certification criteria and subsequent adoption of these standards into milk regulations resulted in considerable improvement in the sanitation and cleanliness of dairies.

Much of the public concern about disease and dissatisfaction with milk was caused by long distance transportation, mostly unrefrigerated (trains to bottling plants and bottled milk to retail outlets or homes). Milk spoiled, but it's important to clarify that spoiled milk is not hazardous – it is simply unmarketable. The heightened awareness of the importance of refrigeration and manufacturer's testing protocols has improved considerably in recent years. “Pasteurization,” which was at that time some sort of heat treatment, helped the manufacturers by enabling more time to transport, process and store milk by killing spoilage organisms.

Other advocates for pasteurization were coming forward from individuals concerned with infant mortality, such as Nathan Strauss. Pasteurization was seen by some public health officials as a quick, cost-effective way to eliminate pathogens in milk.

Epidemics publicly perceived to be associated with drinking milk at that time, including brucellosis (known as Bangs or undulant fever), diphtheria, typhoid and tuberculosis, spread mostly in urban areas that lacked sanitation. Each of these serious diseases is now under control; diphtheria and typhoid by treatment of people who were spreading the disease and improved sanitation requirements for food and water. Brucellosis and bovine tuberculosis were controlled by a massive program of testing and depopulation of cattle. These are all public health successes resulting from federally mandated disease eradication policies.

Conditions have changed considerably since the early 20th century in terms of sanitation and public health. Our knowledge of what it takes to maintain the quality and safety of milk has grown, including our understanding of good herd management, disease-causing and healthy bacteria, our ability to test for pathogens, the capacity to rapidly chill milk and give attention to constant refrigeration, use of stainless steel, improved design of processing equipment, and improved cleaning techniques. Regulations at the state and federal level have and continue to improve milk quality and safety, as do dairy farmers and milk processors.
References


Sixth Annual Meeting of the American Association of Medical Milk Commissions, 1912;
   http://books.google.com/books?id=cqYDAAAAYAAJ&dq=+henry+coit+certified+milk+movement&source=gbs_summary_s&cad=0

   http://www.fda.gov/opacom/backgrounders/milestones.html


Pure Milk is Better Than Purified Milk, Alan Czaplicki, Social Science History, 31:3 Fall 2007, pages 411-433.

John Partridge, PhD, Michigan State University, Department of Food Science and Human Nutrition. Workgroup interview on March 11, 2008.
Topic Two

Benefits and Values

1. What is the nutritional value of milk?

2. Going beyond the Nutrition Facts Label — What other nutritional values should we be considering?

3. What are the additional benefits of milk fresh from the cow?

4. What is the impact of pasteurization on FUW milk’s value?

5. What is the impact of homogenization on FUW milk’s value?

6. Assuming that all milk is not the same, what do production and management practice have to do with FUW milk’s nutritional value, pathogens, color, taste, etc.?

7. What is the impact of consumer preferences on production and management practices of FUW milk?
Summary
Approved April 20, 2010

Topic Two – Benefits and Values

1. What is the nutritional value of milk?

Milk is a complete food. It serves as the sole nourishment and fluid for newborns during a most critical stage of their development. It is an important part of most children’s diet, with dairy products providing calcium and many other nutrients needed for a growing child. For adults, milk is a readily available source of numerous essential nutrients including high-quality, low-cost protein, a minimum of carbohydrate and an appropriate balance of fatty acids. Milk is considered an excellent source of calcium, phosphorous, vitamins B-2 and D-3 and a good source of fat, carbohydrate, protein, vitamins A and B-12. It is considered a poor source of iron, fiber, vitamin C and the B vitamin, folate.

The taste of milk is generally enjoyable, and this pleasure enhances its digestibility.

Nutrition Facts labels list the quantities of certain nutrients in food. The amount of a nutrient is listed as a measured weight, such as in grams (g) or milligrams (mg) or International Units (IU). The other way of indicating proportion is to list a compound using a complicated formula which is based on an estimated intake from a 2,000 or 2,500 calorie diet is indicated as a a Percent Daily Value number (%DV). The energy we derive from food is measured in calories and is listed for fat, carbohydrates, and protein on the label. The calorie number is based on the serving size, listed at the top of the label, multiplied by the calories per gram:

- Fat - 9 calories/gram,
- Carbohydrate - 4 calories/gram, and
- Protein - 4 calories/gram.
Fat Free Milk
Vitamin A & D

Grade A
1 QUART (946 mL)

2% Reduced Fat Milk
37% LESS FAT THAN REGULAR MILK
Vitamin A & D
2% Milkfat
Grade A
Pasteurized Homogenized

Fat reduced from 8g to 5g per serving.

Ingredients: REDUCED FAT MILK, VITAMIN A PALMITEATE, VITAMIN D3

Grade A
1 QUART (946 mL)
Nutritional Components Listed on Nutrition Facts Label

Fats
Fats consist of a large group of compounds that are made up of fatty acids (saturated and unsaturated). Fats are generally soluble in organic solvents and largely insoluble in water. Fats support and cushion organs and protect nerves. Nutritionally, fats are the source of essential fatty acids. In nutritional terms, an essential substance is one that cannot be produced by the body so it must come from the food we eat. Non-essential substances can be synthesized internally. The fat-soluble vitamins A, E, D and K can only be digested, absorbed and transported in association with fats, and the body can store these vitamins in fatty tissue. Milk fat in dairy products is the carrier of these fat-soluble vitamins, as well as important flavor and aroma substances.

The fat content of commercial milk is typically standardized at: ½%, 1%, 2%, or 3.25%. See representative labels on previous page.

Carbohydrates
Carbohydrates are organic compounds that include sugars, starches, cellulose, and gums. They serve as a major energy source. The main carbohydrate in milk is the sugar lactose.

Protein
Proteins are large organic compounds composed of amino acid chains. Proteins are utilized in every physiological process within the body. Milk is a complete protein – it contains all eight essential amino acids and some that are non-essential. The most plentiful protein in milk is casein. Casein proteins are unique to milk and milk products, they are not found in any other foods.

Vitamins and Minerals
Vitamins are organic substances required for many physiological processes. Milk contains fat-soluble vitamins A, D, E, and K. Vitamins A and D work as a team, so both must be available in the proper proportion and at the same time to be assimilated. Milk is also an important source of several water-soluble vitamins: B-1 (thiamine), B-2 (riboflavin), B-3 (niacin), B-6 (pyridoxine), B-12 (cobalamin) and pantothenic acid.

All 22 minerals considered to be essential to the human diet are present in milk. Milk supplies these minerals in the correct proportions. Calcium, magnesium, and potassium are needed together for healthy bones. They also serve to regulate nerve connectivity and muscle and nerve contractions. Appropriate balances of these minerals prevent misfiring and cramping of muscles, including the muscles of the heart. Sodium, potassium, and chloride serve to maintain the osmotic equilibrium of milk with blood.

There is very little difference in the calcium content of reduced-fat dairy products compared to those made with whole milk.
2. Going beyond the Nutrition Facts label —

What other nutritional values should we be considering?

In addition to what is listed on conventional nutrition labels, we find that milk is complex and contains other required, interdependent elements such as enzymes, vitamins, and minerals. Many of these elements are absorbed intact and function directly in our metabolism. Others serve to foster the bioavailability of the basic nutrients—fats, carbohydrates, and proteins, in the milk.

Fats
The fat in whole milk has many benefits. Butterfat is the natural fat of milk. It is the chief component of butter. Historically, it is one of the first fats from animal sources to be used as a food. Butterfat is good for the bones and enhances the immune system. It is directly absorbed, thus giving quick energy instead of being laid down as body fat for future utilization. In addition, fat in the diet gives an increased satiety value by slowing absorption of the food eaten. The slow digestion of fat provides gradual energy and allows the body to absorb needed nutrients along with the fat. The good satiety of whole milk may contribute to eating appropriate amounts of food, i.e., not overeating.

Each butterfat globule is surrounded by a membrane consisting of phospholipids and proteins. These emulsifiers keep the individual globules of butterfat from joining together into clumps and also protect

---

Michigan Fresh Unprocessed Whole Milk Workgroup REPORT 2012
the globules from the fat-digesting activity of enzymes found in the fluid portion of milk. In addition to the conventionally listed fats, Omega 3 and Omega 6 fatty acids occur in whole milk.

The scientific community is looking closely at Conjugated Linolenic Acid (CLA). CLA is a unique fatty acid that is formed in the rumen, the first chamber of the cow and sheep's digestive system that allows them, by bacterial action, to utilize fresh grass as their primary food. The amount of CLA in milk depends on the breed of the animal, its feed and environment, and the seasons. Researchers are excited by the possibility of CLA being effective in cancer prevention, particularly in breast and prostate. Research is suggestive that CLA may strengthen the immune system, and it may also have properties that tend to normalize body fat deposition.

The fat in whole milk contributes 48–50% of the calories and most of the flavor of milk.

“There is no evidence that moderate intake of milk fat gives increased risk of diseases.” - Anna Haug, et al “Bovine milk in human nutrition – a review”

**Carbohydrates**
Milk has a glycemic index number of 30. Foods with a number below 55 are considered 'low' and are therefore good choices for a sugar-restricted diet, such as diabetes. Another plus is that eight ounces of milk contains twelve grams of sugar, a commonly recommended target amount for a snack.

**Proteins**
“The protein in milk has a quality higher than many other foods but the quantity of milk protein is low due to high water content. Milk protein contains all the essential amino acids required by the body for optimum growth, for this reason more of the protein can be used for protein anabolism so there's less chance the protein in milk will be converted to fat and stored.” – American Dairy Science Association, 1999

The hairy casein micelle model referred to as the Holt Hairy Model, where a spherical tangled web and open structure of polypeptide chains cross-link by calcium phosphate nanocluster (colloidal calcium phosphate) in the core provides rise to an external region of lower segment density known as the hairy layer. The embedded gray circles represent the calcium phosphate nanoclusters.
The protein casein represents about 80% of milk protein. Caseins are a large group of related proteins that are bound together with calcium phosphate into aggregates known as micelles (pronounced MY cells). Micelles contain a mixture of the various caseins, as well as the calcium, magnesium, and inorganic phosphorus needed to build bone, muscle, and tissue. The structure and composition of micelles make the casein proteins and the salts of the minerals calcium (Ca), magnesium (Mg) and inorganic Phosphorus (P) more bioavailable. They also form a curd (clabber) in the stomach for slower, more efficient digestion.

There are dozens of other proteins in milk that are more water-soluble than caseins. Because these other proteins remain suspended in the whey left behind when the caseins coagulate into curds, as in cheese making, they are collectively known as whey proteins. Whey protein is absorbed rapidly, resulting in high concentrations of amino acids in the bloodstream for ready energy and muscle strength. Excess calories from carbohydrates and protein, not just fat, are made into fat by the liver and adipose tissue. By the same token, high quality protein, appropriate amounts of carbohydrates and good fat, all contribute to the satisfied feelings of a meal.

Other Nutrients

Enzymes act as catalysts, contributing to nutrient availability (bioavailability). In whole or complete foods such as milk, the enzymes that are needed to digest a compound usually occur along with the compound. For example, lipids need lipases, and proteins need proteases. These and other enzymes are present in milk as it comes from the animal. Lactose needs lactase to make it available. Lactase is not in the milk. It is produced and utilized in the intestines by the action of bacteria, e.g., lactobacilli, lactococci, and lactobifidia. These beneficial bacteria are present in abundance in fresh unprocessed milk. Enzyme activity is generally maximized at body temperature.

Vitamins help control the metabolic processes. Milk provides many vitamins. Vitamins A and D are fatsoluble vitamins that work synergistically. Both are necessary for each to fulfill its nutritional tasks. They occur naturally together in milk. Vitamin D, essential for bone health, is associated with suppression of osteoporosis. Vitamin A is critical for immune function and the health of the eyes. Vitamin B-12 is found in animal foods. There is a significant amount of vitamin B-12 in milk. It plays a key role in folate metabolism, which prevents spina bifida in the developing fetus. B vitamins, especially niacin, are important for the normal functioning of many enzymes in the body and are involved in the metabolism of sugars and fatty acids.

Antioxidants can slow or even prevent cellular damage. Vitamins A & E and the mineral selenium are antioxidants that are present in milk in sufficient amounts to function appropriately. Selenium aids the body in manufacturing CoQ-10, (coenzyme) an enzyme that is specific for heart muscle health. Vitamin K-2 (menaquinone) is the form of the K vitamin found in milk. Mammals make K-2 from K-1 which is found in plants (phylloquinone) and it is also made by the bacteria that line the human gastrointestinal tract. Some studies indicate that Vitamin K helps in maintaining strong bones in the elderly. Calcium cannot be assimilated without vitamin K. Vitamin K also plays an important role in blood clotting.

Whole milk has a balance of nutrients that are provided in a convenient form that is adaptable to many uses, and for most people, pleasant to our taste. The nutritional value of milk is optimized by using whole, full-fat milk.
3. What are the additional benefits of milk fresh from the cow?

Milk fresh from the cow is a complete, living, functional food. Although we have looked at the numerous nutritional components of milk in the previous two questions, the full benefits of milk are only realized when all of these components function as a complex interdependent and balanced process. Included here are components that are not nutrients, although some do contribute to nutritional processes indirectly.

These components include:

**Enzymes**
Enzymes are specialized proteins produced in cells that link, break-up, or accelerate chemical reactions. They are considered catalysts because they are not consumed during the processes they control.

**Intrinsic (Indigenous) Enzymes in Milk**
There are many enzymes that exist naturally in fresh milk, these are called intrinsic enzymes. Some intrinsic enzymes actively participate in the breakdown of components of milk, others breakdown the products of other enzymatic activity, still others have antimicrobial, and/or antiviral activity. As an example, milk, as a complete and adequate food for the newborn calf, contains nearly all of the necessary enzymes to make milk bioavailable. Some enzymes in the newborn calf’s digestive tract are also active in making the components of milk bioavailable. The entire process is complex and designed to function as an integrated system. It is this integrated system that is so important to the newborn calf during the rapid, crucial, and elaborate development that occurs in the weeks after birth. During this time the newborn’s only intake is milk, providing the adequate amount of water, and supplemented with air.

A partial list of well-characterized intrinsic enzymes contained naturally in fresh milk includes:

- Acid Phosphatase
- Alkaline Phosphatases
- β-N-acetylglucosaminidase
- Esterases
- γ-Glutamyl transferase
- Lipoprotein Lipase
- Lysozymes
- Proteinases, including plasmin and cathepsin
- Superoxide dismutase
- Xanthine oxidase
- Amylase
- Catalase
- Glucose oxidase
- Glutathione peroxidase
- Lactoperoxidase
- Phospholipase
- Ribonuclease
- Sulphhydryl oxidase
- Xanthine oxidoreductas
- Aldolase
The enzymes found in milk can be large and complex such as catalase below:

Others like the lysozymes are small and simple:

*3D images are from the International Protein Database

Extrinsic Enzymes
Extrinsic Enzymes are enzymes that are made by microorganisms in milk, not produced by the mammary glands. These enzymes may be active in the milk or within the microorganisms themselves.

There are many such enzymes and they are very complex. Some of the specific enzymes are similar to those in the list of intrinsic enzymes. These enzymes are variable depending on which specific bacteria are present in the milk. For the most part these enzymes participate in the breakdown of milk components to enable utilization by the microorganisms, but they also participate in the processes of bioavailability in the intestinal tract.

Because this list of enzymes is so variable and extensive, it is not practical to list them here.

Immune System Enhancers
- Activation and enhancement of the innate immune system in newborns; these are nonspecific mechanisms that resist pathogens and toxins by interfering with their ability to cause infection.
- Triggering cell-mediated immune mechanisms; this system works by activating specific- response white blood cells to attack new and recurrent exposure to pathogens.
- Stimulation of specific immune reactions; this mechanism reacts in response to antigens by producing antibodies.
- Other specific immune active components: Compliment, Immunoglobulins (IgM, IgA, IgG) and Gamma Interferon
Cellular Elements
Bovine phagocytes and white blood cells in milk continue to be active within the digestive tract until they die, within days or weeks.

Many of the cellular elements measured in the Somatic Cell Count test of healthy cows are exfoliated lining cells that release lysozymes when they are killed in the gastrointestinal tract as a part of the normal digestive process. These lysozymes nonspecifically attack microorganisms.

Additional Antibacterial Components
Digestion produces free fatty acids with bactericidal (kill bacteria) effects (medium- and short-chain fatty acids).

- Bacteriocins- Nisin, colicins, etc. are produced by beneficial microorganisms. There is a growing list of bacteriocins; compounds with bactericidal or bacteriostatic (inhibits bacteria) activity produced by bacteria commonly found in fresh milk. Bacteriocins can be extremely specific or more general in their attack on other microorganisms.

- Mucins- Some pathogens rely on their ability to adhere to the intestinal cells in order to cause illness. Mucins are glycopolarns normally present on mucosal surfaces, including the intestines. The most studied mucin in milk is MUC1, which has been shown to adhere to bacteria and interfere with their ability to adhere to intestinal cells.

- Microorganisms that suppress pathogens by competitive mechanisms-
  - Compete for nutrients;
  - Compete for intestinal attachment sites necessary for some pathogens to produce illness;
  - Compete by limiting colonization of less robust microorganisms (this is also called competitive inhibition), such as pathogens.

- Lactoferrin-(iron binding glycoprotein that scavengers iron from the environment) - It has well documented bacteriostatic and bactericidal activity.

- Lactoperoxidase system- The system consists of the enzyme lactoperoxidase with cofactors, thiocyanate and hydrogen peroxide. The complete functional system is naturally present in fresh milk. This is a potent antimicrobial system approved internationally to preserve milk in locations where refrigeration is not practical by adding more of the two cofactors.

- Lysozymes- Different forms of this enzyme are present in all cells, in a sequestered location. When cells are damaged, their store of lysozymes is released. Lysozymes have broad and effective antibacterial activity. Lysozymes are present in free form in fresh milk and are also released from the breakdown of bovine cells present in the milk.

- Xanthine oxidoreductase- Besides its role in nutrition, this enzyme augments intestinal defenses against pathogens by producing several reactive byproducts.

Beneficial Microorganisms
There are large numbers of different bacteria present in fresh milk. Some of these are included in the Standard Plate Count test; others do not grow under those culture conditions and so are not counted as a part of the test. Both the total numbers and the diversity of bacterial types (genus and species) are variable. Most of these bacteria are beneficial. (Some people would characterize these as probiotics; however, in the ever-evolving definition of probiotics, this term is currently confined to products in which beneficial microorganisms are added. Therefore, we will describe them as beneficial bacteria.)
As mentioned above some of these beneficial bacteria have mechanisms for suppressing pathogens. A few of the best known beneficial bacteria in fresh milk include:

- **E. coli**  
  (the vast majority of *E. coli* is beneficial and naturally formed in our large intestines – the 0157:H7 sub-type is one of the rare exceptions)
- Lactococci
- Lactobacilli
- Bifidobacteria

There are numerous other, mostly anaerobic microorganisms, i.e., microorganisms that live without oxygen, that participate in the digestion of food and the assimilation of nutrients. Nearly all of these organisms enter milk from colonies that become established in the distal portions of the mammary gland passageways. It is probable that the specific genus and species vary between different cows, over time, and depending on the environment.

**Folate Binding Protein**  
Protein that assists in the uptake of Folate in the intestine.

**Vitamin-Cofactors, Promoters or Enablers**  
Some of the trace elements present in milk are essential to vitamin activity, such as carotenes.

**Prebiotics**  
Unlike probiotics, prebiotics are recognized as anything that promotes the growth and activity of beneficial microorganisms. Therefore, milk is inherently a prebiotic since it contains lactose and numerous other components that beneficial bacteria can utilize. One specific prebiotic factor present in fresh milk is lactoferrin, which interestingly is well known as an antibacterial agent, but it also promotes the growth of bifidobacteria.

**Hormones**  
These are nearly all specifically bovine hormones, but there is evidence that they exert some influence prior to their inactivation. The amount of each of these hormones tends to vary during the normal reproductive cycling of the cow, as well as by the seasons of the year. The more common hormones include:

- Bovine growth hormone
- Bovine estrogens
- Bovine calcitonin
- Insulin-like growth factor-1 (IGF-1)
- Bovine prolactin
- Bovine thyroid stimulating hormone

**Vitamin B-12**  
There is a significant amount of vitamin B-12 in fresh milk. This vitamin is not present in plant foods and is a key to Folate metabolism.
Trace Minerals
Specific trace elements are necessary as cofactors for many critical enzymes. The presence and amount of trace minerals is a function of dietary intake of the milk-producing animal. Essential trace minerals in milk include:
Iron, copper, zinc, manganese, cobalt, iodine, chromium, selenium, and molybdenum.

Others
- Freshness- Freshness provides enhanced ability to produce products from milk such as:
  - Cream, Butter, Ghee (Indian clarified butter)
  - Curds & Whey products, e.g., soft cheeses
  - Cultured products such as cheeses, kefir, yogurt, cultured butter and crème fraîche, etc.
    - Some of these rely on microorganisms and communities of microorganisms present in fresh milk that participate in the natural culturing of milk under controlled conditions.
    - Others are produced by using starters, such as for specific cheeses. These starters work best in milk that is less than two days old.
- Taste- Taste is rated high on beneficial values of fresh milk. It is naturally variable, mostly a function of feed, including types of forage, other added foods, and the animal breed. Seasonal variation is particularly noticeable. Geographic location is often responsible for specific, much sought-after tastes.
- Viscosity/Body- Important beneficial value, influenced by the fat content, aggregation of fats and the interactions of proteins.
- Color- Variable depending on the fat content and the nature of forage, particularly on the amount of fresh, rapidly growing grasses.
- Lactoferrin- Included above as an antibacterial property. Its ability to accumulate bioavailable iron is also a benefit.
- Overcoming the symptoms of lactose intolerance- Many people with professionally diagnosed lactose intolerance do not have the symptoms of this condition, even when consuming large amounts of fresh milk.
- Enhancement of mother's breast milk quality by including fresh milk in her diet.
- Fibrinolysis system components- Particularly important in the newborn whose systems for combating inappropriate clotting have not developed fully.
- Reduction in asthma and allergic rhinitis- Numerous well-controlled studies have shown the independent effect of drinking fresh milk on reducing asthma and childhood rhinitis in general and specifically in childhood allergic rhinitis.
- Beneficial in some autistic children
- Anti-stiffness/Anti-arthritis factor- Wurzen factor found in butter fat.
- Risk Reduction of Metabolic Syndrome- Increasing the consumption of milk and other dairy products may reduce metabolic syndrome (MetS) – report states that drinking a pint of milk daily was associated with a 62% reduction of risk for MetS.
- Medical treatments using fresh milk- The “Raw milk diet” has a 150-year history. It was used in the Mayo Clinic and by others and is currently practiced in Europe.
- Functional Medicine- the increasing use of prebiotics, probiotics and fresh milk to treat a variety of intestinal disorders.

- Intact milk fat globules are surrounded by a lipoprotein membrane. This membrane maintains the globule, resists metabolism and contains some of the enzymes and beneficial factors listed above.

4. What is the impact of pasteurization on fresh unprocessed whole milk’s value?
(Refer to Question 1. What is the nutritional value of milk? Question 2. Going beyond the Nutrition Fact Label, and Question 3. What are the additional benefits of milk fresh from the cow?)

Pasteurization is defined in the 2007 Grade “A” Pasteurized Milk Ordinance (PMO) as follows: The terms “pasteurization”, “pasteurized” and similar terms shall mean the process of heating every particle of milk or milk product, in properly designed and operated equipment, to one (1) of the temperatures given in the following chart and held continuously at or above that temperature for at least the corresponding specified time:

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>63°C (145°F)</td>
<td>30 minutes</td>
</tr>
<tr>
<td>72°C (161°F)</td>
<td>15 seconds</td>
</tr>
<tr>
<td>89°C (191°F)</td>
<td>1.0 second</td>
</tr>
<tr>
<td>90°C (194°F)</td>
<td>0.5 seconds</td>
</tr>
<tr>
<td>94°C (201°F)</td>
<td>0.1 seconds</td>
</tr>
<tr>
<td>96°C (204°F)</td>
<td>0.05 seconds</td>
</tr>
<tr>
<td>100°C (212°F)</td>
<td>0.01 seconds</td>
</tr>
</tbody>
</table>

The term “Ultra-Pasteurization”, when used to describe a dairy product means that such product shall have been thermally processed at or above 138°C (280°F) for at least two (2) seconds, either before or after packaging, so as to produce a product, which has an extended shelf-life under refrigerated conditions.  (Refer to Code of Federal Regulations – 21CFR 131.3)

In addition to these time and temperature requirements for heating milk and milk products, the PMO requires that the equipment used to pasteurize and ultrapasteurize milk be properly designed, operated and tested. These requirements are specified in PMO Item 16p, Appendix H and Appendix I. All effects of pasteurization are variable dependent on temperature and time. There are many standards for pasteurization depending on the product being produced and the intended qualities of the end product. Also, the components of milk differ greatly, and making different dairy products requires different levels of heat treatment and protein denaturation.

Impact on Proteins
Proteins are incrementally denatured by heat. With lower heat treatment levels, complex proteins with three-dimensional configuration are altered. With higher heat treatment levels, the primary shape and bonds are altered. At very high heat levels, there are destructive chemical changes.

The casein proteins themselves have been shown to be relatively heat stable. However, the actual bioavailability of the casein proteins is far more complicated. There are a large number of different
casein proteins (as many as 1,000). These are “packaged” in the large and complex physical structure, the micelle. Individual micelles contain a variable mixture of these different caseins. The micelle functions as a reservoir of nutritionally important proteins, and all of the essential amino acids that combine to make up the different caseins, in a structure that is critical in the physical properties of milk, altering the enzymatic digestion of the proteins and affecting the movement through the intestine. The food industry is well aware that casein micelles are altered within the range of pasteurization time and temperatures such that they alter the way milk behaves when used to produce a variety of dairy products. Furthermore, the micelles contain both calcium and phosphorus, internalized in association with the proteins in specific concentrations and in physical forms that facilitate availability during digestion. It is well recognized that heating milk in the range of pasteurization alters the physical properties of the micelles. With heating, the whey proteins become bound to the micelles.

Whey proteins denature more readily, particularly the immunoglobulins.

**Impact on Carbohydrates**
Lactose does undergo the Maillard reaction, the chemical binding of sugar to protein also commonly called the browning effect, which is progressive as temperature is increased. This affects color and taste.

**Impact on Fats**
This is complex because changes to the fat globules, specifically the membranes, are caused by both heat and homogenization. Of all the milk constituents, the milk fat globule is the most drastically altered by the combination of pasteurization and homogenization.

**Impact on Minerals**
The minerals themselves are not affected by heat. However, what they are bound to is. For example, calcium and phosphorus are contained within the structure of the micelles, and thus, their intestinal absorption is affected by the heat treatment level.
### Table – Impact of Heat, Temperature and Time

The table below summarizes broadly and in a qualitative manner the impact of heat, temperature and time on the various nutritional components of fresh unprocessed whole milk. (Refer to Topic Two, Question 3. What are the additional benefits of milk fresh from the cow?)

<table>
<thead>
<tr>
<th>NAME</th>
<th>EFFECTS OF HEAT, TEMPERATURE AND TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intrinsic Enzymes</strong></td>
<td>Some inactivation: Inactivation levels are extremely variable from total inactivation (alkaline phosphatase) to almost no effect (lysozymes).</td>
</tr>
<tr>
<td><strong>Extrinsic Enzymes</strong></td>
<td>Most bacteria are killed, so are not available as sources of extrinsic enzymes. More complex, as killing bacteria through heat doesn’t necessarily eliminate all enzymes.</td>
</tr>
<tr>
<td><strong>Immune System Enhancers Activation and enhancement of newborn innate immune system</strong></td>
<td>To the extent that pasteurization kills most bacteria, they would not be present to trigger a newborn infant’s innate immunity system.</td>
</tr>
<tr>
<td><strong>Triggering cell-mediated immune mechanisms</strong></td>
<td>Killed Cell-mediated immune mechanisms rely on living somatic cells, but pasteurization kills those cells, losing that effect.</td>
</tr>
<tr>
<td><strong>Stimulation of immune reactions</strong></td>
<td>Some denaturation Heat dentures protein in immunoglobulin’s, so they lose their ability to stimulate immune reactions.</td>
</tr>
<tr>
<td><strong>Other specific immune components</strong></td>
<td>Variable All components are affected differently because they are chemically very different.</td>
</tr>
<tr>
<td><strong>Cellular Elements</strong></td>
<td>Killed All living somatic cells, including bovine phagocytes and white blood cells, are killed by pasteurization.</td>
</tr>
<tr>
<td><strong>Additional Antibacterial Components</strong></td>
<td>Variable effects Class of bacteriocins are removed, since the bacteria that produce them are killed. Mucins may be affected.</td>
</tr>
<tr>
<td><strong>Bacteriocins</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Mucins</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Microorganisms</strong></td>
<td>Mostly killed</td>
</tr>
<tr>
<td><strong>Lactoferrin</strong></td>
<td>Some denaturation</td>
</tr>
<tr>
<td><strong>Lactoperoxidase System</strong></td>
<td>System rendered ineffective The enzyme itself isn’t particularly affected, but it doesn’t work without its cofactors, thiocyanate and hydrogen peroxide, making the system ineffective.</td>
</tr>
<tr>
<td><strong>Lysozymes</strong></td>
<td>Little to no effect Lysozymes are heat resistant, but killing bacteria and cells release lysozymes, increase the amounts overall.</td>
</tr>
<tr>
<td><strong>Xanthine oxidoreductase</strong></td>
<td>Activity is reduced Due to damage of the cellular membrane</td>
</tr>
<tr>
<td><strong>Beneficial Organisms</strong></td>
<td>Mostly killed</td>
</tr>
<tr>
<td><strong>Pathogenic Organisms</strong></td>
<td>Mostly killed</td>
</tr>
</tbody>
</table>

---

Michigan Fresh Unprocessed Whole Milk Workgroup REPORT 2012

24
<table>
<thead>
<tr>
<th>NAME</th>
<th>EFFECTS OF HEAT, TEMPERATURE AND TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Folate Binding Protein</td>
<td>Folate utilization reduced</td>
</tr>
<tr>
<td></td>
<td>Folate itself is not particularly affected, but the protein that assists in uptake is denatured by heat.</td>
</tr>
<tr>
<td>Vitamin-Cofactors, Promoters or Enablers</td>
<td>Variable</td>
</tr>
<tr>
<td></td>
<td>Amount of trace elements are not particularly affected by heat, but other cofactors may be.</td>
</tr>
<tr>
<td>Prebiotics</td>
<td>Value diminished</td>
</tr>
<tr>
<td>Hormones</td>
<td>The Workgroup has not found any available data on the affect of heat and time on hormones in milk.</td>
</tr>
<tr>
<td>Vitamin B-12</td>
<td>The Workgroup is not aware of any effects.</td>
</tr>
<tr>
<td>Trace Minerals</td>
<td>The Workgroup is not aware of any effects.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OTHER ATTRIBUTES</th>
<th>EFFECTS OF HEAT, TEMPERATURE AND TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taste, Viscosity/Body, and Color</td>
<td>Affected</td>
</tr>
<tr>
<td>Lactose Intolerance</td>
<td>Heating does not affect the level of lactose in milk.</td>
</tr>
<tr>
<td></td>
<td>Although there are reports that many people with lactose intolerance do not experience symptoms when drinking fresh unprocessed whole milk, the Workgroup does not know if this affect is the result of pasteurization</td>
</tr>
<tr>
<td>Fibrinolysis</td>
<td>The Workgroup is unaware of any effects.</td>
</tr>
<tr>
<td>Enhancement of Mother's Breast Milk from Drinking Milk</td>
<td>The Workgroup does not have available information or studies on the affect of pasteurized milk a mother is consuming on the nutritional value of her breast milk.</td>
</tr>
<tr>
<td>Asthma and Allergic Rhinitis</td>
<td>The reduction of asthma and allergic rhinitis in children when raw milk is consumed is well documented. However, studies have not specifically determined if this is the affect of heating or of some other difference between FUW milk and commercial pasteurized milk.</td>
</tr>
<tr>
<td>Autism</td>
<td>The Workgroup does not know what the cause is or if applying heat and time to milk affects autism.</td>
</tr>
<tr>
<td>Arthritis</td>
<td>The Workgroup does not know what the cause is or if applying heat and time to milk affects arthritis.</td>
</tr>
<tr>
<td>Risk Reduction of Metabolic Syndrome</td>
<td>The Workgroup does not know what the cause is or if applying heat and time to milk affects these.</td>
</tr>
<tr>
<td>Medical Treatments</td>
<td>The Workgroup does not know what the cause is or if applying heat and time to milk affects these.</td>
</tr>
<tr>
<td>Functional Medicine</td>
<td>Beneficial bacteria are reduced by heat, so prebiotics and probiotics are affected.</td>
</tr>
<tr>
<td>Intact Milk Fat Globules</td>
<td>Some denaturation of the milk fat globule membranes</td>
</tr>
</tbody>
</table>
5. What is the impact of homogenization on fresh unprocessed whole milk’s value?

The purpose of homogenization is to decrease the size of the fat globules to prevent a creamline and create a more uniform product. Fat globules are decreased by mechanical disruption.

Homogenization became standard practice because it made fluid milk easier to standardize and removed the creamline as a marketing property. In practice, homogenization is not performed without pasteurization because homogenized milk becomes rancid rapidly.

Homogenization is a physical action that substantially reduces the size of the milk fat globules. In the process, the complex lipoprotein membrane that surrounds the native fat globules is disrupted. This membrane is biologically active, containing many enzymes and a variety of active protein and mucin molecules. One of the critical functions of the membrane is to protect the internal fats from premature digestion. The smaller globules become enveloped by other proteins because the surface area is considerably increased as the globules are reduced in size, and there is not enough of the fragmented native membrane to complete the coating. The substituted proteins (mostly caseins) are not as effective in protecting the contained fats.

6. Assuming that all milk is not the same, what do production and management practice have to do with fresh unprocessed whole milk’s nutritional value, pathogens, color, taste, etc.?

Healthy Cows Provide Quality Milk

Pasture-Based Production Practices

There is evidence that properly managed pasture-based production practices improve the quality of milk. For example, cows that are pasture-based on primarily mixed grasses produce milk that is higher in CLA, beta-carotene, and fatty acids. A diverse grass/clover mix is best, and it does make a difference what types of grass mixes are used and how the pasture is managed. When cows are not on pasture, the fatty acids and vitamins in the milk decrease. A mixture of hay and fibrous grains are good winter feed for animals that are otherwise pastured. Whereas younger grasses have a higher protein content and produce more CLAs, more mature grasses provide more minerals important to reproductive health. A rule of thumb for animals in Michigan is one cow per acre of pasture. Thus, pastures must be managed carefully and actively, and with an eye to long term sustainability to produce high quality milk.

Feeds and Grains

The content of feed, and changes in feeding, affect taste and color of milk. Proper management of fermented feeds reduces animal health risks.

Soil Quality

Soil and manure management practices have an effect on nutrient availability in soils, which, in turn, has an effect on the nutrient composition of grasses and other feeds. This affects the nutritional quality of milk such as CLA, beta-carotene, and fatty acids. Additionally, the way soil and manure are managed has an effect on plant composition, soil microflora and the presence of plant disease- causing organisms in the soil. All of which affect the nutrient value of the feed that the cows consume, and hence, the health of the cows.

Organic matter with appropriate humus content is an essential component of a healthy soil system. Building the system depends on the quality of the humus in the soil and the practices of application of manure or other organic matter sources over time. Decomposition in these systems relies on aerobic
activity, which converts organic matter into humus. Soils that are building organic matter tend to have more beneficial organisms, which help build beneficial soil microflora.

While anaerobic liquid manure systems are prevalent on dairy farms in Michigan, aerobic systems appear to produce manure that is more complimentary to soil quality. Key nutrients such as nitrogen (N) and potassium (K), are more easily managed in aerobic and grazing systems. These nutrients must be managed via application rates; too much of these two nutrients will cause an overfeeding of the plants, and thus disrupting plant metabolism and hence, the nutritional value to the cows.

Variation is part of the value of fresh unprocessed whole milk
The taste/flavor and color of milk naturally varies according to breed of animal and what they are fed. These variations can be affected by farm management practices, which consumers of FUW milk accept and appreciate.

- Whole milk has higher butterfat content. Fat plays the primary role in carrying flavors of milk. A satisfying and pleasant richness is a characteristic of FUW milk. The more frequently a cow is milked, the lower the fat content per milking.
- Temporary variations in the taste of milk can also occur with a change of seasons and feeding patterns. There can be incidental unpleasant tastes resulting when a cow eats certain weeds (e.g. wild mustard garlic and wild onions) just before milking or when she is sick or in the very late part of her lactation cycle. Odors in cow housing and milking environments can cause off-flavors in the milk.
- The color of the milk changes noticeably in the spring when cows are primarily eating green growing grass, and becomes cream-colored because of the increased levels of beta carotene in the butterfat.

7. What is the impact of consumer preferences on production and management practices of fresh unprocessed whole milk?
In a system in which consumers interact directly with the dairy farmer, some farm management choices are influenced by special consumer demands. There is no defined set of standards, however, based on discussions with Michigan consumers and farmers providing FUW milk done by the MI Fresh Milk Council, there are some common preferences:

- They want the way the farm is managed to be dedicated to production of milk intended to be consumed without processing, and farmers that welcome inspection of their operations
- They want the cows to have free access to pasture, not raised and maintained in confinement
- They want the cows fed forage, preferably pastured on grasses
- They want the milk to be in a fresh natural state without processing, e.g., unpasteurized, not homogenized, and with nothing removed and nothing added
- They expect high butterfat content
- They want the animals to be well cared for
- They specifically do not want feed that includes genetically engineered crop products, any soy, or by-products like brewer grain, beet pulp, or cotton seed
- They do not want any pharmaceuticals used to enhance milk production
- They prefer no use on the farm of chemical fertilizers, herbicides or pesticides
- They are willing to pay for quality
- They are willing to go out of their way to get the milk
References

This is the full link to the Haug article used in all of Topic Two -- Values and Benefits

Question 1: What is the nutritional value of milk?

- "Comparison of Nutritional Content of Various Milks" David B. Fankhauser, PhD, Professor University of Cincinnati, Cincinnati, Ohio
  http://biology.clc.uc.edu/fankhauser/Cheese/milk_content.htm
- "Daily Values – A guide for Nutrient Labeling", University of Texas
  http://www.utexas.edu/courses/ntr311/nutinfo.dvalues.html
- Dietary Supplement Fact Sheet: Calcium" (Chart) 2005
  The National Institutes of Health Office of Dietary Supplements
- "Calcium and Milk" 2004
  Harvard University School of Public Health
- "Nutrition Information – Whole Milk" Chart
  http://www.nutritiondata.com/facts
- Dairy Chemistry and Physics” Douglas Goff, PhD, Professor of Food Science, University of Guelph, Toronto, Canada
  http://www.foodsci.uoguelph.ca/dairyedu/chem.html http://www.foodsci.uoguelph.ca/dairyedu/chem.html
- "Building Strong Bones: Calcium Information for Health Care Providers”
  The National Institute of Child Health and Human Development (NICHD)
- "Milk's Unique Nutrient Package", The National Dairy Council

Books

- MILK Its Remarkable Contribution to Human Health and Well-Being by Stuart Patton, PhD, Professor Emeritus, Food Science, Pennsylvania State University, Transaction Publisher, NJ 2004
- On Food and Cooking, the Science and Lore of the Kitchen by Harold McGee, Chapter 1. Milk and Dairy Products, Scribner, NY, 2004
  http://www.curiouscook.com

Question 2: Going beyond the Nutrition Facts Label — What other nutritional values should we be considering?

- "Bovine milk in human nutrition – a review”
  Table 1: Additional nutrients in milk and their main health effects, Anna Haug, et al
- Nutrient Values and Weight – Milk, whole 3.5% milk fat (chart), USDA
  www.nal.usda.gov/fnic/foodcomp/cgi-bin/list_nut_edit.pl
- “Protein Content of Milk” Journal of Dairy Science, Vol. 82 No. 6, 1115–1117, The American Dairy Science Association

Books

- The Family Cow by Dirk van Loon, Storey Books
- Keeping a Family Cow by Joann S. Grohman, Coburn Press

Michigan Fresh Unprocessed Whole Milk Workgroup REPORT 2012

28
Question 3: What are the additional benefits of milk fresh from the cow?

**Enzymes:**

**Mucin:**

**Trace Minerals:**

**Allergies & Asthma:**
- "Which aspects of the farming lifestyle explain the inverse association with childhood allergy?" By Michael R. Perkin, MSc and David P. Strachan, MD, Division of Community Health Sciences of St George's University of London, London, UK Journal Allergy Clinical Immunology 2006; 117:1374–81
- "Unpasteurized milk: health or hazard?” By M. R. Perkin, Division of Community Health Sciences of St George’s University of London, London, UK Clinical and Experimental Allergy, 2007; 37, 6227–630
- "Inverse association of farm milk consumption with asthma and allergy in rural and suburban populations across Europe” The PARSIFAL study group (European Union grant) Journal compilation © 2006 Blackwell Publishing Ltd, Clinical and Experimental Allergy, 37:661 670

**Metabolic Syndrome:**

**Questions 4, 5: What is the impact of pasteurization on fresh unprocessed whole milk’s value?**

**What is the impact of homogenization on fresh unprocessed whole milk’s value?**
- Interview with Dr. John Partridge, Professor at Michigan State University (MSU) Food Science & Human Nutrition

**Question 6: Assuming that all milk is not the same, what do production and management practice have to do with fresh unprocessed whole milk’s nutritional value, pathogens, color, taste, etc.?**
- Interview with Edwin Blosser, Midwest Bio-Systems
- Interview with Dr. George Bird, Professor of Entomology at MSU
- Interview with Joe Scrimger, Bio-Systems
- Interview with Warnke Family, Warnke's Emerald Acres Farm
- "Outbreaks assoc with unpasteurized milk and soft cheese: an overview of consumer safety", Food Protection Trends April 2009

**Question 7: What is the impact of consumer preferences on production and management practices of fresh unprocessed whole milk?**
- **Safe Handling – Consumers' Guide - Preserving the Quality of Fresh, Unprocessed Whole Milk by Peggy Beals, RN**
Topic Three

Risks

1. What are the risks for fresh unprocessed whole milk, including all types of risks, such as adverse consequences, intolerance and allergens?

2. Where do these risks originate?
Summary
Approved August 23, 2011

Topic Three – Risks

Introduction
The workgroup follows a set of Topics and within each Topic a set of questions. For Topic Three -- Risk, the workgroup combined Question 1. What are the risks for fresh unprocessed whole milk, including all types of risks, such as pathogens, adverse consequences, intolerance and allergens with Question 2. Where do these risks originate?

They reviewed each of the four (4) groups of bacteria that are considered important causes of current foodborne illnesses in this country: Campylobacter jejuni, Listeria monocytogenes, Salmonella and the O157:H7 subtype of Escherichia. coli. They also reviewed the bacteria that cause human illnesses that dominated the public health concerns in the past. And they reviewed information on noninfectious adverse reactions to milk.

The summary includes the following sections:

- for each of the four pathogens a Milkborne Bacterial Human Pathogen Summary
  (outlining a description, types of diseases in animals and humans and information on outbreaks)

- for each of the four pathogens a Scenario for transmission to people
  (which systematically outline patterns of spread of illness with emphasis on routes of transmission that pertain to milk consumption)

- A discussion of Infectious Dose

- A narrative on the Illnesses of Historical Interest

- A discussion of the Categories of Risk Other Than Infectious Disease for People Consuming Fresh Unprocessed Whole Milk (FUW Milk)

- A Table of Terms
  Recognizing that some of the terms in these documents of Topic Three might need explanation, the workgroup developed a Table of Terms, with a description (not dictionary definitions) to help the reader understand the terms as they are used in the context of the Summary on Risk. For the readers’ convenience the terms in the Table of Terms are highlighted in grey at their first use in each section. The Table of Terms begins on page 67.

---

Milkborne Bacterial Human Pathogen Summaries

*Campylobacter jejuni*

**Scientific Name:** genus: Campylobacter  species: jejuni  abbreviated: C. jejuni

**Recognized Subtypes within the species:**
There are several commonly used systems of subtyping with from 60 to 100 recognized subtypes using these different techniques. [1] [2] [3]

**General**
- Gram negative, rod shaped, motile bacterium. Only natural habitat is the intestinal tract of many warm blooded animals. But is widespread in the natural environment when persistent animal fecal contamination occurs. Also common as a transient contaminant in home kitchens, water and food manufacturing facilities.
- Easily cultured and detected when present in large numbers (such as in human diarrhea specimens). However, it is specifically difficult to culture from unpasteurized milk because of the multiple conditions listed below.
- Conditions that promote growth/survival: Optimal growth is within living cells. Growth is optimal at 108°F. Survive best in warm wet conditions.
- Conditions that inhibit growth/survival: Generally described as “fragile”, this bacteria is sensitive to air (oxygen), drying, acidic environments and grows poorly, if at all, at room temperatures and does not grow well outside of warm blooded animal hosts. Does not compete well with other bacteria and usually isolation techniques require inhibiting those other bacteria. The numbers decline over time in unprocessed milk; particularly when refrigerated or exposed to air. Unprocessed milk with other bacteria tends to become acidic because of the growth of the other bacteria. Specific research on fate of *Campylobacter jejuni* isolated from human cases inoculated into unpasteurized milk under laboratory conditions, documented inactivation over several days. [4]

**Disease Description**

**Animals**
Present in healthy birds and other animal intestines (carrier state) but rarely causes disease.

**Humans**
- Acute gastroenteritis with diarrhea categorized as campylobacteriosis. Nearly all human infections are from *C. jejuni*, but a few are from *C. coli*.
- The most common foodborne illness in the US with two million cases per year (1 illness per 150 people each year).
- Interval from consumption to symptoms is 3-5 days. Illness is usually self-limiting (get well without antibiotics) lasting for 3-12 days. However, in untreated cases individuals may continue to shed infectious bacteria for 7 weeks. A true persistent carrier state (colonizing in intestine without illness) in humans is rare.
- Because of huge numbers of bacteria present in diarrhea, culturing in the medical laboratory is a practical means of making the diagnosis.
- There are at least four virulence steps necessary for human illness (1. adheres to intestinal cells, 2. grows in the intestine, 3. enters the cell and proliferates, and 4. produces toxin).
- During 2009 there were 911 reported cases of campylobacter gastroenteritis in Michigan. Frequency of illnesses in humans is seasonal, highest in June, July and August.
Category of Human Disease

- Causes acute enteritis with nausea, abdominal cramps, severe diarrhea which may be bloody and mild fever
- Infectious dose: from 500 to 10,000 virulent bacteria depending on foods consumed and health of the person
- Immunity results from frequent direct contact with farm animals

Complications of Human Infection

Rare; a form of Guillian-Barre Syndrome occurs in about 1 out of 1,000 human cases of campylobacteriosis. This inflammatory neurologic syndrome has been associated with a number of other viral and bacterial infections.

Reservoir (potential source)

- Humans with campylobacter enteritis shed 1,000,000 bacteria per gram of diarrhea
- All warm blooded animals, particularly birds, become exposed in infancy and persist as carriers of campylobacter in their intestines throughout life
- Chickens shed 1,000,000 or more colony-forming-units per gram (cfu/gram) [5]
- Water, contaminated from animal manure
- Cows whose intestines are temporarily colonized with C. jejuni shed comparatively low numbers in feces [6]
- Shedding directly from an infection into the milk does not occur
- A study in rural Michigan found that poultry husbandry carried the greatest risk of human campylobacter enteritis [7]

Food Implicated in Outbreaks

Surveys show that 20-100% of retail chicken packages are contaminated. It is estimated that one drop of fluid from fresh packaged chicken contains an infectious dose.

Outbreaks

Most campylobacter foodborne outbreaks are limited to a few cases of illness; however some outbreaks from contaminated water supplies have sickened thousands.

- Fresh unprocessed whole milk USA 1999-2011 [8] – Total 383 illnesses (average 31.9 per year)
- For all foods, estimated annual illnesses from Campylobacter spp. in the USA, based on data collected in 2006-2008 [9] – 845,024
Numbered Specific References

Unless referenced separately most of the comments are from the FDA “Bad Bug Book” Foodborne Pathogenic Microorganisms and Natural Toxins Handbook.
www.cfsan.fda.gov/~mow/chap1.html


[8] Illnesses enumerated for outbreaks were obtained from a comprehensive listing of incidents with official reports for the period, January 1, 1999 to March 30, 2011. All incidents were entered into the database from news releases and public reports from national and state agencies, media articles, published listings from public interest groups and litigation websites, scientific publications, as well as from personal information. Numbers displayed in the Pathogen Summary documents include both confirmed and presumed illnesses given in final reports without any evaluation of the way the officials made their determination. There is no judgment on the manner of the investigation nor on the strength of the conclusions. Only incidents within the USA were included, and only when the investigation specified consumption of fluid fresh unprocessed milk as the presumed source. Both cow and goat dairies that were specifically operated for the purpose of supplying fresh unprocessed milk to consumers were included.

Listeria monocytogenes

Scientific Name: **genus:** listeria  **species:** monocytogenes  **abbreviated:** L. monocytogenes

**General**
Gram positive, motile, small rod shaped bacterium. This organism is widely found in nature. In nature it multiplies under a broad range of conditions including -2 to 80°F, and in the presence or absence of oxygen. It is capable of survival over long intervals and under adverse conditions. Its ability to multiply and survive under adverse conditions (particularly refrigeration) gives it a competitive advantage. However, growth is very slow with a doubling time of 1-2 days at 39°F. Some strains are able to form biofilms. Strains are remarkably stable; one persisted in a processing plant for 12 years.

In addition to its presence in the environment some subtypes are capable of entering living animal cells and altering their growth requirements thus enabling them to rapidly multiply and spread between cells resulting in illness.

**Recognized Virulent Subtypes within the species**
This is an extremely well studied and complex organism. There are more than 13 documented serotypes using the H (flagellar) and O (somatic) characteristics. The commonly used serotyping (1/2a, 1/2b, 1/2c, 3a etc.) are based on “O” antigens. Three lineages have been used to categorize this species; each with different patterns of serotypes and characteristic environmental niches.

<table>
<thead>
<tr>
<th>Lineage</th>
<th>Isolates Primarily From:</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Human Illness</td>
</tr>
<tr>
<td>II</td>
<td>Foods &amp; non-humans illness</td>
</tr>
<tr>
<td>III</td>
<td>Animal &amp; some human illnesses</td>
</tr>
</tbody>
</table>

Most human illnesses are associated with the serotypes 1/2a, 1/2b and 4b. [1]

**Disease Description**
Perhaps best understood as an accidental pathogen in humans but primarily a source of disease in a large number of non-human animals. [2]

**Humans**
There are several different disease patterns. Within individual outbreaks there is a dominant pattern.

**Disease patterns:**
1. **Systemic:** Spreads to organs in the body. In these cases the virulent pathogen circulates in the blood (bacteremia). The most common locations for organ infections are: brain, liver and the pregnant uterus. These illnesses tend to be severe, hospitalization and mortality common.

2. **Perinatal illnesses:** The pregnant woman may have only a mild gastroenteritis or flu-like episode. However, if bacteria enter the blood stream, infection during pregnancy is most likely localized in the uterus; resulting in disease in the embryo, placenta, or newborn. The transmitted disease is often severe with high mortality.

3. **Gastroenteritis:** Mild, self-limiting illness.
- The infectious dose is extremely variable, ranging from 100 to 1,000,000 or higher bacteria. [1] It is believed that many people (and animals) are occasionally exposed, some with very high doses, without evidence of illness. The incubation period in human illnesses varies from several days to many weeks.

- 98% of human illnesses are with serovars 1/2a, 1/2b and 4b

- The most common serotype virulent in humans with systemic listeriosis is 4b; the most associated with gastroenteritis is 1/2a.

- There are widely spaced outbreaks with many ill people; suggesting that there are epidemic clones.

- Most human cases, not related to pregnancy, are in adults and are acquired by ingestion of contaminated food. Only 7% of cases occur in the healthy general public. The other cases have an underlying immunocompromizing condition (cancer, HIV/AIDS, immunosuppressant medications). Spread between humans is uncommon.

- Although of public health importance, “it appears that L. monocytogenes represents an opportunistic human pathogen and that human infections are likely to contribute little if anything to the ecological success or dispersal of L. monocytogenes.” [2]

---

### Classification of Illness Caused by *Listeria monocytogenes*

<table>
<thead>
<tr>
<th>Type of Illness</th>
<th>Mode of Transmission</th>
<th>Infections Dose</th>
<th>Severity</th>
<th>Incubation Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin Infection</td>
<td>Direct physical contact</td>
<td>Very High</td>
<td>Mild Self-limiting</td>
<td>Several Days</td>
</tr>
<tr>
<td>Neonatal Infection</td>
<td>Direct contact between mother and newborns, or other infected newborn</td>
<td>Unknown</td>
<td>Severe, usually central nervous system and frequently death</td>
<td>1-12 days</td>
</tr>
<tr>
<td>Pregnant Women</td>
<td>Foodborne</td>
<td>High</td>
<td>Mild flu-like symptoms or mild gastroenteritis; but consequences to fetus or newborn is usually severe</td>
<td>Unknown</td>
</tr>
<tr>
<td>Non-pregnant adults</td>
<td>Foodborne</td>
<td>High</td>
<td>Mild, but rarely can be severe with hospitalization for systemic disease. May lead to death</td>
<td>1 day to months Mostly 3 to 4 weeks</td>
</tr>
<tr>
<td>Gastroenteritis</td>
<td>Foodborne</td>
<td>Extremely High (10,000,000 organisms)</td>
<td>Vomiting, diarrhea, fever often mild and self-limiting</td>
<td>1 or more days</td>
</tr>
</tbody>
</table>
Animals
Predominately in ruminant animals (sheep, cattle, goats and occasionally pigs) but also in non-ruminants, birds, fish and reptiles. The pattern of diseases is very similar to those described above for humans. Except that in domestic ruminants, infection may spread through the herd and can be severe. Manure from cattle with listeriosis (circling disease) and from infected products-of-abortion contain very high concentrations of L. monocytogenes. And as with humans, there is evidence that animals may be exposed without illness. Transient colonization is common. Incidence in cattle is reducing, generally attributed to awareness of risk from poorly managed silage (containing as many as 1,000,000 organisms per gram) as a major source of listeriosis.

Category of Pathogen – For all Animals

- Causing acute enteritis with nausea, abdominal cramps, and mild diarrhea.
- Causing systemic diseases localizing predominately in the liver, brain, and pregnant uterus.
- Uterine infections in pregnancy resulting in infections of the embryo or newborn.

Complications of Human Infection
Hospitalization with the systemic disease is common. Death rate following systemic infections is high.

Reservoir
Widely found in the environment and animals. Has a competitive advantage in salty or cold environments. Although much is known about the growth and survival in various ecosystems, transmission and principle sources are poorly understood, perhaps because it has developed different mechanisms in different systems. It appears that Listeria monocytogenes represents an opportunistic human pathogen and that human infections are likely to contribute little if anything to the ecological success or dispersal of Listeria monocytogenes.
Foods Implicated in Human Outbreaks

Fresh, undamaged or unprocessed foods do not support the growth of this organism.

By all measures, ready-to-eat meats (such as deli meats) are the most frequently associated with outbreaks. Contamination in these products occurs in the processing plant environment, including the processing equipment. Because of the association with processing environments, the list of implicated foods is very long including processed meats such as pâté, salami, hot dogs, processed fish, cheeses, processed vegetables and salads. Specific foods associated with outbreaks are related to trends in food consumption and processing rather than to the individual foods themselves.

Foodborne human illness is mostly associated with those processed foods which ordinarily have a long self-life at refrigerated temperatures.

Outbreaks for Listeria monocytogenes:

- Fresh unprocessed whole milk USA 1999-2011 [4] – 0 illnesses
- For all foods, estimated annual illnesses from Listeria monocytogenes in the USA based on data collected in 2006-2008 [5] – 1,591

General References

FDA Bad Bug Book Foodborne Pathogenic Microorganisms and Natural Toxins Handbook
http://www.fda.gov/food/foodsafety/foodborneillness/foodborneillnessfoodborneopathogensnaturaltoxins/badbugbook/ucm070064.htm

Advisory Committee on the Microbiological Safety of Food’s Draft Report on Increased Incidence of Listeriosis in the UK, 2008

Epidemiological and Experimental Studies of Listeria Infection, with special reference to fecal excretion in ruminants, contamination of raw milk, presence in silage and growth at low temperatures, Jaana Husu, [Definitive thesis and associated published articles; Helsinki, 1990]


Numbered Specific References


[4] Illnesses enumerated for outbreaks were obtained from a comprehensive listing of incidents with official reports for the period, January 1, 1999 to March 30, 2011. All incidents were entered into the database from news releases and public reports from national and state agencies, media articles, published listings from public interest groups and litigation websites, scientific publications, as well as from personal information. Numbers displayed in the Pathogen Summary documents
include both confirmed and presumed illnesses given in final reports without any evaluation of the way the officials made their determination. There is no judgment on the manner of the investigation nor on the strength of the conclusions. Only incidents within the USA were included, and only when the investigation specified consumption of fluid fresh unprocessed milk as the presumed source. Both cow and goat dairies that were specifically operated for the purpose of supplying fresh unprocessed milk to consumers were included.


Salmonella
Scientific Name: genus: *Salmonella spp.*

General
Salmonella are gram negative, rod shaped, motile bacteria. Their normal habitat is the intestinal tract of many warm and cold-blooded animals. But with widespread fecal contamination it can be found throughout the environment. It is also identified as a contaminant in, water supplies, food manufacturing facilities, and home kitchens. It survives for long times in the environment, but does not generally multiply in the environment. However, some animal feeds and processed foods that are high in protein can support their growth when not refrigerated. Salmonella does not compete well with other bacteria and is inhibited in acidic conditions. Studies indicated that the few serovars that cause disease in humans and the equally small number that cause disease in cows are distinctly different. Essentially all of the subtypes of salmonella have been initially discovered from illnesses in different animals. The general opinion is that this organism has "host adapted" to many animals over time.

Recognized Subtypes (Serovars)
Two species are generally listed: enterica and bongori. *Enterica* is divided in 6 subspecies: enterica, salamae, arizonae, diarizonae, indica and houtenae. Most of the human public health interest is in the subtype, *Salmonella enterica* subtype enterica. [1]

Recognized Virulent Subtypes
Species have a confusing naming system, and many names were derived from specific animals or disease outbreaks. Some species or named serovars contain human virulent strains. Although some serotype names imply specific animals, many are widely distributed in other animals and the environment. *Salmonella enterica* Typhi causes typhoid, but this is not a significant pathogen in the USA today because the human disease has been controlled (See the History topic). There are more than 2,500 documented serotypes; of these only about 50 have been associated with human illness. Many different virulence factors have been identified. The virulence factors differ between subtypes, and sometimes even within specific serotypes. Even if a specific named serotype has been associated with human illness, this does not mean that any strain of that specific named serotype found in another animal or as a contaminant in food is capable of causing illness in humans.

Disease Description

Animals
Most animals that are clinically ill with salmonella subtypes have gastroenteritis. Systemic infections and abortions are known to be associated with specific subtypes and animals. Like typhoid in humans, some of the named serotypes are a significant health problem in specific animals. There are "host-adapted" subtypes most of which cause specific diseases and in specific animal hosts. Such host-adapted subtypes commonly develop carrier states. The more generalized
subtypes isolated from many different animals, may cause severe illness in a specific animal host, but cause gastroenteritis in the other animals. Most salmonella found in cows are long-term colonizers.

**Humans**
Salmonellosis is the most common bacterial foodborne illness in the US; occurring mostly as sporadic cases with acute gastroenteritis. The interval from consumption to symptoms is shorter than for other milkborne gastroenterities (12 hours to several days). A human carrier state is recognized for typhoid which is host-adapted to humans. Some studies indicate a small number of people with non-typhoidal salmonella gastroenteritis become carriers. Among many of the named serovars isolated from humans somewhere in the world, only a few are seen with any frequency; most have not been isolated from humans for decades. Although the FDA gives an infectious dose of 15-20 cells for Salmonella spp., a USDA review of minimal infectious dose studies using human volunteers list ranges from 100,000 – 1,000,000,000 for specific serovars. [2]

**Category of Pathogen**
Essentially all subtypes cause illness in some animal. Most cause a mild acute enteritis with nausea, abdominal cramps, and mild diarrhea, that last for a short time and generally does not require treatment. However, specific subtypes cause severe systemic disease in specific animals.

**Complications of Human Infection**
Rare

**Reservoir**
- All birds and many amphibians may shed large amounts of bacteria in feces
- Water, contaminated from animal sources
- Cattle and cows, temporarily colonized, shed low numbers in feces.
- Contaminated feed is a significant source of recolonization within herds.

**Other Food Implicated in Outbreaks**
Most human cases are from eggs, packaged fresh poultry and meat and foods prepared from these items.

**Outbreaks for Salmonella**
- Fresh unprocessed whole milk USA 1999-2011 [3] – Total 39 illnesses (average 3.3 per year)
- For all foods, estimated annual illnesses from Salmonella spp. in USA based on data collected in 2006-2008 [4] – 1,027,561

**References**
FDA Bad Bug Book Foodborne Pathogenic Microorganisms and Natural Toxins Handbook.
www.cfsan.fda.gov/~mow/chap1.html

Numbered Specific References


[3] Illnesses enumerated for outbreaks were obtained from a comprehensive listing of incidents with official reports for the period, January 1, 1999 to March 30, 2011. All incidents were entered into the database from news releases and public reports from national and state agencies, media articles, published listings from public interest groups and litigation websites, scientific publications, as well as from personal information. Numbers displayed in the Pathogen Summary documents include both confirmed and presumed illnesses given in final reports without any evaluation of the way the officials made their determination. There is no judgment on the manner of the investigation nor on the strength of the conclusions. Only incidents within the USA were included, and only when the investigation specified consumption of fluid fresh unprocessed milk as the presumed source. Both cow and goat dairies that were specifically operated for the purpose of supplying fresh unprocessed milk to consumers were included.


Escherichia coli

Scientific Name: genus: Escherichia species: coli abbreviated: E. coli

General Description and Information
Gram negative, rod shaped bacterium, many but not all are motile. They grow well in oxygen containing or depleted environments. Its natural habitat is the intestinal tract of most warm-blooded and some cold-blooded animals. But with fecal contamination it is widespread in the natural environment. E. coli can also be found as contaminants in home kitchens, water and food manufacturing facilities. Optimal growth is at 99°F. Easily cultured and detected. However, due to the diversity of these bacteria there is no universal growth media for laboratory isolation. It is widely publicized that E. coli grows extremely rapidly, doubling in less than one half hour. These growth rates are under laboratory conditions in optimal growth media and at 98.6°F.

Nearly all E. coli are benign and some are extremely beneficial and participate in digestion and metabolism in the intestinal tract.

Recognized Subtypes Within the Species
There are a number of commonly used systems for distinguishing forms of E. coli resulting in hundreds of recognized subtypes based on different characteristics. The “O” antigen types and the “H” antigen types (also used in the subtyping of other bacteria) yield subtypes using differences in molecules on the surface of the bacteria. The designation of the most publically recognized subtype, E. coli O157:H7, relies on differences in both of these subtyping systems (Identified as #157 in the growing list of 181 different “O” antigens and #7 in the list of 53 “H” antigens).
*E. coli* is probably the most thoroughly researched bacterial species. Some of the research is prompted by the bacteria's important role in digestion. Other researchers are prompted by the rare but important subtypes associated with illnesses. Even within the studies on those subtypes that can cause disease there are different category schemes. Illness results from a number of different and often sequential behaviors, and this has led to some commonly used ways to distinguish categories of *E. coli*.

**Categories of those subtypes virulent in humans: Virulence factors**
At least 3 virulence factors are commonly recognized. A factor that damages lining cells (intestine, other organs, and blood vessels). A factor that damages red blood cells (hemolysis). And toxins (resembling the shigatoxins produced by the bacteria Shigella dysenteriae). [1]

Many of the human illnesses are the result of bacterial toxin production. Subtypes that produce this toxin are collectively referred to as: Shiga Toxin *E. coli* (STEC). There are hundreds of subtypes of STEC only a few have been associated with human illnesses. The equally small numbers of isolates that are shed from cows are mostly different from those found in humans. [2]

Another commonly used way to categorize the virulent subtypes of *E. coli* is based on the nature of the disease they produce. The FDA's Bad Bug Book separates the virulent subtypes into four principle categories based on the nature of the injury accompanying infection.

**Categories of Principle Virulent Subtypes**

1. Enterohemorrhagic (EHEC). [Hemorrhagic Colitis] These are the most well known of the categories of current significance in public health. They are characterized by the breakup of red blood cells when there is infection. The *E. coli* O157:H7 subtype belongs in this category.

2. Enteropathogenic (EPEC). [Most common infantile diarrhea] This category cause watery diarrhea but the *E. coli* in this category do not produce any of the typical toxins seen in the other categories.

3. Enteroinvasive (EIEC). [Often referred to as bacillary dysentery] This category causes a mild form of dysentery.

4. Enterotoxigenic (ETEC). [Gastroenteritis or traveler's diarrhea] This category produces a mild form of illness with watery diarrhea. Worldwide “traveler’s diarrhea” is caused by this category. They produce toxins related to those produced by a different bacterial genus Shigella. However, destruction of red blood cells is not prominent.

With the current widespread public awareness of foodborne illnesses from the specific subtype *E. coli* O157:H7 tests were developed to easily identify this subtype in clinical laboratories. Unlike most forms of *E. coli*, this subtype was not able to utilize sorbitol as an energy source in laboratory cultures. Widely available, and FDA approved, procedures for distinguishing the O157:H7 subtype using antibody mixtures enable confirmation quickly and inexpensively. One of the consequences of the ready availability of the tests for the specific subtype O157:H7 is that other categories and subtypes causing diarrheal illness are not being recognized by hospital laboratories.

The enteropathogenic (EPEC) category of *E. coli* was once prominent in childhood diarrheal illness. During the 1960s and 70s illness from this category became uncommon in the USA. [3] This maybe the result of acquired public immunity.
SIDEBAR on Lateral Transfer of Genetic Material. [6]

Bacterial DNA has been studied extensively, and the DNA of *E. coli* more than any other bacteria. Of interest is the finding that the DNA that codes for several of the virulence factors, including the shigatoxins, originates from “lateral transfer” from other bacterial species. This is extremely complex and technical. However, understanding the basics of this process is critical to the understanding of virulence and the apparent disconnect between the naming of subtypes of *E. coli* and their ability to cause illness in humans.

Bacteriophages are viruses that infect bacteria. Typically a specific bacteriophage is able to infect bacteria by attaching to their cell wall, inserting their genetic material into the cell, subverting the normal activities of the bacteria into production of replicas of the bacteriophage’s genetic material, manufacture of the structural components of the virus, assembly of many new copies of the bacteriophage, disruption/killing of the infected bacterium and dispersal of huge numbers of the bacteriophage.

On rare occasions when the copies of the bacteriophage genetic material is being produced within an infected bacteria, random pieces of that bacteria’s DNA can become inserted into the newly produced bacteriophage’s genetic material. And on rare occasions when bacteriophage infect a bacterium, the process to make new bacteriophages aborts and the infected bacterium is not killed, but the injected genetic material remains and continues to be copied as that bacterium multiplies. So on extremely rare occasions the ability to make new specific proteins is added to a bacterium’s repertoire. And on rare occasions, that “enhanced” bacteria is able to produce new protein that was not produced by its ancestors. All of these individual occasions are rare, but because of the huge number of times these things happen in the real world, remarkably unusual things do happen.

The shiga toxin in *E. coli* O157:H7 is similar to a toxin produced by the bacteria *Shigella dysenteriae* (responsible for endemic dysentery in many countries). And there is evidence that the appearance of the genetic code for this toxin present in uncommon subtypes of *E. coli* is an example of lateral transfer via bacteriophage.

The more general “O” and “H” subtyping schemes are not based on the ability to cause illness. They are convenient and widely used when describing the *E. coli* subtypes. This does result in the important fact that simply because the subtype is *E. coli* O157:H7 does not categorize the subtype as one that causes disease in humans. There are people ill from *E. coli* infections, which have a subtype that is not O157:H7. Furthermore, not all *E. coli* O157:H7 are able to infect humans and cause illness.

SIDEBAR on Differing Perspectives.

Some of the confusion caused by the complexity of the different forms of *E. coli* is the result of the focus of different groups/laboratories that deal with these bacteria.

1. A research microbiologist sees the full complexity of the forms of *E. coli*. They look for ways to organize that complexity into manageable categories, and develop methods that distinguish the forms that are the focus of their interest. The result is a proliferation of different methods to distinguish forms that behave in different ways.

2. The medical community and medical laboratories see *E. coli* as the cause of illness, and focus on diagnosing and treating the illnesses. They utilize rapid and convenient ways to determine the cause of diarrhea and enable treatment as quickly as possible. The laboratories are equipped with the latest practical methods for detecting the current medically important subtypes. In practice all the isolates they encounter are virulent having been obtained from people with significant diarrhea. There is no need to spend days and dollars to determine which category of disease since the patient’s symptoms tell you.

3. The agricultural schools’ interest in *E. coli* generally focuses on risk management. Their attention is on detection, prevalence and survival of forms of *E. coli*. They need techniques that are able to find the extremely uncommon forms identified as pathogens, within a world crowded with the generic forms.

4. The public health/epidemiology groups focus on surveillance and causation. They are interested in proving that isolates from a cluster of illnesses can be found in food/food establishments, and determining as convincingly as possible the source/cause of the illnesses so that they can prevent additional illness. They are interested in subtyping to the extent that it narrows the search, but rely on DNA techniques to enable matching. Serotyping is often predetermined by the submitting medical laboratories that rely on protocols that detect *E. coli* O157 when bloody stool is submitted from a child.
Disease Description

Animals

E. coli rarely causes illness in wild or domestic animals. However, subtypes that cause illness in humans may reside as temporary intestinal colonizers in domestic animals. It is commonly accepted that cattle feces are a major reservoir of E. coli O157:H7 in the USA.

Humans

Acute, usually self-limiting gastroenteritis. The interval from consumption to symptoms is shorter than other foodborne enteritis, usually only a couple of days. Reviews show 100,000 illnesses, 3,000 hospitalizations and 90 deaths annually in the USA from the subtypes with shigatoxins (STEC). [4] The frequency of different E. coli serotypes isolated from humans with illness varies significantly in different regions of the world.

Because there are multiple virulence factors, research discloses considerable variety of strains with variation in human virulence and severity of illness. [5] The variation in the incidence of hemolytic uremic syndrome (HUS) in infants in different outbreaks is in part related to different forms of virulence factors and the types of shigatoxins produced by the specific subtype causing the diarrhea.

The prevalence of E. coli O157:H7 has been extensively studied. Human illnesses and cow colonization increase during warm months. Prevalence of colonization and shedding is higher in calves than adult cows. Changes in feed causes changed prevalence in cows.

The normal intestinal microflora contains about 1,000,000,000 bacteria per gram of feces. Of these as many as 1,000,000 colony forming units (cfu) are beneficial E. coli. Cows with transient colonization with E. coli O157:H7 usually shed about 500 cfu per gram of feces. There are reports of “super-shedders” that may be more persistently colonized and shed higher numbers of organisms.

Category of Pathogen

The rare virulent forms of E. coli generally cause self-limiting acute enteritis with nausea, abdominal cramps and mild diarrhea that can be bloody. The severity and pattern of symptoms varies considerably with various categories of virulent forms. As the general public is exposed to specific subtypes, immunity is acquired and the illness pattern shifts to other subtypes. The usual route of infection is oral following consumption of food/drink or hand-to-mouth transfer.

Infectious dose

With the numerous subtypes and virulence forms it is difficult to give a specific infectious dose for the group. Reports range from 10 organisms to 100,000,000 organisms.

Complications of human infection

The most significant complication is hemolytic uremic syndrome (HUS). This complication has been studied extensively and has received considerable public attention. The true incidence is unknown but in the subset of hospitalized infants with bloody diarrhea caused by E. coli O157:H7 about 15% develop some degree of HUS. The syndrome includes damage to red blood cells and associate renal damage that can result in renal failure. [6]
Reservoirs

Water
Water does not naturally contain E. coli. However, water contaminated with E. coli from animal (including human) sources is very common.

Cattle
Cattle can become temporarily colonized by forms that are virulent in humans. These colonies shed in low numbers intermixed with the normal E. coli in the feces. Contaminated feed, drinking water and contact with other cattle shedding the virulent forms of bacteria are significant source of recolonization within the herd.

Humans
Humans are the ultimate source of human virulent forms of E. Coli.

Other foods implicated in outbreaks
Ground beef is the most frequently implicated food source (USDA FSIA 5/10). Other foods include: leafy greens, seed sprouts, unbaked cookie dough, nuts, and fresh fruit juices.

Outbreaks for E. coli 0157:H7

- Fresh unprocessed whole milk USA 1999-2011 [7] – Total 50 illnesses (average 4.6 per year)
- For all foods, estimated annual illnesses from E. coli O157:H7 in the USA based on data collected in 2006-2008 [8] - 63,153.
General References

FDA Bad Bug Book  Foodborne Pathogenic Microorganisms and Natural Toxins Handbook:
Note: the FDA Bad Bug Book includes different sections based on the category of E. coli categories rather than as a unified chapter.


Numbered Specific References

www.cdc.gov/mmwr/preview/mmwrhtml/rr5812a1.htm?s_cid=rr5812a1_x

http://aem.asm.org/cgi/content/short/73/22/7338

[3] Crane. 2010 Lessons from Enteropathogenic Escherichia coli. available online:

www.cdc.gov/mmwr/preview/mmwrhtml/rr5812a1.htm

www.pnas.org/cgi/doi/10.1073/pnas.0710834105


[7] Illnesses enumerated for outbreaks were obtained from a comprehensive listing of incidents with official reports for the period, January 1, 1999 to March 30, 2011. All incidents were entered into the database from news releases and public reports from national and state agencies, media articles, published listings from public interest groups and litigation websites, scientific publications, as well as from personal information. Numbers displayed in the Pathogen Summary documents include both confirmed and presumed illnesses given in final reports without any evaluation of the way the officials made their determination. There is no judgment on the manner of the investigation nor on the strength of the conclusions. Only incidents within the USA were included, and only when the investigation specified consumption of fluid fresh unprocessed milk as the presumed source. Both cow and goat dairies that were specifically operated for the purpose of supplying fresh unprocessed milk to consumers were included.

Scenario for Transmission

Throughout this section items identified in Bold are factors with the greatest potential for leading to illness.

Scenario(s) for Transmission of Virulent Campylobacter jejuni to People

Key requirements for transmission
- Must be virulent form of C. jejuni.
- Most be in adequate numbers (500 or more bacteria)
- Person must be susceptible (does not have full immunity), but not immunocompromised
- Must get into the intestinal tract of person (ingestion)

It's all about numbers. Microbiologists have worked hard to develop techniques/conditions that enable C. jejuni to multiply in large numbers in the laboratory. However, in nature C. jejuni does not multiply outside of living cells of the animal intestine. During infection virulent forms will multiply in the intestine. However, the principle of infectious dose is based on the observation that there must be a large enough mass of healthy virulent bacteria before infection happens. Becoming ill requires ingestion of adequate numbers of virulent C. jejuni. So nearly all circumstances of foodborne C. jejuni illness involve contamination with large numbers so that enough survive the interval and conditions prior to ingestion.

Source and/or Vehicle for Transmission

People
- People ill with diarrhea- the bacteria multiply and shed very high numbers of virulent C. jejuni in stool. Shedding persists after illness/diarrhea has subsided. These subtypes are by nature virulent.
- A carrier state with persistent high shedding is not well documented for C. jejuni.
- People with colonization that might transiently shed at low levels have not been described.
- People can be a vehicle for transmission of infectious stool to:
  o Other people
  o Animals
  o The environment including: water, feed, milk

Animals
- Poultry
  o Extremely high prevalence of C. jejuni in the intestine without causing illness. The bacteria multiply in the intestine and shed in high numbers within feces. There is a significant likelihood that the subtypes present would be virulent in humans.
  o Most likely to be the source of contamination in home and commercial food preparation areas from fresh meat and juices contaminated during evisceration and processing.
  o Greatest risk of infection is from direct (physical) contact with living poultry.
- Cattle/cows
  o Feces/manure
  o Cows can be colonized with limited multiplication of the bacteria and low shedding. These instances are transient, have variable subtypes over time and within a herd. These subtypes are unlikely to be virulent in humans.
  o Super shedding has been documented. Multiplication is still limited but there can be persistent shedding. In these instances there is usually a persistent subtype, still unlikely to be virulent in humans.
  o Direct physical contact with manure on animals or the ground.
Environment

- Feces – only significant if contain high numbers of virulent bacteria
- Water – (must be contaminated with fecal material with high numbers of virulent bacteria). Survival is dependent on temperature and time.
- Biofilm – longer survival of C. jejuni within preformed biofilm from non-pathogen bacteria (C. jejuni are motile)
  - Persistent within equipment, piping, containers, under normal cleaning operations (experts consider this as the most significant source of contamination of milk).
  - Requires mechanical scrubbing to remove from surfaces
  - Microscopic flakes of biofilm carry embedded bacteria and are not easily diluted, resulting in uneven distribution.
- Animal Feed (contaminated with feces/manure).
  - Shared feeding; not significant since would need bacteria in the mouth.
  - Distributed on ground that has feces/manure.
  - Secondarily contaminated with contaminated water.
  - Contaminated by person shedding high numbers

Milk

- It maybe theoretically possible with C. jejuni mastitis to shed directly into milk from the udder but may only have been reported once in the literature.
- Contamination of milk after milking
  - From any of the previously listed sources but must be in high concentration
  - Should be visible in a milk filter if contamination is manure. (Milk filters are designed to trap large particles and make such contamination more conspicuous.)
  - Incidental contamination would usually be diluted in the bulk tank
  - There is poor survival in fresh whole milk at refrigerated temperatures
  - Combination of factors that inhibit multiplication of bacteria in fresh milk (see Topic Two – Benefits and Values). A decrease in numbers of any bacteria in milk reduces the effectiveness of these inhibitions.
- Rinse water contaminated with milk (increased survival)
- Microscopic flakes of biofilm in bulk tank, milk lines, milking equipment (not visible). Might pass through milk filter

Other foods

- Fresh poultry meat.
- Fresh shellfish (rarely C. jejuni).
- Leafy vegetables (biofilm) contaminated by bird feces containing virulent forms of C. jejuni.
- Any food contaminated by person shedding high numbers of virulent forms.

Contamination of containers by people, contaminated water, fecal/manure

- Food containers – inside or outside
- Transportation containers or equipment.

Scenario(s) for Transmission of Virulent Listeria monocytogenes to People

- Must be virulent form of L. monocytogenes
- Virulent form must be in adequate numbers to cause illness
- Assumes person must be susceptible (does not have full immunity)
- Generally assumes transmission by ingestion
Most cases of human listeriosis are not associated with investigated outbreaks. Since the sporadic cases are rarely investigated there is little information on the modes of transmission or sources of the virulent form of *L. monocytogenes*. This is complicated further because of the potential of long incubation times. Conclusions on definitive sources, reservoirs and modes of transmission are also distorted since outbreaks from *L. monocytogenes* are extremely rare and outbreaks vary considerably.

The systemic form of human "foodborne listeriosis, is a relatively rare but serious disease with high fatality rates (20-30%) compared to other foodborne microbial pathogens." [1]

Being elderly or a child is not in itself a major risk factor for listeriosis. However, conditions that are more likely to occur in different age groups (leukemia, cancer, dialysis, use of immunosuppressive drugs) are major risk factors.

Nearly all cases of foodborne listeriosis in people are associated with consumption of very high numbers of virulent organisms, and are associated with foods and food handling that enable multiplication of the bacteria prior to consumption.

It is generally accepted that the general public consumes food contaminated with *L. monocytogenes*, occasionally and repeatedly throughout their lives. There is little information on the immunological effect of this exposure.

**Source and/or Vehicle for Transmission**

**People**
- People with gastrointestinal illness—during these illnesses the bacteria multiply and are shed very high numbers of the causative subtype of *L. monocytogenes* in their stool.
- Adults with systemic infections (listeriosis) have organisms in their blood stream and have very high concentrations of *L. monocytogenes* within the infected organs. Other people are unlikely to become infected from contact with the ill person.
- A carrier state with persistent high shedding is not well documented for *L. monocytogenes*.
- People with colonization that might transiently shed at low levels are most common within populations that have greater exposure to environmental *L. monocytogenes*, such as farmers and meat processors. Recent studies show a small number of the general adult public may intermittently shed *L. monocytogenes* in their stool without symptoms, but it is not known if these were virulent forms.
- People could be a vehicle for transmission of infectious bacteria in their stool to:
  - Other people. People exposed to cases of listeriosis may transiently shed *L. monocytogenes* in their stool, but rarely have symptoms.
  - Animals.
  - The environment, including: water and feed.

Current reviews conclude that the findings listed above are not significant contributors to human illnesses.

In contrast, pregnant women with *L. monocytogenes* in their blood stream, even if not significantly ill themselves, are the principle source of transmission to their fetus or newborn.

**Animals**
- Cattle/cows, sheep and goats
  - Feces/manure
    - Cows can be colonized with limited multiplication of the bacteria and low shedding in
manure. These instances are transient, have variable subtypes over time and within a herd and the subtypes are unlikely to be virulent in humans.

- Super shedding is reported. Multiplication is still limited but there can be persistent shedding. These maybe a significant contributor to herd exposure, however, the subtypes are unlikely to be virulent in humans.
  - Infected fetuses, newborns, and products of conception (amniotic fluid, placenta, and blood) contain large numbers of forms virulent in the animals. Workers exposed to these materials may become infected. These materials also contribute to the cycling of *L. monocytogenes* in the general farm environment.
  - Wild, land and aquatic animals are not considered a significant source for human listeriosis.

**Environment**

- *L. monocytogenes* is widely distributed in the environment.
- Silage – Poorly managed silage is generally accepted as the principle source of listeriosis in cows/cattle. A greater variety of strains are isolated from silage than from animal infections suggesting that far more strains will multiply in poorly managed silage than are able to cause infection in exposed domestic animals.
- Feces – Generally accepted as a source of *L. monocytogenes* in the farm environment. However, there are far more strains of *L. monocytogenes* in the environment than are found in the farm’s animals. Manure spread on fields may contribute to contaminated crops. This has been shown to be a source of human listeriosis when the crop was subsequently stored in cool damp conditions for months (e.g. cabbage). Fecal contamination of foods entering processing plants may contribute to the introduction of *L. monocytogenes* into processing plant environments.
- Water contamination is a significant source, reservoir and transmitter of environmental listeria and is a component of the generalized contamination in the farm environment.
- Animal Feed other than silage may be contaminated with feces/manure or water.
- Can be contaminated by person shedding high numbers.

Current reviews conclude that the sources listed above are not significant as the source or transmission resulting in human listeriosis.

**More Significant Sources or Methods of Transmission of *L. monocytogenes* to Humans**

- Biofilm - There is longer survival of *L. monocytogenes* within biofilm. Although the ability to form their own biofilm is variable among different strains, given time, strains with poor production of biofilm are able to establish biofilm.
  - Biofilm is important to the persistence within processing plant environment, equipment, piping, containers, under normal cleaning operations.
  - Requires physical cleansing to remove from surfaces.
- Microscopic fragments of biofilm carry embedded bacteria. Such fragments do not easily dilute in the product, resulting in uneven distribution.
- Processing environments: Commercial, retail and home food processing environments are considered the most significant contributor to human listeriosis. These locations and handling practices harbor and enhance the ability of *L. monocytogenes* to multiply slowly, persist over extremely long periods, and compete in the environmental ecosystems at refrigerated temperatures and contaminate a variety of foods. Slicing of processed refrigerated meats is one of the most risky procedures.
- Contaminated water is a significant source, reservoir and transmitter of environmental listeria in processing plants.
Milk
- Mastitis is an uncommon location for systemic listeriosis in cows, but might contribute to spread in a herd. However, the pattern of strains virulent in cows is different than from clinical cases in humans.
- Contamination of milk after milking:
  - Contamination from manure would require a very large amount to reach infectious doses.
  - Contamination from other dairy environmental sources with conditions that enable multiplication of *L. monocytogenes* including drains and residual wash water.
  - There is poor survival of inoculated *L. monocytogenes* in fresh whole milk, even at refrigerated temperatures.
- Processed milk has been linked to rare outbreaks of listeriosis. However, this contamination was from the processing environment not from inadequate pasteurization or from contamination with pre-pasteurized milk. *L. monocytogenes* is capable of multiplication in processed milk. Most problems with dairy products have been related to cheese.
- Although fresh unprocessed whole milk would qualify as a ready-to-eat food; in regard to the conclusion that ready-to-eat foods are a significant source of listeriosis, unprocessed fluid milk does not fit. That is because it is the processing of the foods that confers the most significant risk.

Fresh unprocessed whole milk has not been linked to human cases of listeriosis in the USA over the last ten years.

Other foods
All reviews and risk analyses conclude that processed foods (ready-to-eat foods) are the principle source of all of the types of foodborne listeriosis. The patterns in these outbreaks implicate the processing plants themselves and not the specific food. Environmental contamination in food processing operations with *L. monocytogenes* is widespread and persistent. Risk factors include: the plants themselves, the equipment, packaging and storage. Risk significantly increases with the length of storage under refrigeration of the processed product. Recently it has been shown that food delivery services such as deli-type establishments appear to increase the risk for processed meats that are served cold.

Intact fresh unprocessed or undamaged foods have not been linked to human listeriosis.

References

Numbered Specific References
Scenario(s) for Transmission of Virulent Salmonella spp. to People

- Must be a salmonella subtype virulent in people
- **Virulent** form most be in adequate numbers to cause illness
- Applied to the general population (do not have full immunity or compromised immune condition)
- Generally assumes transmission by ingestion

The vast majority of cases of human salmonellosis are not associated with investigated outbreaks. Since the sporadic cases are rarely investigated there is little information on the sources or modes of transmission of the virulent subtypes of Salmonella spp. Conclusions on definitive sources, reservoirs and modes of transmission are also distorted since outbreaks from Salmonella spp. are extremely rare, the subtypes are usually different and outbreak characteristics vary considerably. When outbreaks are recognized they often include large numbers of illnesses and significant rates of hospitalization and some deaths. Systemic infections are uncommon. However, in very rare large outbreaks the pattern suggests a more virulent form, with more systemic infections (predominately in elderly with associated debilitating conditions), associated with increased rates of hospitalization and more deaths.

Because typhoid fever (caused by the subtype *Salmonella enterica* serovar Typhi) is not a significant health problem in the USA at this time, it is not included in this summary.

Nearly all cases of foodborne salmonellosis in people are associated with consumption of high numbers of virulent organisms, and are associated with foods and food handling that enable multiplication of the bacteria prior to consumption.

It is generally accepted that the general public occasionally and repeatedly consumes food contaminated with various subtypes of salmonella throughout their lives. There is little information on the immunological effect of this exposure.

There have been a number of studies that looked at human cases. Each tends to have their own pattern of virulent subtypes, and sources. These change with time, region, and method of collecting isolates. It is common to find studies that span longer periods of time, that show changes in prevalence (both increases and declines) over years. This may be the result of changes in public immunity levels, or alterations in the expression of virulent factors in the subtypes.

Source and/or Vehicle for Transmission

**People**
- With gastrointestinal illness- During these illnesses the bacteria multiply and are shed with very high numbers of salmonella in their stool.
- Excluding typhoid fever, a carrier state with persistent high shedding is not well documented for the subtypes of salmonella virulent in humans.
- People could be a vehicle for transmission of infectious bacteria in their stool to:
  - Other people through handling of food.
  - The environment, including: water and feed.
Animals
- All domestic animals have significant disease caused by Salmonella spp. However, the specific subtypes are frequently animal specific.
- Human illness results from consumption of meat or meat products that have been processed, stored or served under conditions that enable multiplication of salmonella.
- Eggs can be contaminated on the outside from poultry shedding salmonella
- Egg content can be infected with the Salmonella enterica Enteritidis from hens with ovarian infections.
- Wild land and aquatic animals also have significant disease but the subtypes are also frequently animal specific. Human illness associated with animal disease usually results from direct physical contact with a pet that is sick or is shedding high numbers of a virulent subtype.
- A carrier state within animal groups is well recognized as a source of transmission to humans through direct contact or through ingestion of meat or from contamination of other food products.

Environment
- Water contamination is a significant source, reservoir and transmitter of environmental salmonella and is a component of the generalized contamination in the farm environment. It is also a significant source of transmission to humans.
- Animal Feeds may be contaminated through direct contact with animals or humans, feces/manure or water.
- Processing environments: Many of the recent outbreaks have been traced to processed foods. And the processing environments are sometimes contaminated. However, trace backs have also implicated specific ingredients (that both directly introduce virulent bacteria, or contaminate the processing environment/equipment). Ingredients are often processed, and the processing environment or the source of the ingredient may have contributed to the spread.

Milk
- Mastitis is an uncommon location for salmonella infection in cows. The subtypes virulent in cows are different than from subtypes associated with human illnesses.
- Contamination of milk after milking:
  o Contamination from manure would require very large amounts of contaminant to reach infectious doses in the farm tank.
  o Contamination from other dairy environmental sources. This would be significant only with conditions that enable multiplication of Salmonella such as in animal feed.
  o There is poor survival of inoculated Salmonella spp. in fresh whole milk at refrigerated temperatures.

Other Foods
- Although many foods have been associated with human salmonella gastroenteritis, except for eggs, there is no real pattern for specific foods. Almost every cluster of illnesses is associated with a different food. Current outbreaks although rare can be large and each are associated with contamination of a specific food. Most have in common: handling, storage, or serving conditions that enable multiplication of salmonella. In contrast the outbreaks caused by Salmonella enterica Enteritidis are specifically caused by eggs infected within the laying hens.

Major Reference
FDA Bad Bug Book (distribute 2010 article from MSU on Michigan farm with salmonella)
Scenario(s) for Transmission of Virulent E. coli to People

- Must be a virulent form of E. coli
- The subtype O157:H7 has the most abundant and reliable information; so will focus the scenario on this subtype (serotype)
- Must be in adequate numbers (10 or more bacteria in serving consumed)
- Person must be susceptible (does not have full immunity), but not immunocompromised
- Must get into the intestinal tract of person (ingestion) to cause illness

Infection and Illness
There has been discussion about the distinction between infection (meaning establishment of bacteria with multiplication in or on the cells of the intestine) and illness (meaning persons with symptoms such as diarrhea, abdominal pain, fever, etc.). This distinction is not always important in understanding epidemiology of foodborne illnesses, however, with the virulent forms of E. coli there is some advantage to understanding this. Obviously illness does not happen without infection. But infection does not automatically mean illness. With certain bacteria, persistent infection in the absence of illness is described as a carrier state. In the case of the virulent forms of E. coli, a true carrier state has not been reported. However, a transient colonization with modest multiplication either prior to the onset of symptoms or without symptoms is possible in humans and is the dominate situation in cattle (e.g. E. coli O157:H7).

It's all about numbers
Suitable conditions for E. coli multiplication are widespread, primarily within the intestines of most animals, but also many foods (intact, damaged, processed or cooked). During human illnesses, virulent forms will multiply in the intestine and large numbers of the virulent forms are shed in the diarrheic stool. Becoming ill requires ingestion of adequate numbers of virulent E. coli, however with the O157:H7 subtype the commonly accepted infectious dose is 10 bacteria in a serving. Some human studies cite higher numbers for infectious dose, and with other serotypes the accepted dose is much higher. Much of the epidemiological information about human illness with the virulent strains of E. coli O157:H7 is more easily understood if you consider that there is an initial stage of infection; with illness following in some of the infected people.

Although there are abundant conditions favorable for the multiplication of the common E. coli, large numbers of studies using E. coli O157:H7 establish that with this subtype there is a reduction in numbers over time, rather than multiplication. Survival is the consistent measurement, not multiplication. Except for active infectious disease when the virulent forms are present from contamination of feces, the non-virulent forms are present in far greater numbers, and competitively multiply more rapidly than the virulent forms. There is a study that showed increases in E. coli O157:H7 when inoculated into mismanaged silage, and some reports of increases in the intestinal tract of common flies and birds when allowed to ingest contaminated material.

Source and/or Vehicle for Transmission (subtype O157:H7)

People
- People ill with diarrhea- the virulent forms including the subtype O157:H7 multiply and shed in very high numbers and are the dominant bacteria in their stool. Shedding persists after illness/diarrhea has subsided. The subtypes that are shed with diarrhea are by nature virulent.
• A carrier state with persistent high shedding is not well documented for E. coli O157:H7.
• People with colonization that might transiently shed at low levels have not been described in the literature.
• People can be a vehicle for transmission of infectious stool to:
  o Other people. Data from outbreak investigations consistently document secondary illness in people in physical contact with those with illness. The percent of the cases that are considered to be secondary infections is not large. However, the data may be skewed since it is possible that many of the contacts do not become primarily ill because they have some degree of prior immunity. Given that likelihood the percent of secondary infections may be underestimated because of that same prior immunity. In an epidemiological analysis of US outbreaks from 1982-2002 from the CDC published in 2005 by Rangel, et al. 21 percent were associated with ground beef, 21 percent unknown, and the next highest was person-to-person 14 percent. All dairy products were 2 percent.
  o Animals – see below.
  o The environment including: water, feed, milk, containers, food preparation surfaces and food.

Animals
• Cattle/cows – High prevalence of E. coli O157:H7 in the intestine without causing illness. The bacteria colonize the intestine (highest rate in the end of the colon) and shedding in low numbers within feces (500 cfu/gram of feces). Colonization is more frequent in calves and heifers. There are occasional “super-shedders”, which shed at higher numbers (~1,000 cfu/gram feces) and persist with a single strain of E. coli O157:H7.
• Other animals
• Feces/manure from domestic animals
  o Can be colonized with limited multiplication of the bacteria and low shedding. These instances are transient, have variable subtypes over time and within a herd and subtypes are unlikely to be virulent in humans.
  o Super shedding is reported. Multiplication is still limited but there can be persistent shedding.
  o Fecal contamination (other than from human diarrhea) will contain all other fecal bacteria in their normal relative numbers. Therefore, any virulent forms will be subject to the competitive inhibition and other factors that suppress multiplication. Furthermore, any food that is contaminated with fecal material will have extremely high levels of background fecal bacteria, intermixed with any rare E. coli O157:H7 that might happen to be present.
• Direct physical contact with manure on animals or the ground.
• E. coli O157:H7 has been isolated from bird feces and flies.

Environment
(All are examples of contamination, not the source and studies document the rate of survival, not increase in numbers)
• Feces – only significant if contains high enough numbers of virulent bacteria. Numbers decline with time.
• Water – (must be contaminated with fecal material with high numbers of virulent bacteria). Survival within contaminants is dependent on temperature and time.
• Biofilm – survival of E. coli O157:H7 within preformed biofilm. Preformed from non-pathogen bacteria or produced by E. coli O157:H7. Persistent within equipment, piping, containers, under normal cleaning operations. Requires physical cleansing to remove from surfaces.
• Biofilm produced by E. coli O157:H7 is well studied. It forms within the intestinal contents but also on the lining cell surface of the colon.
• Microscopic fragments of biofilm carrying embedded bacteria. These free floating fragments do not easily distribute resulting in uneven distribution.
Animal Feed
When contaminated with feces/manure or by oral bacteria through shared feeding.
  • Distributed on ground that has feces/manure
  • Secondarily contaminated with contaminated water
  • **Contaminated by person shedding high numbers**
    • In cattle herds the intermittent recycling of strains of *E. coli* O157:H7 are likely to result from the re-ingestion from contaminated feed, water, and other environmental contacts. However, there is no evidence that the total population of *E. coli* O157:H7 increases under these conditions. [see separate diagram of cycle that follows below]

Milk
  • As the direct/primary source. It may be theoretically possible with *E. coli* mastitis shedding directly into milk from the udder
  • Contamination of milk during and after milking
    o From any of above sources but must be in high concentration. Should be visible in the milk filter if contamination is manure. Milk filters are designed to trap large particles and make such contamination more conspicuous.
    o Incidental contamination would usually be diluted in the bulk tank
    o There is poor survival in fresh whole milk at refrigerated temperatures (Massa et al. 1999) [1]
    o Combination of factors that inhibit multiplication of bacteria in fresh milk. (see Topic Two – Benefits and Values)
  • Rinse water contaminated with milk (increased survival compared to whole milk)
  • The microscopic fragments from biofilm in bulk tank, milk lines, and milking equipment.

Other foods
  • Ground beef.
  • Leafy vegetables contaminated by manure, water, and human contact; increases with damage, cutting, and plant diseases.
  • Fruit juices when fruit is contaminated (humans, on ground, flies).
  • Any food contaminated by person shedding high numbers of a virulent form.

Contamination of containers by people, contaminated water, fecal/manure
  • Bottles – inside or on outside
  • Transportation containers or equipment.
Fig. 1. Transmission of *E. coli* O157:H7 in the environment giving rise to a cycle of infection that may enable maintenance of the organism in cattle herds. Effective control of *E. coli* O157:H7 requires suppression at as many points in the cycle as possible in order to minimize the incidence of foodborne disease associated with this human pathogen.


Numbered Specific References


Discussion of Infectious Dose

Infectious dose is used to indicate the number of virulent bacteria that if consumed would cause illness. In the context of the Topic on Risk, the term is used to apply to the general public, exclusive of persons who have acquired immunity, or those who for various reasons are uniquely susceptible to infection. There is no single number of virulent bacteria that when consumed will result in illness. There are even many different ways of expressing infectious dose:

1. Minimal infectious dose – the smallest number of virulent bacteria that must be consumed to cause illness.
2. 50% infectious dose – the number of virulent bacteria that when consumed at one time would result in half of the general public becoming ill.

In principle it would seem that if a bacterium is virulent even one bacterium would cause illness. In practice, however, that does not hold true for a variety of reasons.

The way in which the infectious dose has been determined varies:
1. Theoretical – calculated from real and experimental data
2. Volunteer studies – determined by having a group of people consume food specifically mixed with known numbers of a virulent strain of bacteria
3. Epidemiologic – calculated from data on serving size and concentration of bacteria found on food associated with an outbreak
4. Laboratory – based on experiments using animals

Within the foodborne illnesses it has been found that many factors affect the infectious dose:
1. Virulence of the specific strain of bacteria
2. Nature of the food with which the bacteria are associated
3. Other food ingested at the same time
4. Serving size
5. Sequence of repetitive consumption of individual servings
6. Individual differences in personal susceptibility
7. Differences in the environment of the intestinal tract of the specific individual consuming the food
8. Health, concurrent medications or concurrent illnesses of the person consuming the food
9. Health/vitality of the bacteria consumed

It is unusual to have the specific criteria used to define the infectious dose explained when the term is generally used. Except in specific instances the number used in the workgroup's Summary Statements is the "generally or widely accepted" number.
Other Pathogens of Historical Milk-Related Public Health Concerns

In the late 1800's several epidemic diseases dominated the public health scene in the USA. As advocates for laws requiring pasteurization organized their campaigns, they focused the public on the role of milk in several of these diseases. Although only one of these, human tuberculosis, continues to be a significant public health concern, each are reviewed here for historical value.
(See also Topic One – History)

Diphtheria is caused by the bacteria Corynebacterium diphtheriae, a virulent pathogen host adapted to humans. This is a severe infection of the upper respiratory area. Corynebacterium diphtheriae is essentially an obligate parasite of humans, transmitted between people. It is not a zoonotic disease (it does not grow in cows or other animals). Historically examples of localized outbreaks of diphtheria were linked to persons with active infections or human carriers who were milking, processing or distributing milk. The organism does not survive long in the environment, and does not grow in milk. Pasteurization does kill these bacteria in milk. Pasteurization would only be protective in those extremely rare circumstances when large numbers of virulent bacteria contaminated the milk itself from an infected person or carrier coughing directly into the milk, or from sputum containing large numbers of the virulent bacteria getting into the milk from handling prior to pasteurization. The majority of these clusters were linked to people handling the milk after pasteurization would have occurred and during distribution to homes. Diphtheria was effectively controlled by public health interventions, specifically mandated immunization of the public. Examination of the medical records show that the number of cases had a uniform steady decline starting (1880's), well before pasteurization was commercially used, and had a very low incident at the time mandatory pasteurization was adopted in the United States.

Scarlet fever is a group of skin disease that can include significant upper respiratory infection caused by forms of streptococci that produce a toxin that destroys red blood cells. Regional epidemics have occurred throughout the world, including significant occurrences at different times in the mid to late 1800's and 1900's in the United States. In the epidemic occurrences the disease is highly contagious through person to person contact. A few investigations of localized clusters of scarlet fever in the early 1900's were attributed to milk handlers that had skin rashes. The real relevance of these cases was that the cases were published because of the distinct finding of a link of cause and effect. A consistent finding in these cases was that the infection originated from a milk handler (not the animals). In some of these historical reports, boiling the milk protected the family. The milkborne spread of the pathogen may have contributed in a minor way to the general public health impact of scarlet fever during this period in history. During the turn of the century (1890-1920) physicians were only beginning to associate skin rashes with scarlet fever. Milking was by hand and contamination of fresh milk from a rash on the hands was possible. However, the significant route of transmission of the epidemic forms was historically and continues to be by direct physical contact between people. The significant public health impact of scarlet fever was nearly eliminated with the recognition that: the disease was caused by bacteria; the association of the skin rashes to the severe respiratory infections; isolating people with the infection and keeping people who had skin rashes from handling food, including milk.

Bovine tuberculosis is a chronic debilitating disease of cows caused by Mycobacterium bovis. The disease was endemic in the United States during the late 1800's and first half of the 1900's. Incidence in domestic herds in Michigan was above 30% in some areas. Severely infected cows can shed bacteria in their feces and with active mastitis, directly into milk. The cows become ill over long periods of time, and are extremely sick, and milk production drops significantly. Infection can be transmitted to other animals, and to a limited extent to humans. Human infection is acquired predominately by direct
physical contract with a severely ill animal. There is rare documentation of transmission to people from consuming heavily contaminated milk. Pasteurization is effective against this bacterium. Unlike human tuberculosis which is transmitted through airborne droplets the bovine form does not spread through the air. When human infection of the bovine form is from consumption of milk or hand to mouth transfer, very large numbers of virulent organisms must be introduced, and the disease is localized in the lymph nodes of the neck, or along the intestinal tract. During the late 1800's and early 1900's it was difficult to distinguish the bovine disease from the human form and many scientists believed they were the same disease. However, the diseases in humans can be distinguished now, since we know that the human form is a disease of the lungs, and the bovine form is a disease of the regions of the intestinal tract from the mouth to the abdomen. The number of “extrapulmonary” forms in people was small compared to the pulmonary forms. Public health records of the time, which included the small number of bovine forms of disease, show a uniform steady decline starting well before pasteurization was commercially used, and with a very persistent low incident at the time mandatory pasteurization was adopted in the United States. Because the bovine disease had significant economic impact in cattle and dairy operations, an aggressive federal eradication program of testing and killing has essentially eliminated the disease in the United States. And an active surveillance program continues to watch for and eradicate the disease imported from other countries. Currently Michigan has a specific problem due to persistent bovine tuberculosis in the deer and other animals in a confined region of the Lower Peninsula and is spending considerable resources to protect the domestic cattle herd from any chance of spread. Bovine tuberculosis is not a current public health risk in the United States.

**Human tuberculosis** is a disease caused by *Mycobacterium tuberculosis*. This form of tuberculosis is primarily a chronic disease of the lungs that may last for years without any symptoms, but can become active if the person's immune system is compromised. When the disease is active, and in rarer circumstances of dissemination throughout the body, these debilitated persons can infect other people. Infection is predominately spread through airborne droplets containing the virulent pathogen, inhaled and causing infection in the lungs. This organism is an intracellular **obligate parasite** in humans. In the vast majority of cases the organism remains growing slowly within cells of the lung, does not cause illness, and is not infectious. This is not a zoonotic disease, other animals do not become infected from humans, and spread does not occur from animals including cows. Although bovine and human tuberculosis are fundamentally different diseases, during the late 1800's the distinction was not widely recognized. And “tuberculosis” was epidemic in the United States and a major public health concern. As a result advocates of pasteurization were able to argue that “tuberculosis”, that was known to be a disease of cows, was coming from the cows through milk. The small proportion of “tuberculosis” that was the bovine form is discussed above. The major proportion of “tuberculosis” that was human, does not infect cows, and therefore can not be transmitted through milk. There were people with tuberculosis that were milking, and processing and distributing milk. Milk and milk containers could only be a vehicle for transmission of human tuberculosis in the rare circumstance that the milkers or handlers had active tuberculosis and were coughing up infectious sputum. And although pasteurization was ultimately managed so that it would kill most *Mycobacterium tuberculosis*, pasteurization would only have intervened in the transmission from humans to humans, if the contamination from infected sputum occurred prior to when pasteurization would have occurred. If *Mycobacterium tuberculosis* was present in milk, it would cause disease of the intestinal lymph nodes (not the lungs) and only if present in extremely high numbers. Clinical studies have shown that nearly all intestinal tuberculosis is the results of a person with active human pulmonary disease swallowing sputum containing huge numbers of the pathogen. If transmission of human tuberculosis occurred in association with milk, it is far more likely that it would have been from contamination of the outside of milk bottles with drying and airborne distribution. Human tuberculosis was epidemic in the United States and persists as a small but significant public health problem today. Pasteurization of milk is unlikely to have ever been a significant
intervention in the epidemic. Examination of the historical medical records show that the number of cases of "tuberculosis" had a uniform steady decline starting (1880's), well before pasteurization was commercially used, and with a very low incident at the time mandatory pasteurization was adopted in the United States.

**Typhoid fever** is a human disease caused by *Salmonella enterica* subtype Typhi. This bacterium is an obligate parasite of humans. It is not a zoonotic disease and does not infect other animals. Typhoid fever was epidemic in the United States during the 1800's and early 1900's. It is transmitted from person-to-person through ingestion of material contaminated from the stools of infected people or rare carriers and drinking contaminated water. Historically examples of localized outbreaks of typhoid fever were linked to persons with active infections or human carriers who where milking, processing or distributing milk. The advocates of mandatory pasteurization used these incidents in their campaigns. Pasteurization does kill these bacteria in milk. Pasteurization would only be protective in those extremely rare circumstances when large numbers of virulent bacteria from an infected person or carrier's feces was introduced directly into the milk from handling prior to pasteurization. The majority of those clusters investigated and published were linked to people handling the milk, after pasteurization would have occurred, during handling or distribution of milk to homes. Typhoid fever in the United States has been effectively controlled by public health interventions including: public (both municipal and rural) water and sewage management, isolation and treatment of carriers, and human immunization. Examination of the historical medical records show that the number of deaths had a uniformly steady decline starting well before pasteurization was commercially used, and with a very low incident at the time mandatory pasteurization was adopted in the United States.

**Brucellosis (undulant fever, Bang's disease)**

Brucellosis is a serious disease in many domestic animals including cows caused by members of the genus brucella. Each species of brucella tends to predominate in a group of animals and have different patterns of disease; however, crossover between animal groups happens. The species associated with human disease is also variable. The natural environment for the growth and multiplication of these bacteria is inside the cells of animals. In humans brucellosis can present with acute symptoms, but also may take months before symptoms become evident. Fever, with a characteristic undulating pattern, and generalized weakness are a manifestation of the systemic spread of the infection. Most human infections are the result of direct physical contact with infected animals or material from infected animal abortions. In cows, goats and sheep there is a tendency of the disease to include infections of the mammary glands and the uterus. Milk production is significantly reduced in infected animals. Even so, infected dairy animals can shed large numbers of the bacteria in the milk they produce. The milk ring test has been historically available to quickly detect a cow with brucella mastitis. The current standards for pasteurization are set to inactivate brucella in milk. Historically milkborne brucellosis in humans was a significant public health risk. Because of the economic impact of reduced milk production and reproductive failures a nationally mandated program to eliminate brucellosis in cattle was initiated in the 1950's. This aggressive 'test-and-kill the herd' policy has effectively eradicated this disease in cattle and cows. As a result, human brucellosis has become extremely rare in the United States, and is found predominately in immigrants and foreign travelers.
Categories of Risk
Other Than Infectious Disease for People Consuming
Fresh Unprocessed Whole Milk

Allergies to milk
These are immunologic reactions in individuals to some component of milk. Nearly all are triggered by proteins. These reactions are classified as hypersensitivity because they can be triggered by very small amounts of milk, or the presence of very small amounts of the specific allergic component in non-dairy products. It is generally accepted that the proteins that trigger these reactions must migrate from inside the intestine into the tissues and intercellular spaces of the body, intact (not digested) to initiate the reaction. Therefore “permeability” of the intestinal lining cells is an important factor in the initial sensitivity and in the triggering of subsequent reactions. The severity of the reaction is different in different people, ranging from mild symptoms to sudden life-threatening conditions with significant numbers of deaths. Milk allergies are considered the second most common food allergy after allergies to eggs. Because of the large number of people affected, the widespread use of milk or milk proteins in prepared foods, and the fact that the reactions are triggered by very small amounts, food labeling regulations require statements if there are any milk protein ingredients in the product.

Early childhood cow’s milk allergy
This allergy adversely affects 2-8 % of infants in the USA. This is a reaction to cow’s milk usually seen when a newborn child is weaned from human breast milk to commercial formulas. Some studies show that the same reaction may occur with goat or sheep milk. The infant reacts with a variety of symptoms including simple refusal to drink the formula, rashes (the most common reaction), vomiting, diarrhea and rarely, acute pulmonary distress. One of the characteristics of this immunologic reaction is that as the child grows older the sensitivity to the protein allergen in the milk goes away within a few years.

Persistent casein milk allergy
It adversely affects 1-4 % of the adult public in the USA. This allergy is well recognized, however the relationship with childhood cow’s milk allergy is still being researched. One view is that some of the children with cow’s milk allergy do not become milk tolerant and their allergy persists into adulthood. Another view is that the persistent form of milk allergy may be first realized in early childhood but are immunologically distinct from the much more common childhood milk allergy. The immune reaction in the adult cases that persist is more intense and more specific. This is a hypersensitivity immune condition, meaning even very small amounts of the specific, (usually protein) antigen will trigger a significant reaction, and the reactions can be more severe. With a large range of findings, reports say that between 15 to 70% of the children with the generic early childhood allergic reaction to milk, will maintain the hypersensitivity into adulthood. It is clear that the persistent milk allergy is predominantly hypersensitivity to the casein molecules, but individuals can be triggered by different classes of casein and even the whey proteins (lactoglobulins). Some individuals with this form of milk allergy did not exhibit any reaction to milk in their childhood, and some “outgrow” the hypersensitivity later in their adult life.

Nearly all research on milk allergies have used commercial cow’s milk. There does not appear to be any study that used fresh unprocessed whole milk. And we are unaware of any collection of reports from persons or newborns drinking fresh unprocessed whole milk that would suggest that the allergic reactions do not occur when the milk is fresh and unprocessed. However, because these immunological reactions are very specific to the configuration of the protein allergen, studies could be conducted to see if milk proteins subject to pasteurization and homogenization and those native to the unprocessed milk have the same frequency of allergenic reactions.

Michigan Fresh Unprocessed Whole Milk Workgroup REPORT 2012
Lactose intolerance
Lactose intolerance (also called lactose maldigestion, or lactose malabsorption) adversely affects 10% of the public in the USA (15% of the households), 29 million Americans. [Opinion Research 2007] Lactose intolerance is not a disease it is a condition that arises in some people as they become older. The symptoms are variable amounts of abdominal pain, diarrhea, and intestinal gas. People usually learn that the symptoms occur when they drink milk or consume any dairy product. Lactose is the sugar in milk (of all mammals) and lactose is only present in the milk of mammals. Lactose is most effectively digested by an enzyme lactase (which is a β-galactosidase) forming glucose and galactose. These two sugars are readily absorbed from the small intestine and provide a rapid source of energy (glucose) and a more long term source of energy (galactose). Lactase is produced by the surface lining cells of the small intestine. As milk is consumed our intestinal lactase splits the lactose into glucose and galactose which are readily absorbed in the small intestine. In some people the amount of lactase produced by the lining cells declines as they get older. The amount of reduction is genetically controlled, and varies from person to person, and in people with different ethnic backgrounds. If the amount of lactase in the small intestine is not adequate to digest all of the lactose passing by, then the residual continues into the large intestine, which does not produce lactase. Within the large intestine the complex and variable microflora do digest the residual lactose but byproducts of these processes produce gas, irritate the intestine and cause the symptoms of the condition.

To the extent that some of the lactose in the consumed milk is already digested before it reaches the large intestine by mechanisms other than the intestinal lactase activity, the residual entering the large intestine is reduced. This could happen in the milk prior to consumption as well as within the transit of the milk after it is consumed. There is a large group of naturally occurring bacteria (many present in the dairy environment) that either digest lactose for their own energy needs, or produce exogenous lactases that digest lactose and produce byproducts within the milk. The digestion of lactose by some of these bacteria increases the acidity of the milk by their actions. The result of the activity of others is to convert lactose into glucose and galactose, resulting in an increase in sweetness of the milk. Many exogenous lactases are inactivated by the conditions in the stomach. However, this inactivation is minimized in the presence of milk. If these bacteria are allowed to be present in the milk, and are not inactivated by heating, they will effectively decrease the lactose load.

Susceptible individuals learn to avoid milk and, depending on the severity of their condition, may need to avoid even small amounts of lactose presence as ingredients in non-dairy products. The list of foods that contain lactose is very long, and even some prescription medications utilize lactose as an ingredient. There is considerable controversy about the naming of the condition, the diagnostic criteria and accuracy of the diagnosis. Consequently the size of the affected population is also controversial. There are hundreds of published studies on the prevalence of lactose intolerance. But it is impossible to give a definitive answer to the most obvious question, 'how many people have lactose intolerance?'. The variability in the reported prevalence is due to differences in population groups, differences in diagnostic criteria, differences in amount of lactose in the challenge dose used, and to some extent the bias of the group performing the study. North American Caucasian populations have a low percentage, African American have a high percentage. Examples published include: 50-100% of African Americans, 5-15% of Caucasian Americans. Almost all current reviews stress that many more people believe that they have lactose intolerant than are diagnosed by laboratory tests. Even with the lowest reported prevalences there are millions of adults in the USA who have this condition. The public health impact from lactose intolerance is not that these people become sick—it is that people who avoid milk because of their lactose intolerance are missing the nutritional benefits of having milk in their diets.
There are testimonials from individuals, who had not been drinking milk (because of lactose intolerance), that they are able to regularly drink fresh unprocessed whole milk. To explore this anecdotal information in more detail, an extensive questionnaire was distributed in May 2007 to families that belong to cowshare dairy groups in Michigan. Included in the questionnaire were questions about lactose intolerance. Of the 2,500 individuals surveyed, 6% reported having received a professional diagnosis of lactose intolerance. More than 80% of those individuals reported that they did not experience symptoms of lactose intolerance after drinking fresh unprocessed whole milk. While not confirmatory, the results suggest that for potentially a large number of people, drinking fresh unprocessed whole milk may represent an alternative to abstaining from milk altogether. The testimonies and findings from this survey do not provide objective criteria of lactose intolerance nor provide an explanation for the findings.

**Adulterants**

- From feed. Feeds are a potential source of ingredients or contaminants that could end up in the milk produced in the cows. Chemicals applied to forage as part of management, in pasture or once harvested, could also contaminate the milk produced in the cows.

- Residuals from cleaning operations or pharmaceutical treatments of the cows, and drugs used to enhance milk production can end up in the milk.

Both the public's perception of the consequences of adulterants or residuals, as well as scientific findings of their adverse effects, strongly influence fresh unprocessed whole milk consumer choices.

---

**Adverse Consequences Unique to Fresh Unprocessed Whole Milk Consumption**

**Initial reaction to higher butterfat content**

There have been instances in which people have had intestinal reactions when consuming generous servings of fresh whole milk for the first time. There may be a temporary laxative effect. One of the unofficial suggestions is that people trying this milk for the first time should start out drinking small amounts.

**Initial reaction to higher concentration of microorganisms**

There have been instances in which people have had transitional changes in intestinal reactions to microorganisms when they first start consuming fresh whole milk. One of the interpretations is that this may be a reaction of their intestinal microflora to the input of additional bacteria in the fresh unprocessed whole milk they drank.

**Changes in flavors**

There are changes in the taste of fresh unprocessed whole milk from time to time, related to the feed, condition of the lactating animals and other factors. Milk readily absorbs smells from the environment, so some off flavors may come from milk exposed to the farm, milking area, home or refrigerator smells. Consumers need to understand that this is to be expected. However, there are occasional times when some or many consumers notice a change in the milk that they find objectionable, or change the way the milk behaves. Families are told that when this happens they should contact the farmer.
## Table of Terms

<table>
<thead>
<tr>
<th>Word or Phrase</th>
<th>Synonym</th>
<th>Description Particularly Suitable for Discussion of Foodborne Bacterial Pathogens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biofilm</td>
<td></td>
<td>Some bacteria are able to secrete a biochemical netting that can cover and protect colonies from other bacteria, germicides, and other adverse conditions. When these nettings form on the surface of containers, tubing or mechanical structures, the biofilm can shield the underlying bacteria. Biofilm is not visible without magnification with a microscope. It is not uncommon for bacteria to grow under biofilm produced by other bacteria.</td>
</tr>
<tr>
<td>Carrier state</td>
<td></td>
<td>Person or animal without symptoms of illness that harbors and sheds virulent bacteria that can infect others or contaminate the environment.</td>
</tr>
<tr>
<td>Challenge dose</td>
<td></td>
<td>In the specific discussion of testing for lactose intolerance, the amount of lactose introduced (ingested) that is used to trigger a response that is then measured by the specific test.</td>
</tr>
<tr>
<td>Colonization</td>
<td></td>
<td>Some pathogens are able to grow within the intestinal tract of humans or animals, without causing illness. To distinguish this from infection, when it occurs without illness it is termed colonization.</td>
</tr>
<tr>
<td>Colonizers</td>
<td></td>
<td>When an animal's intestinal tract contains virulent bacteria that are shed in the feces, however, the animal is not ill.</td>
</tr>
<tr>
<td>colony forming units</td>
<td>cfu</td>
<td>Unit of measure for numbers of bacteria in a sample. Describes the number of colonies that form from a sample. When bacteria multiply on culture they form masses called colonies. Since bacteria often adhere to each other, it is not possible to be sure that each colony results from the multiplication of a single starting bacterium. Therefore, the term colony forming units is used to acknowledge that the origin of the colony could have been a single bacterium or a group of bacteria that were stuck together.</td>
</tr>
<tr>
<td>Compete</td>
<td></td>
<td>Ability to grow/multiply of a specific type of bacteria when surrounded by other types in the same environment.</td>
</tr>
<tr>
<td>Competitive Inhibition</td>
<td>Competitive exclusion</td>
<td>Within many environments there are large numbers of different bacteria, many of which are present in very large numbers. In such complex environments, those bacteria present in small numbers grow more slowly or may be excluded. There are many explanations for this inhibition including; the ability of some bacteria to secrete products that kill or injure other bacteria, the competition for nutrients and physical interactions.</td>
</tr>
<tr>
<td>Culture</td>
<td></td>
<td>Laboratory technique to enable individual bacteria present in a specimen to grow/multiply forming masses/colonies visible to the unaided eye. Also a mixture of nutrients specifically formulated to enable specific types of bacteria to grow/multiply.</td>
</tr>
<tr>
<td>Endemic</td>
<td></td>
<td>A specific disease occurrence that is widespread across large geographic area. Usually pertaining to a single animal or group of animals.</td>
</tr>
<tr>
<td>Enteritis</td>
<td>Gastroenteritis</td>
<td>Illness involving the cells lining the intestinal tract, including the stomach, small and large intestine.</td>
</tr>
<tr>
<td>Epidemic</td>
<td></td>
<td>Disease that is a significant public health problem spreading and infecting large numbers of people, or specific animals.</td>
</tr>
<tr>
<td>Epidemic clones</td>
<td></td>
<td>Occasionally an outbreak occurs with unusually high numbers of severe illness complications. The strain identified is often called an epidemic clone. Most commonly used with listeriosis.</td>
</tr>
<tr>
<td>Word or Phrase</td>
<td>Synonym</td>
<td>Description Particularly Suitable for Discussion of Foodborne Bacterial Pathogens</td>
</tr>
<tr>
<td>---------------</td>
<td>---------</td>
<td>---------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Exogenous</td>
<td>extracellular</td>
<td>Exogenous toxins are those that are active outside of the bacteria that produce the toxin. Endogenous toxins remain inside the body of the bacterium. In the context of lactose intolerance, exogenous enzymes are active outside of the intestinal cells or bacteria that produced them. Endogenous enzymes function within the body of the bacterium.</td>
</tr>
<tr>
<td>Extrapulmonary</td>
<td></td>
<td>Localized disease in parts of the body other than the airways and lungs.</td>
</tr>
<tr>
<td>Filter</td>
<td>Inline filter (sock filter) Milk filter</td>
<td>Membrane filter in the pipe lines from the milking to the bulk storage tank, designed to remove particles from the milk.</td>
</tr>
<tr>
<td>Flagella</td>
<td></td>
<td>A specific type of thread-like projection from the cell wall of some types of bacteria that enable movement.</td>
</tr>
<tr>
<td>Flagellar serotypes</td>
<td>“H” antigens</td>
<td>Category of subtypes distinguished by the proteins in the bacteria’s flagellum. Testing is made easier since the characteristic is on the outside of the bacteria.</td>
</tr>
<tr>
<td>Forage</td>
<td></td>
<td>Natural animal feed composed of grasses and non-woody plants as eaten in pasture, or harvested as hay. Generally does not include the seeds or roots.</td>
</tr>
<tr>
<td>Fresh, Unprocessed Whole Milk</td>
<td>FUW Milk</td>
<td>The product intended for direct human consumption since “raw milk” is used to describe milk intended for pasteurization.</td>
</tr>
<tr>
<td>Gastroenteritis</td>
<td>Enteritis, gastrointestinal illness</td>
<td>Illness involving the cells lining the intestinal tract, including the stomach, small and large intestine.</td>
</tr>
<tr>
<td>Genus</td>
<td></td>
<td>Scientifically established subgroup under “Family”. The genus name is the first word in the official name for a bacterial group, e.g., Listeria monocytogenes. Listeria is the genus, monocytogenes is the species.</td>
</tr>
<tr>
<td>Gram negative</td>
<td></td>
<td>Large group of bacteria identified under the microscope because they stain “negative” with dyes included in the Gram Stain. After the method is complete individual bacteria have a pink color.</td>
</tr>
<tr>
<td>Gram positive</td>
<td></td>
<td>Large group of bacteria identified under the microscope because they stain “positive” with dyes included in the Gram Stain. After the method is complete individual bacteria have a purple color.</td>
</tr>
<tr>
<td>H (serotypes)</td>
<td>Flagellar antigens</td>
<td>A protein associated with flagella (projections on surface of bacteria that enable motility), easily identified by commercially available tests and used to distinguish between serotypes of bacteria, e.g., E. coli H7.</td>
</tr>
<tr>
<td>Hemolytic uremic syndrome</td>
<td>HUS</td>
<td>Serious complication associated with certain forms of toxins produced by some virulent bacteria that may cause temporary kidney failure particularly in children.</td>
</tr>
<tr>
<td>Horizontal transfer</td>
<td>Lateral Transgenic</td>
<td>Genetic information that has been transferred between different species usually with viruses acting as the transfer agent. In contrast to ancestral genetic information. Genetic material that has been passed down over a long time from generation to generation. The DNA is within a chromosome. See sidebar in Pathogen Summary – E. coli page 45.</td>
</tr>
<tr>
<td>Host adapted</td>
<td></td>
<td>A particular subtype of bacteria has become selectively virulent in a single animal. Does not grow or multiply in other animals.</td>
</tr>
<tr>
<td>Immunity</td>
<td>resistance</td>
<td>General term used to describe mechanisms that resist infection</td>
</tr>
<tr>
<td>Incubation times</td>
<td></td>
<td>Interval between ingestion of virulent bacteria and onset of symptoms of illness</td>
</tr>
<tr>
<td>Word or Phrase</td>
<td>Synonym</td>
<td>Description Particularly Suitable for Discussion of Foodborne Bacterial Pathogens</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Infectious dose</td>
<td>Virulent</td>
<td>Amount of a virulent bacteria that will cause illness when consumed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>See Discussion – Infectious Dose. Page 60.</td>
</tr>
<tr>
<td>Infectious</td>
<td></td>
<td>Capable of establishing physical location to grow and multiply in a host. Also</td>
</tr>
<tr>
<td></td>
<td></td>
<td>meaning a form of bacteria that can be spread from one infected individual to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>others.</td>
</tr>
<tr>
<td>Inoculated</td>
<td></td>
<td>Mechanically introduce a type of bacteria. Usually in the context of an experiment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>to determine fate of a specific type of bacteria. Example: inoculating 100,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>individual bacteria into milk to determine whether they will grow, multiply,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>become inactivated or are killed.</td>
</tr>
<tr>
<td>Intercellular space</td>
<td>Interstitial</td>
<td>In tissues, the space between cells.</td>
</tr>
<tr>
<td>Intestinal microflora</td>
<td></td>
<td>The complex of microorganisms that populate the gut. Includes all forms of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>microscopic organisms.</td>
</tr>
<tr>
<td>Intracellular obligate</td>
<td></td>
<td>Organism that will only grow within living cells of the host animal.</td>
</tr>
<tr>
<td>parasite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isolate</td>
<td></td>
<td>Specific bacteria that originate from a single cultured colony, considered to all</td>
</tr>
<tr>
<td></td>
<td></td>
<td>be identical to the bacteria that multiplied to form the colony.</td>
</tr>
<tr>
<td>Lineage</td>
<td></td>
<td>Grouping of bacterial subtypes generally related to genetic heritage.</td>
</tr>
<tr>
<td>Listeriosis</td>
<td></td>
<td>In general any illness caused by listeria. However, it is more commonly used to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>describe the extremely rare, severe systemic illness excluding the far more</td>
</tr>
<tr>
<td></td>
<td></td>
<td>frequent mild forms of gastroenteritis.</td>
</tr>
<tr>
<td>Mastitis</td>
<td></td>
<td>Any infection of the mammary glands.</td>
</tr>
<tr>
<td>Milk Ring Test</td>
<td>Brucella milk</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ring test (BRT)</td>
<td>Screening test for brucella infection in dairy herds producing milk.</td>
</tr>
<tr>
<td>Matching</td>
<td></td>
<td>Some significant laboratory evidence that two or more isolates/strains of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>bacteria were the &quot;same&quot; or very similar.</td>
</tr>
<tr>
<td>Motile</td>
<td></td>
<td>Capable of self propelled movement, usually determined by observing the bacteria</td>
</tr>
<tr>
<td></td>
<td></td>
<td>with a microscope.</td>
</tr>
<tr>
<td>O (serotypes)</td>
<td>Somatic</td>
<td>Technically a portion of a large molecule embedded in the cell wall of bacteria.</td>
</tr>
<tr>
<td></td>
<td>Antigens</td>
<td>Differences in this portion of the molecule are used to distinguish subtypes of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>bacteria. Commercial reagents enable rapid identification of the different subtypes.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E.g., E. coli O157 is number 157 in the list of different O antigens which have</td>
</tr>
<tr>
<td></td>
<td></td>
<td>been identified in different subtypes of E. coli.</td>
</tr>
<tr>
<td>Obligate parasite</td>
<td></td>
<td>Will only grow and multiply within the cells of a host.</td>
</tr>
<tr>
<td>Outbreak</td>
<td></td>
<td>Technically two or more illness in people that are linked by a common source and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>within a specified time course.</td>
</tr>
<tr>
<td>Pathogen</td>
<td></td>
<td>General term for group of bacteria that have been associated with illness. Usually</td>
</tr>
<tr>
<td></td>
<td></td>
<td>in the form of the scientific name for the group.</td>
</tr>
<tr>
<td>Perinatal illness</td>
<td></td>
<td>Illness that occurs during the development of the fetus and in the newborn.</td>
</tr>
<tr>
<td>Persistent carrier state</td>
<td></td>
<td>Continuing to shed virulent bacteria for a long time (years) after an infection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>but without symptoms of illness.</td>
</tr>
<tr>
<td>Rod shaped</td>
<td>Rod shaped</td>
<td>Bacteria with elongated body when viewed in the microscope. In contrast to cocci</td>
</tr>
<tr>
<td></td>
<td></td>
<td>which are spherically shaped?</td>
</tr>
<tr>
<td>Word or Phrase</td>
<td>Synonym</td>
<td>Description Particularly Suitable for Discussion of Foodborne Bacterial Pathogens</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Ruminant animals</td>
<td></td>
<td>Sub-classification of animals (including cows, goats, and sheep) that have a digestive system that efficiently digests grasses and hay (leafy plants high in cellulose fiber).</td>
</tr>
<tr>
<td>Secondary Infection</td>
<td>Secondary Illness</td>
<td>Within a cluster of illnesses associated with a common cause, when someone becomes infected from close contact with someone in the cluster, rather than from ingesting the food; they are categorized as secondary infections. In contrast those who become infected from consumption of the food are considered primary infections.</td>
</tr>
<tr>
<td>Self limiting</td>
<td></td>
<td>Illness resolves without medical interventions.</td>
</tr>
<tr>
<td>Serotype</td>
<td>serovar</td>
<td>Category of subtypes distinguishable by different protein antigens (typically distinguished by the use of commercial antibody preparations).</td>
</tr>
<tr>
<td>Serovar</td>
<td>Serotype</td>
<td>Subtype distinguishable by different antigens (typically distinguished by the use of commercial antibody preparations). This is used with subtypes of the genus salmonella. In most other organisms the term serovar is used to distinguish subtypes of a species based on differences in a surface protein on the organism.</td>
</tr>
<tr>
<td>Somatic antigen</td>
<td></td>
<td>Characteristic of an antigen contained within the body, of a bacterium.</td>
</tr>
<tr>
<td>Species</td>
<td></td>
<td>Scientifically established subgroup under &quot;Genus&quot;. The species name is the second word in the official name for a bacterial group, e.g., Listeria monocytogenes. Listeria is the genus, monocytogenes is the species.</td>
</tr>
<tr>
<td>Sporadic cases</td>
<td>isolated cases</td>
<td>In epidemiology are those individuals with illness that have no known associated with other ill individuals.</td>
</tr>
<tr>
<td>spp.</td>
<td></td>
<td>When used in a scientific name the scientific abbreviation for “all species” e.g., Salmonella spp. Meaning all of the species within the genus salmonella.</td>
</tr>
<tr>
<td>Strains</td>
<td>subtypes</td>
<td>A term used for subtypes of a species.</td>
</tr>
<tr>
<td>Subclinical</td>
<td></td>
<td>Infectious state when the outward signs of illness are minimal.</td>
</tr>
<tr>
<td>Subspecies</td>
<td></td>
<td>Recognized subdivisions of the named species.</td>
</tr>
<tr>
<td>Subtype</td>
<td>Substrain</td>
<td>General term used to describe different groups within a named species.</td>
</tr>
<tr>
<td>Super Sheddners</td>
<td></td>
<td>When there is colonization of pathogens in the intestines of animals, the condition is generally transient, and the concentration of pathogens shed in the feces is low. However, there are uncommon individual animals that tend to have persistent colonization and shed much higher concentrations of the pathogen in their feces. These individual animals are called super sheddners.</td>
</tr>
<tr>
<td>Susceptible</td>
<td></td>
<td>Person who is capable of becoming infected</td>
</tr>
<tr>
<td>Systemic disease</td>
<td>widespread</td>
<td>The infectious bacteria have spread from the intestine into the body, usually through the blood stream and may infect other organs of the body.</td>
</tr>
<tr>
<td>tolerant</td>
<td>transient</td>
<td>In the context of allergic milk reactions, tolerant describes the finding that some people with milk allergies find that at a later time they no longer react to milk. Some people contrast persistent cow's milk allergy with transient/tolerant forms.</td>
</tr>
<tr>
<td>Toxin</td>
<td></td>
<td>Molecule, often a protein, produced by a bacteria that cause damage or illness. Some bacterial toxins remain within the bacteria (endogenous), others are secreted outside (exogenous).</td>
</tr>
<tr>
<td>Word or Phrase</td>
<td>Synonym</td>
<td>Description Particularly Suitable for Discussion of Foodborne Bacterial Pathogens</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Transient colonization</td>
<td>Temporary intestinal colonizers</td>
<td>Some pathogens are able to grow within the intestinal tract of humans or animals, without causing illness. When this colonization occurs for only a short time, or intermittently it is termed transient. The usual pattern in these cases is that the concentration of pathogens shed in the feces is low.</td>
</tr>
<tr>
<td>Unprocessed milk</td>
<td>raw milk</td>
<td>Milk that has not been pasteurized, homogenized, separated or otherwise mechanically altered after milking.</td>
</tr>
<tr>
<td>Virulence factors</td>
<td></td>
<td>Individual component of a virulent bacteria necessary in the sequence of steps leading to illness.</td>
</tr>
<tr>
<td>Virulent</td>
<td></td>
<td>Technical term describing the ability of a specific subtype of bacteria that have the genetic information necessary to cause illness.</td>
</tr>
<tr>
<td>zoonotic</td>
<td></td>
<td>Infectious diseases transmitted to humans from infected animals. Occasionally applied to human infections transmitted from animals even if the animals were not sick.</td>
</tr>
</tbody>
</table>
Topic Four

Risk and Benefit Management

1. What steps are necessary to minimize the health risk for consumers of fresh unprocessed whole milk?
2. Who is responsible for minimizing risk, as it relates to fresh unprocessed whole milk?
3. What steps can be taken to mitigate or prevent adverse impacts on the entire dairy industry in the event of a milk borne outbreak originating from milk consumption?
4. What management practices enhance benefits?
Summary
Approved August 28, 2012

Topic Four – Risk and Benefit Management

Introduction
In addressing the Working Group's Topic: Risk & Benefit Management questions 1 and 2, “What steps are necessary to minimize the health risk for consumers of fresh unprocessed whole milk?” and “Who is responsible for minimizing risk, as it relates to fresh unprocessed whole milk?”, we built on information and discussions in the previous Topics with additional information from consumers and practicing farmers. The group is not suggesting that the guidelines should be associated with a certification process, regulatory standards and/or “best practices”. The working group decided that we would provide guidelines, not propose rules/regulations, goals or requirements. And as we progressed through an orderly review of the risks, we determined that the guidelines would be best expressed in general terms. We also decided that providing these guidelines in the form of a table would facilitate understanding of our summaries by listing columns for “Issues/Concerns”, “Management Practices” - “(How)”, “Why”, and “Who”. The texts in each box are intended to suggest areas of management and are intentionally brief rather than detailed and specific. The items in the table Risk Management Summary are grouped in categories; however, there is no intent to list by priority or importance. These are a set of guidelines that should assist the farmer and consumer when considering their practices and management choices. We are unable to document evidence that would enable ranking the importance of the guidelines, nor to determine that any guideline is the optimal way to avoid risk.

You will see that the guidelines go beyond the traditional items included in risk management of food production. Usually such lists focus almost entirely on mitigating consumer illnesses. The market for Fresh Unprocessed Whole Milk (FUWmilk) is driven largely by consumer demand for this product. Some of the items are based on recognition of some of the specific factors that are important to the current consumers in Michigan - including factors they want and those that they do not want. Our group did not attempt to determine the rationale for these consumer preferences, other than accepting that they strongly influence current consumer choice for this product. And because the production of FUW milk is primarily consumer driven and certain dairy practices are unacceptable to these consumers, we expanded our listing to include items that could result in loss of consumers. We also expanded our listing to include items concerning the health of the dairy animals.

Our summary makes the important point that risk management is the responsibility of all those that handle FUWmilk, including farmers, handlers, and consumers.

Our group recognizes that it is not possible to actually determine that any of the items in the table have a proven record of reducing associated health risk. As shown in the workgroup's Topic: Risks, since the total numbers of clusters of illnesses attributed to the consumption of FUWmilk (the workgroup agreed to use the term fresh unprocessed whole milk (FUWmilk) to describe the product intended for direct human consumption since “raw milk” is used to describe milk intended for pasteurization) is small, investigations of these incidents have not determined a specific practice that might have been responsible for transmitting the infections. In many cases dairies that were associated with a cluster of illnesses have continued to supply FUWmilk without any recurrence of illnesses in their consumers. There is some research on linking specific practices to the transmission of infections, but none specifically using FUWmilk. Nearly all traditional mitigation suggestions are based on actions that might theoretically influence foodborne infections. However, we are unable to find any documentation of actual reduction
in the rate of clusters of illnesses attributed to FUWM when specific practices were changed. Therefore, it is important for farmers and consumers to understand that following the guidelines in the table below, either entirely or individually, will not guarantee that the produced and consumed milk will never be a vehicle for milkborne illnesses. The workgroup does not imply that production, handling and consumption of milk following these guidelines will result in fewer illnesses and certainly they are not an assurance/guarantee that the milk will always be safe. Nothing can guarantee that any food is always safe.

These guidelines considered conditions as they exist in Michigan in 2012. These will most likely evolve as producers, consumers and researchers learn more about Fresh Unprocessed Whole Milk.

### Table of Risk Management

#### HYGIENE

<table>
<thead>
<tr>
<th>Issue/Concern</th>
<th>Management Practice</th>
<th>Why</th>
<th>Who</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keep dairy housing clean</td>
<td>Have a management plan to keep housing areas clean</td>
<td>Consumer choice &amp; animal health</td>
<td>Farmer</td>
</tr>
<tr>
<td>Wear clean outer garments</td>
<td>Use footwear and coveralls appropriate to area of operations</td>
<td>Minimize contamination with high concentrations of pathogens virulent in people. Consumer preference.</td>
<td>All</td>
</tr>
<tr>
<td>Keep milking and milk handling areas clean</td>
<td>Regular cleaning and good housekeeping</td>
<td>Consumer choice, animal health and minimizing contamination</td>
<td>Farmer, Consumer</td>
</tr>
<tr>
<td>Keep equipment and containers clean</td>
<td>Regular cleaning</td>
<td>Consumer choice, animal health and minimizing contamination</td>
<td>Farmer, Consumer</td>
</tr>
<tr>
<td>Separate source of water from dairy animals</td>
<td>Avoid animals contaminating water supplies</td>
<td>Consumer choice &amp; animal health</td>
<td>Farmer</td>
</tr>
</tbody>
</table>
## CONSUMER PREFERENCES

<table>
<thead>
<tr>
<th>Issue/Concern</th>
<th>Management Practice</th>
<th>Why</th>
<th>Who</th>
</tr>
</thead>
<tbody>
<tr>
<td>Providing undesirable feed</td>
<td>Choice of feed</td>
<td>Changes taste of milk or how milk can be used</td>
<td>Farmer</td>
</tr>
<tr>
<td>Undesirable ingredients in feed</td>
<td>Choice of feed</td>
<td>Consumer wants to avoid certain ingredients in feed</td>
<td>Farmer</td>
</tr>
<tr>
<td>Lack of communication between Farmer and Consumer/Written agreement</td>
<td>Have a formal contract between farmer and consumer</td>
<td>Many reasons</td>
<td>Farmer, Consumer</td>
</tr>
<tr>
<td>Consumer rejection of products</td>
<td>Respond to consumer's desires about feed and animal treatments</td>
<td>Consumer choice</td>
<td>Farmer</td>
</tr>
<tr>
<td>Do not import milk from another dairy</td>
<td>Only use milk from your dairy animals</td>
<td>Consumer choice. Trace back is severely compromised. Increased risks from management of other dairy</td>
<td>Farmer</td>
</tr>
<tr>
<td>Labeling as milk</td>
<td>Labeling</td>
<td>Insure that consumers know that it is fresh unprocessed whole milk</td>
<td>Farmer</td>
</tr>
<tr>
<td>Maintain creamline</td>
<td>Do not separate out cream from milk, appropriate feed, and select herd genetics</td>
<td>Consumers want to have cream and want assurance the milk is not degraded</td>
<td>Farmer</td>
</tr>
<tr>
<td>Real-time communication between farmer and consumer</td>
<td>Provisions in Contract and establish trust and personal interactions</td>
<td>Feedback on changes in milk: taste/smell, ability to make products, adverse reactions, and speed of traceback and recall when necessary</td>
<td>Farmer, consumer</td>
</tr>
</tbody>
</table>

## DAIRY ANIMALS

<table>
<thead>
<tr>
<th>Issue/Concern</th>
<th>Management Practice</th>
<th>Why</th>
<th>Who</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check quality of feed supplier</td>
<td>Know feed supplier and monitor quality of any feed</td>
<td>Feed can be a source of infectious agents or toxic contaminants.</td>
<td>Farmer</td>
</tr>
<tr>
<td>Maximize forage and minimize grain</td>
<td>Utilize pasture</td>
<td>Animal health and quality of milk are optimized if appropriate feed is supplied. Consumers have preferences</td>
<td>Farmer</td>
</tr>
<tr>
<td>High quality feed</td>
<td>Pasture, Optimize forage types and quality to suit the animal/genetics</td>
<td>Optimize animal health, quality of milk produced. Consumers are often very concerned about animal nutrition</td>
<td>Farmer</td>
</tr>
<tr>
<td>Use local feed sources</td>
<td>Purchase feed locally</td>
<td>Influence consumer choice</td>
<td>Farmer</td>
</tr>
<tr>
<td>Keeping beneficial biology of intestinal tract</td>
<td>Manage quality of feed</td>
<td>Feed choice influences intestinal tract biology</td>
<td>Farmer</td>
</tr>
<tr>
<td>Issue/Concern</td>
<td>Management Practice</td>
<td>Why</td>
<td>Who</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-----------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Keeping soil in balance</td>
<td>Ongoing soil monitoring including microbiology</td>
<td>Feed choice influences intestinal tract biology</td>
<td>Farmer</td>
</tr>
<tr>
<td>Keeping soil organic content high</td>
<td>Monitor soils and augment with appropriate organic material</td>
<td>Improve quality of feed</td>
<td>Farmer</td>
</tr>
<tr>
<td>Maintain quality of imported feed</td>
<td>Insure that imported feeds are of high quality</td>
<td>Animal health</td>
<td>Farmer</td>
</tr>
<tr>
<td>Improving soils</td>
<td>Test soils, Soil management plan</td>
<td>Improve quality of feed</td>
<td>Farmer</td>
</tr>
<tr>
<td>Avoid animal stress</td>
<td>Attention to farm design and management</td>
<td>Consumers are concerned about animal welfare. Stress can adversely affect animal health.</td>
<td>Farmer</td>
</tr>
<tr>
<td>Cleaning up manure</td>
<td>Avoid accumulations of manure</td>
<td>Animal health and consumer concern about farm management and milk quality.</td>
<td>Farmer</td>
</tr>
<tr>
<td>Closed herd</td>
<td>Maintain closed herd</td>
<td>Consumer choice &amp; animal health</td>
<td>Farmer</td>
</tr>
<tr>
<td>Control herd genetics, for example butterfat, protein and animal health.</td>
<td>Develop herd genetics</td>
<td>Animal health, animal stress and milk quality.</td>
<td>Farmer</td>
</tr>
<tr>
<td>Colostrum</td>
<td>Segregate milk from dairy animals that recently calved</td>
<td>Colostrum is not milk</td>
<td>Farmer, Consumer</td>
</tr>
<tr>
<td>Keep herd small in number</td>
<td>Management choice</td>
<td>Keep operations manageable, minimize infectious diseases in herd</td>
<td>Farmer</td>
</tr>
<tr>
<td>Lactation management.</td>
<td>Avoid late lactation milk</td>
<td>Farmer preference. Potential adverse taste of milk</td>
<td>Farmer</td>
</tr>
<tr>
<td>Milkings per day</td>
<td>Decide on frequency of milking</td>
<td>Farmer preference</td>
<td>Farmer</td>
</tr>
<tr>
<td>Maintain adequate ventilation</td>
<td>Design barn with good ventilation</td>
<td>Animal health and consumer concern about farm management</td>
<td>Farmer</td>
</tr>
<tr>
<td>Minimize confinement of dairy animals</td>
<td>Make choices on design of housing</td>
<td>Consumers are concerned about animal welfare. Design of housing influences dairy animals behavior, cleanliness, stress can affect animal health</td>
<td>Farmer</td>
</tr>
<tr>
<td>Nature of stall design</td>
<td>Make choices on design of stalls</td>
<td>Consumers are concerned about animal welfare. Design of stall influences dairy animals behavior, cleanliness, stress</td>
<td>Farmer</td>
</tr>
<tr>
<td>Provide clean bedding</td>
<td>Maintain clean area for animals to bed both indoors and outdoors</td>
<td>Animal health and consumer concern about farm management</td>
<td>Farmer</td>
</tr>
<tr>
<td>Keep milk from suspect dairy animals separate</td>
<td>Identify unhealthy dairy animals and keep their milk separate</td>
<td>Human health</td>
<td>Farmer</td>
</tr>
<tr>
<td>Issue/Concern</td>
<td>Management Practice</td>
<td>Why</td>
<td>Who</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Reduce contact with fresh manure</td>
<td>Keep environment, housing, animals, containers, equipment, and people handling milk, clean.</td>
<td>Consumer choice &amp; animal health. Keep milk visibly clean for consumer acceptance.</td>
<td>Farmer</td>
</tr>
<tr>
<td>Filter milk</td>
<td>Filter milk</td>
<td>Avoid clumps of material that might contain high concentrations of undesirable bacteria</td>
<td>Farmer</td>
</tr>
<tr>
<td>Chill milk immediately</td>
<td>Chill milk immediately to 42°F or less within 45 minutes of milking</td>
<td>Maintain levels and types of microorganisms in milk, maintain taste and shelf life</td>
<td>Farmer</td>
</tr>
<tr>
<td>Evenly distribute butterfat</td>
<td>Keep cream evenly suspended when filling consumers containers</td>
<td>Consumers want the cream</td>
<td>Farmers, Handlers, Consumers</td>
</tr>
<tr>
<td>Keep milk cold</td>
<td>After chilling maintain at 35°F to 38°F through distribution and home storage till milk is consumed.</td>
<td>Extend shelf life. Maintain microbiological balance in milk. Minimize enzymatic and other undesirable changes in the milk.</td>
<td>Farmers, Handlers, Consumers</td>
</tr>
<tr>
<td>Do not keep milk at refrigerated temperatures for months</td>
<td>Suggest 'consume-by'time</td>
<td>Avoid growth of listeria and other undesirable microorganisms that might increase to undesirable concentrations in the milk.</td>
<td>Farmer, Consumer</td>
</tr>
<tr>
<td>Maintain open and trusting relationship between farmer and consumer</td>
<td>Formalize relationship (contract). Keep personal relationship. Maintain reliable and rapid means of communication between consumers and farmers.</td>
<td>The consumer is a valuable monitor of the quality of the milk. Since they consume and use their milk regularly, changes in the taste/ smell, appearance, and the way it behaves (including self life, and ability to make products, are more likely to be noticed. If there is an open and trusting relationship it is more likely that undesirable changes in the milk will be recognized.</td>
<td>Farmer, Consumer</td>
</tr>
<tr>
<td>Distribute to a well-defined consumer pool</td>
<td>Formalize relationship (contract). Encourage trust. Maintain personal contact.</td>
<td>The ability to trace problems, identify causes of any problems, and facilitate rapid and effective corrective action is enhanced.</td>
<td>Farmer, Consumer</td>
</tr>
<tr>
<td>Initial reaction to drinking FUWmilk</td>
<td>When drinking FUWmilk for the first time, consume in moderation.</td>
<td>Consumption of any new food product can lead to gastrointestinal issues</td>
<td>Consumer</td>
</tr>
</tbody>
</table>
## MONITORING, LABORATORY TESTING, AND RECORD-KEEPING

<table>
<thead>
<tr>
<th>Issue/Concern</th>
<th>Management Practice</th>
<th>Why</th>
<th>Who</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cull persistent, high shedders</td>
<td>Monitor for pathogens in animals, if individual dairy animals are positive they should be removed from the farm</td>
<td>Dairy animals may be colonized with pathogens, but usually only for short times and they shed low concentrations of those pathogens. However, rarely colonization persists and these individuals may shed higher concentrations. They are potential sources of contamination of the herd, and the farm environment.</td>
<td>Farmers</td>
</tr>
<tr>
<td>Maintain records, observations animal health</td>
<td>Monitor, save</td>
<td>Enable quality control management. Promote transparency. Enhance consumer confidence.</td>
<td>Farmer</td>
</tr>
<tr>
<td>Monitoring animal behavior</td>
<td>Observe animals for behavior suggestive of listeriosis</td>
<td>To avoid listeriosis in herd</td>
<td>Farmer</td>
</tr>
<tr>
<td>Monitoring animal behavior and vaccination</td>
<td>Test for bovine viruses or vaccinate</td>
<td>Maintain herd health</td>
<td>Farmer</td>
</tr>
<tr>
<td>Observe animals in herd</td>
<td>Observation of behavior; testing with somatic cell count (SCC)</td>
<td>Herd and individual animal health, to enable prompt and appropriate interventions</td>
<td>Farmer</td>
</tr>
<tr>
<td>Testing animals upon entering herd</td>
<td>Test all new animals entering herd for bovine tuberculosis, brucella, Johnne's</td>
<td>To avoid communicable diseases in herd</td>
<td>Farmer</td>
</tr>
<tr>
<td>Decreasing environmental contaminants</td>
<td>Monitor farm environment, avoid contamination of farm with biological, chemical and physical hazards.</td>
<td>Animal health</td>
<td>Farmer</td>
</tr>
<tr>
<td>Testing/Record maintenance</td>
<td>Test, monitor, save and display records</td>
<td>Enable quality control management. Promote transparency. Enhance consumer confidence.</td>
<td>Farmer</td>
</tr>
<tr>
<td>Adverse event</td>
<td>Develop and maintain a written plan to address an adverse event that may occur.</td>
<td>A rapid response and evaluation may minimize potential consequence of adverse event.</td>
<td>Farmer</td>
</tr>
<tr>
<td>Issue/Concern</td>
<td>Management Practice</td>
<td>Why</td>
<td>Who</td>
</tr>
<tr>
<td>---------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>Vigorous cleaning of equipment</td>
<td>Monitor for bacteria in milk by using one of the available tests. Watch for high spikes of bacterial counts. If cause of these spikes can not be easily explained and corrective action taken, then vigorously clean the milking, milk handling and milk storage equipment.</td>
<td>Many microorganisms in milk are able to form biofilm, which are sequestered and persistent environments for proliferation of microorganisms. When biofilm with masses of bacteria become free in the milk they can be a source of periodic high spikes in bacterial counts in the milk. Biofilm is difficult to remove, without aggressive cleaning, including mechanical brushing.</td>
<td>Farmer</td>
</tr>
<tr>
<td>Keep high concentrations of virulent pathogens from containers</td>
<td>Avoid contamination of milk containers with high concentrations of pathogens virulent in people. This includes keeping sick people from handling containers.</td>
<td>Milk containers can transmit infectious bacteria if the contamination is with high concentrations and the time after contamination is short.</td>
<td>Farmers, Handlers, Consumers</td>
</tr>
<tr>
<td>Keep people with virulent pathogens from contact with milk.</td>
<td>Sick people, particularly those with diarrheal infections, must avoid contact with farm animals, milking operations, handling of milk and milk containers.</td>
<td>Because these people shed high concentrations of virulent microorganisms that are virulent in people. Avoid contamination with high concentrations of microorganisms that are virulent in people.</td>
<td>Farmers, Handlers, Consumers</td>
</tr>
<tr>
<td>Avoid contamination of milk with infectious material from poultry processing.</td>
<td>Separate milk handling operations from poultry processing/butchering operations</td>
<td>Poultry intestinal tracts commonly contain high concentrations of pathogens that could infect people. During processing the pathogens could contaminate milk being handled in the same area.</td>
<td>Farmers</td>
</tr>
<tr>
<td>Separate calves from dairy animals</td>
<td>Birthing area and young dairy animals should be kept in an area away from the dairy herd</td>
<td>Although colonization with pathogens is transient and shedding is with low numbers, it has been shown that calves may have a higher prevalence of colonization, and shed with higher numbers of pathogens</td>
<td>Farmer</td>
</tr>
<tr>
<td>Separate dairy animals from poultry</td>
<td>Minimize comingling of poultry with dairy animals. If poultry are present, the flock should be tested for shedding of pathogens virulent in people</td>
<td>Poultry are a common source of high concentrations of pathogens. If the pathogens are virulent in people, the poultry can be source of colonization in dairy animals.</td>
<td>Farmers</td>
</tr>
<tr>
<td>Separate milking and storage of milk areas from poultry.</td>
<td>Minimize comingling of poultry with dairy animals, milking operations, and milk handling areas. If poultry are present, the flock should be tested for shedding of pathogens virulent in people.</td>
<td>Poultry are a common source of high concentrations of pathogens. If the pathogens are virulent in people, the poultry can be source of colonization in dairy animals, direct contamination of milk and containers with numbers of virulent pathogens that could infect consumers.</td>
<td>Farmer</td>
</tr>
</tbody>
</table>
### SOURCES OF PATHOGENS VIRULENT IN PEOPLE

<table>
<thead>
<tr>
<th>Issue/Concern</th>
<th>Management Practice</th>
<th>Why</th>
<th>Who</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separating farm animals</td>
<td>Design and equip facilities to separate groups of farm animals.</td>
<td>To minimize the spread of potential virulent pathogens.</td>
<td>Farmer</td>
</tr>
<tr>
<td>Separation of poultry from areas where milk containers are filled</td>
<td>Minimize comingling of poultry with dairy animals, milking operations, and milk handling areas. If poultry are present, the flock should be tested for shedding of pathogens virulent in people. Poultry should be kept out of areas where milk containers are filled.</td>
<td>Poultry are a common source of high concentrations of pathogens. If the pathogens are virulent in people, the poultry can be source of colonization in dairy animals, direct contamination of milk and containers with numbers of virulent pathogens that could infect consumers.</td>
<td>Farmer, Handler, Consumer</td>
</tr>
<tr>
<td>Avoid handling milk in areas of the home where fresh meat and poultry has been handled.</td>
<td>If fresh meat and poultry has been handled in the kitchen, the surfaces and utilities should be cleaned before milk is handled in the same area, or by the same people.</td>
<td>Fresh meats are a common risk of pathogens in high concentrations. Fluids in the packaging can contaminate surfaces, equipment and people.</td>
<td>Consumer</td>
</tr>
<tr>
<td>Culling individual animals</td>
<td>Monitor herd</td>
<td>Animal health, improve handling of animals</td>
<td>Farmer</td>
</tr>
</tbody>
</table>

### WATER

<table>
<thead>
<tr>
<th>Issue/Concern</th>
<th>Management Practice</th>
<th>Why</th>
<th>Who</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleaning before milking</td>
<td>Clean teats before milking. Avoid accumulations of dirt on dairy animals</td>
<td>Animal health</td>
<td>Farmer</td>
</tr>
<tr>
<td>Insuring that irrigation water is clean</td>
<td>If irrigation is necessary, avoid using contaminated water.</td>
<td>Animal health</td>
<td>Farmer</td>
</tr>
<tr>
<td>Keeping dairy animals out of water</td>
<td>Separate dairy animals from standing water</td>
<td>Animal health</td>
<td>Farmer</td>
</tr>
<tr>
<td>Keeping manure out of water</td>
<td>Separate dairy animals from standing water</td>
<td>Animal health</td>
<td>Farmer</td>
</tr>
<tr>
<td>Locating the well away from sources of contamination</td>
<td>Avoid contamination of well water</td>
<td>Well water is used in cleaning.</td>
<td>Farmer</td>
</tr>
<tr>
<td>Maintain clean, fresh water supply for animals</td>
<td>Monitor with testing of all water supplies</td>
<td>Water is essential for animal health. Water can be contaminated without visible change.</td>
<td>Farmer</td>
</tr>
<tr>
<td>Testing water for contamination</td>
<td>Monitor with testing of all water supplies</td>
<td>Water is essential for animal health. Water can be contaminated without visible change.</td>
<td>Farmer</td>
</tr>
</tbody>
</table>
Question 3. What steps can be taken to mitigate or prevent adverse impacts on the entire dairy industry in the event of a milkborne outbreak originating from milk consumption?

The workgroup encourages more people to include milk in their regular diet and is concerned about factors that would reduce the public’s perception of milk’s benefits. Both the advocates for fresh unprocessed whole milk and organized dairy are eager to increase the consumption of milk.

The risk that there will be a reduction of consumption of conventional milk if we enable raw milk (FUW milk) production –
An independent survey conducted in Michigan found that many people who are currently obtaining fresh unprocessed whole milk (FUW milk) want to include milk in their diet, but do not want the product that is widely available in the retail markets. Many of those using herdshare operations to obtain FUW milk were not previously drinking conventional milk. Enabling these people to consume a product (FUW milk) enhances the mutual goal of having more people include milk in their diet. The workgroup is not aware of any evidence that making FUW milk available reduces the market for conventional milk.

The risk that there will be a reduction in the conventional milk market resulting from announcements of foodborne outbreaks attributed to raw milk (FUW milk) –
There is accumulating evidence that there is a reduction in the market for a category of food that is the target of an ongoing investigation of illnesses. This has been documented for incidents in which media attention accompanying public health announcements is widespread and continues over a period of time.

Several factors are associated with this adverse impact on the public’s purchasing patterns.
1. Initial public health investigations have progressed to the point that a category of food is strongly suspected as the vehicle for the spread of illnesses and this prompts mentioning a particular food category in the public notice and media reports.
2. The illnesses occur over a large or unspecified portion of the country, prompting widespread (both regional and national) and there is sustained media attention.
3. Illnesses continue to be reported well after the index cases, prompting repeated announcements about the suspect food category and continuing media attention which caused general alarm in the public.
4. There is a “recall” of the suspect food category, visible in the retail stores.
5. During the height of the media attention the investigation has not narrowed the source of the illnesses to a specific product or producer.
6. Despite specificity in the updated agency news releases the media attention sometimes fails to make it clear that only a subset of the food category is suspected and other supplies of the food are not implicated. The public alarm grows and the public attributes the threat to a food, not a product or producer.

Even though marketing research has shown that the adverse impact on sales is only temporary even a temporary impact could have significant market risk for the dairy industry since milk has nationwide sales and is frequently and consistently purchased by many households - milk is one of the most common items in the consumer’s grocery cart.

However, there are several factors that differentiate the marketing impact of milkborne illnesses from the recent incidents with fruit, leafy crops, nuts and meat:
- Incidents attributed to raw milk are local because the producer’s distribution is geographically very limited particularly with herdshare operations.
• Analysis of incidents attributed to raw milk show that most have a very short media time span - typically several days or a week.
• We are not aware of a milkborne outbreak that was not quickly associated with the specific product and a specific producer. Therefore, the initial, and often only announcements, target raw milk specifically and identify a specific producer.
• Over the last decades the public has learned that "raw milk" is a different product than the commercial milk that they see and purchase in the grocery stores. Public announcements and the resulting media attention have consistently emphasized the product distinction specifically in all coverage. When raw milk is suspected no one fails to make the public aware that this is raw milk and not the product Grade "A" pasteurized milk that they are purchasing.

With milk the possible marketing risk is not theoretical. We have actual experience which enables objective observations. There have not been any scientifically controlled studies on the market effect of raw milk outbreak coverage. But it is difficult to imagine that the public's awareness of raw milk outbreaks can increase above the current dramatic attention that occurs with every incident that is attributed to raw milk. And many of the news releases from government agencies are designed to heighten the public's worry about becoming ill from dairy products that have not been pasteurized.
4. What management practices enhance benefits?

Fresh Unprocessed Whole Milk has inherent benefits to the consumer and the farmer. There are certain practices that are understood to preserve and enhance these benefits. Many of these benefits are described in Topic Two – Benefits and Values: Question 6. Assuming that all milk is not the same, what do production and management practices have to do with fresh unprocessed whole milk’s nutritional value, pathogens, color, taste, etc.? and Question 7. What is the impact of consumer preferences on production and management practices of fresh unprocessed whole milk?

### Table of Benefit Management

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Practices</th>
</tr>
</thead>
</table>
| Beneficial bacteria in FUW milk                       | Pasture-based living conditions  
|                                                       |  - Exposure to a variety of fresh high quality forages contributes to a balanced and diverse population of bacteria and enables reduced grain feeding  
|                                                       |  - Maintain appropriate level of the ration as forage  
|                                                       |  - High forage intake helps keep the rumen healthy  
|                                                       |  - A healthy animal  
|                                                       |  - Balanced soils, quality feed, and well managed living conditions promote normal bacteria  
|                                                       |  - Keep milk cold  
|                                                       |  - Maintains existing balance of bacteria  
| Enzymes                                               | A healthy animal  
|                                                       |  - Balanced soils, quality feed, and excellent living conditions promote a healthy animal  
| CLAs, Omega 3s (Beneficial Fatty Acids)                | Minimal grain feeding  
|                                                       |  - Ample fresh forage and minimal grain promote well balanced fatty acid chains  
| Flavor                                                | Introduce new feeds slowly  
|                                                       |  - This keeps the rumen in balance and the milk consistent  
|                                                       |  - Limit noxious aromatic feeds, especially the turnip and onion families  
|                                                       |  - The butterfat in milk transfers flavor from the diet  
|                                                       | General cleanliness  
|                                                       |  - Milk takes flavors from its surroundings  
|                                                       |  - Unclean equipment will overwhelm desirable flavors  
|                                                       | Keep milk cold  
|                                                       |  - Cold milk retains good flavor  

---

Michigan Fresh Unprocessed Whole Milk Workgroup REPORT 2012
85
4. What management practices enhance benefits? continued

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding and Appreciation of Milk</td>
<td>Education</td>
</tr>
<tr>
<td></td>
<td>- Be willing to spend time with consumers to answer questions and make suggestions</td>
</tr>
<tr>
<td></td>
<td>- Self-education makes for a better relationship and a more rewarding experience</td>
</tr>
<tr>
<td></td>
<td>Encourage home processing</td>
</tr>
<tr>
<td></td>
<td>- Home processing fosters appreciation of all processing and a better understanding of the medium</td>
</tr>
<tr>
<td></td>
<td>Give access to the farm</td>
</tr>
<tr>
<td></td>
<td>- Regular exposure to the farm and its workings will encourage a greater understanding of milk</td>
</tr>
<tr>
<td>Consumer Confidence</td>
<td>Give access to the farm</td>
</tr>
<tr>
<td></td>
<td>- If the consumer is pleased with the farm, it increases confidence in dairy</td>
</tr>
<tr>
<td></td>
<td>Build relationships</td>
</tr>
<tr>
<td></td>
<td>- Familiarity makes input and concerns more comfortable</td>
</tr>
<tr>
<td></td>
<td>Test</td>
</tr>
<tr>
<td></td>
<td>- Milk consistently documented as clean gives confidence to the consumer as well as the producer</td>
</tr>
<tr>
<td></td>
<td>General cleanliness</td>
</tr>
<tr>
<td>Traceability</td>
<td>Testing of milk</td>
</tr>
<tr>
<td></td>
<td>- A consistent testing program can help identify potential problems if there are changes from established patterns</td>
</tr>
<tr>
<td></td>
<td>Organize a regular pickup day with contact information</td>
</tr>
<tr>
<td></td>
<td>- Consumers can easily be alerted of impure milk</td>
</tr>
<tr>
<td></td>
<td>- Troubleshooting is simplified</td>
</tr>
<tr>
<td></td>
<td>- Accurate recordkeeping facilitates identification of shareholders</td>
</tr>
<tr>
<td>Vitamins &amp; Minerals</td>
<td>Sun exposure increases Vitamin D content</td>
</tr>
</tbody>
</table>
Topic Five

Consumer Choice Options

1. How might consumer access to fresh unprocessed whole milk be achieved?

2. How might people who are considering choosing to drink fresh unprocessed whole milk be properly educated and informed on their choice?
Summary
Approved August 28, 2012

Topic Five – Consumer Choice Options

1. How might consumer access to fresh unprocessed whole milk be achieved?

Based on the attitudes of current consumers of fresh unprocessed whole (FUW) milk, the following was surmised.

Currently consumers of FUW milk go to great lengths to get their milk. Many make weekly trips out to the farm. Taking their own bottles and filling them from the cooled milk supply. Some car pool share this responsibility, however, many are making the weekly trip alone. Others make weekly trips to dedicated drop off points, including farmer’s markets, where they can pick up their weekly allotment of their cow share.

Though the consumers of FUW milk understand the restrictions to access of this product and are willing to do what it takes to obtain it. Many expressed a desire to be able to purchase milk in a retail setting. They are frustrated by what they see as unnecessary restrictions to this product and outright prohibition of their ability to make their own food choices.

At this point in time, consumers believe, until the government is willing to objectively look at the data which clearly shows that the risk of drinking FUW milk is relatively nil, consumers are content to continue with the present arrangements of the herd share program. They are also anxious to know that this arrangement will be acceptable to the state so that they and the farmers can have confidence in the certainty of their access to FUW milk. Many expressed the need for more farmers to participate in this program, increasing the supply as well as giving farmers the opportunity to have a successful business by meeting the demand.

2. How might people who are considering choosing to drink fresh unprocessed whole milk be properly educated and informed on their choice?

Government policy should not prevent consumers from making responsible food choices. Educating the consumer about FUW milk should really be the consumer’s responsibility. Just as it is the consumer’s freedom to decide if they want to smoke cigarettes, drink alcohol, take medications, eat sushi, consume artificial sweeteners, drink espresso, eat soy products, eat GMO foods, or eat a vegan diet/hi carb diet/animal protein diet. Consumers make these decisions every day. Choices about food are essential to our health and well-being. There is plenty of information available to the consumer who is looking for it on the benefits and risks of drinking FUW milk.
Food Safety & Inspection Program

SECTION: General

Fresh Unprocessed Whole Milk

Policy

Policy

This policy is built upon the recommendations of the Fresh Unprocessed Whole Milk Workgroup. The workgroup agreed to use the term Fresh Unprocessed Whole (FUW) milk to describe the product intended for direct human consumption since “raw milk” is used to describe milk intended for pasteurization.

Michigan Dairy Laws state in MCL 288.538 and in MCL 288.696, “Only pasteurized milk and milk products shall be offered for sale or sold, directly or indirectly, to the final consumer or to restaurants, grocery stores, or similar establishments”. The Food Law states in MCL 289.6140, “Only pasteurized ingredients from a department-approved source shall be used for milk and milk products manufactured, sold, served, or prepared at a retail food establishment.”

In a herd share operation, consumers pay a farmer a fee for boarding their animal (or a share of an animal), caring for the animal and milking the animal. The herd share shareholder then obtains (but does not purchase) the raw milk from his or her own animal.

Herd share operations include the following elements.

- There should be a signed and dated written contract between a single herd share farmer and shareholder.
- There must be a workable means of communication between the farmer and all of the households receiving milk.
- Milk should be from a single farm and not co-mingled

Key points

- The Michigan Department of Agriculture and Rural Development (MDARD) does not license or inspect the herd share portion of a dairy farm.
- Herd share programs are considered to include only FUW milk intended to be consumed by people.
- FUW milk is not for sale or resale.
- FUW milk cannot be distributed from a licensed food establishment.
- Products such as butter, yogurt, cheeses, etc. made from FUW milk were not included in the workgroup’s discussions and are not considered by MDARD to be part of a herd share operation and therefore are subject to applicable MDARD laws and regulations.
- Advertising of herd shares is not regulated by MDARD.

The workgroup felt comfortable with these decisions based on the fact that there is a defined consumer pool, rapid traceback is possible and the farmer and shareholder are both responsible for maintaining the quality of the milk.