

DISSERTATION

SCIENCE OF FOOD FERMENTATION: DEVELOPMENT OF A UNIVERSITY  
CURRICULUM AND OUTREACH EDUCATIONAL MATERIALS

Submitted by

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## ABSTRACT

### SCIENCE OF FOOD FERMENTATION: DEVELOPMENT OF A UNIVERSITY CURRICULUM AND OUTREACH EDUCATIONAL MATERIALS

While food and beverage fermentation is rooted in thousands of years of global traditions, today it is experiencing a revitalization by consumers interested in the health benefits and organoleptic qualities. A research-based, learner-centered, introductory-level, undergraduate academic curriculum was developed to address the need for understanding biochemical processes related to fermented food and developing critical thinking skills. Course findings, supporting research, and demand from consumers and outreach educators, guided complementary outreach materials development on related fermentation topics.

The curriculum for FTEC 210, *Science of Food Fermentation*, was designed, implemented, and evaluated for outcomes in Year 1 (n=15) and Year 2 (n=22). The course focused on science, history, culture, gastronomy, safety, health, and nutrition aspects of fermented foods and beverages, while addressing core food science competencies in food chemistry, microbiology, food processing, and applied food science. Curriculum development was designed around students' initial knowledge level, and then gaps were addressed for deeper understanding. Learning events alternated between direct instruction and experiential learning to engage diverse undergraduate learners in problem solving and application and inspire cognitive growth through evaluation and creation.

Student change in knowledge, attitudes, and behaviors was assessed via pre-course and post-course questionnaires compared to a control group. Qualitative interviews, conducted mid-

semester in Year 1, and course survey comments from Years 1 and 2, clarified quantitative data and provided feedback on curriculum usefulness and course satisfaction. Areas of analysis included demographics and grades, for reflection on student comprehension, content delivery, and assessments. Complementary teaching materials requested by and created for Extension educators and consumer use included an online training, a hands-on workshop, and related outreach publications.

Students enrolled in FTEC 210 significantly increased knowledge from pre to post course ( $P < .0001$ ), and their mean increase in knowledge was significant in comparison to the control group ( $P < .005$ ). All students reported increased consumption of fermented food and drinks, and indicated active learning, in laboratory exercises, furthered opportunities for positive impacts on their education including self-studies and home practices.

Curriculum content and informal hands-on student yogurt variation trials led to outreach publication development. Outreach trainings integrated experiential learning with research-based information to nurture retention and confidence. Requests from the public health community for the dissemination of credible fermentation information continues to guide fermentation outreach material development beyond the scope of this project.

In this mixed methods study, results showed the curriculum had impact and relevance for cognitive development of university students and food knowledge application across disciplines, including integration of cultural diversity education and incorporation of biochemical processes. The use of experiential learning in course design enabled students to construct new knowledge through integrating base knowledge from lecture, collective interaction with lab partners, and hands-on learning practices in this course. This food fermentation curriculum met academic

demands, increased student understanding and confidence, and supported material development for outreach dissemination.

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## CHAPTER 1: INTRODUCTION

Preservation of food products by fermentation has been a part of culinary history long before the science, safety, and nutritional attributes of fermented food and drinks were fully understood. The health, economic, safety, and alcoholic attributes of fermented products ensures that they will stay rooted in the world diet (Steinkraus, 1997). Fermented products including yogurt, kefir, cheese, beer, wine, pickles, sauerkraut, bread, salami, and tempeh are commercially available to consumers today and interest in this area is on the rise. With an increased focus on improved food safety, gastrointestinal and overall health, and diverse fermented consumable product development, this is an appropriate time to provide research-based do-it-yourself education to diverse audiences, in the science that harnesses the activities of microorganisms for beneficial results. Colorado State University (CSU) is establishing a reputation in this unique area of science through the creation of a Fermentation Science and Technology (FST) major in the Department of Food Science and Human Nutrition (FSHN), with the acceptance of students beginning Fall 2014. The FST major was created on the backbone of a strong departmental brewing science and functional foods program as well as viticulture and enology concentration in the Department of Horticulture and Landscape Architecture. Prior to the establishment of the major, there was need for developing an undergraduate introductory-level course on the science of food fermentation, as well as making available research-based outreach materials that would encourage consumers to safely use local ingredients to ferment their own nutritious and desirable products, while increasing awareness of the nutritional and culinary benefit of fermented food and drinks.

CSU, as a land-grant institution and Carnegie Research University (Very High Research Activity), has long been a reputable resource for the educational welfare of its students and the local and state community. CSU offers diverse curriculum for students' academic interests across eight colleges, close to sixty departments and schools, and over sixty-five undergraduate majors. The new Fermentation Science and Technology major within the Department of Food Science and Human Nutrition housed in the College of Health and Human Services, strengthens the existing FSHN degree programs for undergraduates to major in Nutrition and Food Science, which includes concentrations in dietetics and nutritional management, nutrition and fitness, nutritional sciences, and food safety and nutrition; and a major in Hospitality Management. Departmental outreach efforts through Extension, grant the state community access to evidence-based information for their educational needs. In addition, as the Colorado land-grant institution, educational success of university students feeds into outreach potential by way of disseminating knowledge gained through the curriculum as community members.

Universities in the United States that offer programs in fermentation science are limited, but now growing along with the fermentation revival. Most of these programs focus on brewing or enology, distinguishing the program at CSU as one of few that provides students an educational opportunity for career preparation in multiple food and beverage industries. CSU is the first university in the Rocky Mountain Region to provide undergraduate students a course and major strictly on the science of fermentation.

The overarching goal to provide a service and seek information, not proof, directed the objectives for my research project. The following specific aims were posed to guide the process.

## Specific Aims

1. Develop an undergraduate level course that will address existing gaps in fermentation science education at Colorado State University and enable progress towards a degree program in the field of fermentation.
2. Expand on current outreach Extension materials addressing fermented foods and drinks, yogurt in particular, to provide current developmentally appropriate educational materials to diverse audiences.
3. Evaluate Aims 1 and 2 for meeting fermentation educational needs of distinct audiences including: undergraduate students at CSU, Colorado Extension field agents, and potentially nationwide consumers of online publications.

Creation of a university course affords the opportunity to develop complementary educational materials providing outreach to the local, state, and national community. Extension is the premier resource for up-to-date research-based materials on food preservation. Training of CSU Extension Nutrition, Health, and Food Safety agents in food preservation topics is ongoing and previously did not include an overview of the science of fermentation. On-line fact sheets are available to consumers on food preservation topics such as canning, freezing, and drying but the information available on fermented foods is very limited. As of this publication, the only CSU fact sheets directly related to fermentation are # 9.337 Making Soft Cheeses (not currently available) and #9.304 Making Pickles.

The development of a fermentation overview course for CSU students and community-driven outreach materials extends important benefits to Colorado consumers. The course is relevant for undergraduate students across disciplines to apply knowledge in fields of food

science and safety, nutrition, hospitality management, microbiology, biology, agricultural sciences, environmental health, animal sciences, sociology and other social sciences. In addition, the course integrates cultural diversity applications into food education. Outreach community members reached include diverse rural and urban audiences who are interested in fermentation as a food preservation technique, for its cultural and historical significance, as an application of food microbiology, for entrepreneurial food product development, and for research-based information on potential health attributes. The provision of material resources to a national audience through this research project will aid in establishing CSU as a respected source for information in the field of fermentation.

## CHAPTER 2: LITERATURE REVIEW

### **Fermentation**

Food and beverage fermentation is a biochemical process whereby microorganisms metabolize carbohydrates and transform the existing raw agricultural substrate into a unique desirable product via production of metabolic end-products including lactic acid, ethanol, and carbon dioxide. Fermentation is presumed to be the oldest food processing technique. It is theorized that early discovery was by accident, yet with the discovery that the agricultural products not only kept well, but also tasted good, substrates were then intentionally fermented. Historical evidence for cultural production and consumption of fermented beverages dates back to over 9000 years ago in ancient China. McGovern and others (2004) have chemically confirmed the earliest known fermented beverage produced was a wine-like beverage made from a mixture of rice, honey, and fruit.

The proposed earliest solid food intentionally produced through fermentation was over 8000 years ago in the “Fertile Crescent” (Fox & McSweeney, 2004). This was the time when plants and animals were initially domesticated; people recognized that the milk of their goats and sheep was nutritive and wanted to store it for themselves and used what they had available: the stomachs from animals. Storing the milk in the animal stomachs activated spontaneous fermentation and initiated lactic acid bacterial growth which increased the acidity of the milk to the isoelectric point (pH 4.6) at which the milk protein casein coagulates. This initial product was fat trapped in a gel, much like a layer of sour cream. The acidity of the milk had the potential to activate enzymes present in the storage stomachs that would curdle the cultured milk, resulting in butter or cheese. These and other international findings indicate that fermented foods

and drinks have a long history in the diets of diverse cultures and the economic growth of communities. Fermented products became a part of global indigenous cultures and were passed on through traditions. For example, fermented dairy, such as kefir and yogurt products, are still more commonly consumed than fluid milk in the region within present day Middle Eastern countries that include Turkey, Iraq, and Syria.

It was not until the 1800's that chemists began to understand that fermentation of food was due to microorganisms (Barnett, 2003a). Yeasts were the primary microorganisms of study because they were identifiable using microscopic technology of the era and alcohol industries funded research. In 1857, Louis Pasteur published his findings on yeast fermentation in which he was able to show that fermentation was initiated by living organisms (Barnett, 2003a). Until the Industrial Revolution, production of fermented food and drinks was limited to small-scale production. Large-scale fermentation processes and defined starter cultures were developed with the shift to large-scale food production during the early stages of the Industrial Revolution (Caplice & Fitzgerald, 1999).

### ***Ecology***

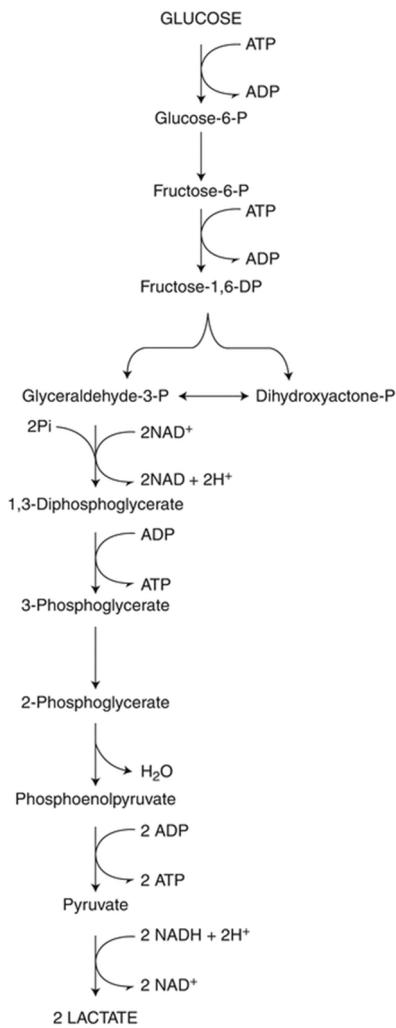
Fermentation is a biological food processing technique and growth of nontoxigenic beneficial microorganisms is desirable. Unlike canning, where sterilization and heat processing are required to effectively remove all microorganisms, many fermented products are described as alive. The microorganisms used may be preexistent on food (i.e. on cabbage for sauerkraut) or added as starter culture (i.e. inoculating milk for yogurt). Without the use of starter cultures, there is more variability in the bacteria present and potential for less consistency with the end product. Commercial enterprises often rely on identifying distinguishing microorganisms for

sought after organoleptic qualities in order to minimize resource expenditures. In the case of fermenting cabbage for sauerkraut, a cheap and easy ferment of an already healthful vegetable, addition of *Leuconostoc mesenteroides* did not appreciably alter sensory attributes, while allowing for decreased salt concentrations across variations in raw agricultural substrates, and in some instances improving phytochemical levels (Johanningsmeier, McFeeters, Fleming, & Thompson, 2007; Peñas, Frias, Sidro, & Vidal-Valverde, 2010). The direct environment and geographical region can impact culture presence in the microbial ecosystem and consequently end product variability. *Lactobacillus sanfranciscensis*, one bacterial species within the diverse ecology of yeasts and bacteria that make up the iconic San Francisco sourdough bread, may not be specific to the region, as is still under consideration, yet may not out-compete indigenous lactic acid bacteria if used to produce sourdough in other regions (De Vuyst et al., 2014).

Fermentation occurs through an anaerobic conversion of carbohydrates by microorganisms to the metabolic end products. There are two kingdoms of fermenting microorganisms: fungi, which are multicellular and include yeast and molds, and unicellular eubacteria. Most of the fermenting bacteria are functionally classified as lactic acid bacteria (LAB) because they are carbohydrate fermenting bacteria that produce lactic acid as a major metabolic end product. Primarily this includes genera of the phylum *Firmicutes* in the order *Lactobacillales* such as *Lactobacillus*, *Streptococcus*, *Leuconostoc*, *Pediococcus*, *Lactococcus*, *Enterococcus*, *Weisella*, *Carnobacterium*, *Oenococcus*, *Tetragenococcus*, and *Vagococcus*, as well as related genera *Bifidobacterium* (Holzapfel & Wood, 2014). LAB are categorized as either homolactic or heterolactic contingent on the metabolic pathway and end products, primarily determined by family. Homolactic bacteria follow the glycolysis or Embden-Meyerhof-Parnas (EMP) fermentation pathway (see Figure 1) whereas heterolactic bacteria follow the

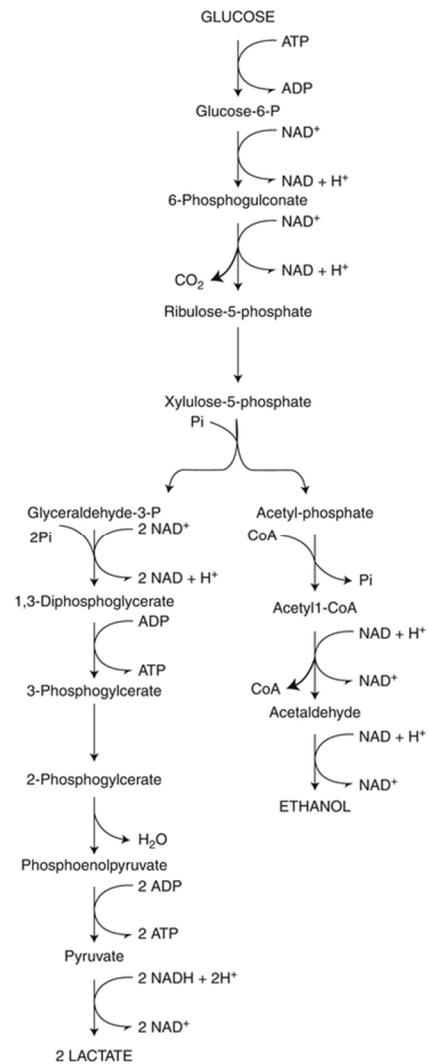
phosphoketolase pathway (see Figure 2). Homofermenters primarily include families *Enterococcaceae*, *Lactobacillaceae*, and *Streptococcaceae* and convert one mole of glucose to two moles of pyruvate, which are reduced to lactic acid in the absence of oxygen.

Heterofermenters primarily include families *Leuconostocaceae* and species within the *Lactobacillus* genera. Following this pathway utilizes one mole of glucose to produce one mole each of lactic acid, carbon dioxide, and ethanol (Endo & Dicks, 2014).



**Figure 1:** Embden-Meyerhof-Parnas pathway: homolactic bacteria metabolism of glucose to lactate.

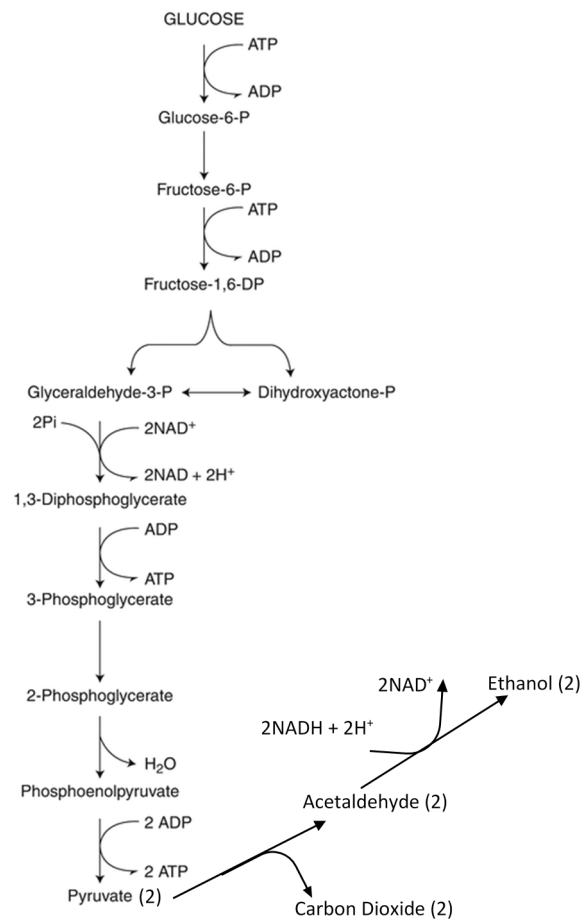
Image from: (Doyle, Steenson, & Meng, 2013)



**Figure 2:** Phosphoketolase pathway: heterolactic bacteria metabolism of glucose to lactate, ethanol, and carbon dioxide.

Image from: (Doyle et al., 2013)

Nineteenth century studies on fermentation by yeast led to initial findings on glycolysis, or carbohydrate metabolism (Barnett, 2003b). Yeast fermentation first undergoes glycolysis utilizing the enzymes comprising the EMP pathway, yet the catabolism of pyruvate leads to ethanol production, via conversion first to acetaldehyde, not lactate, and carbon dioxide (see Figure 3) (Barnett, 2003b; Dickinson & Kruckeberg, 2006). Other lactic acid bacteria are often also present in yeast fermentations and will produce organic acids that decrease the pH of the product and contribute to organoleptic qualities. The same yeast and grain ingredients can produce unique consumable end products due to processing and sought after metabolic end products, for example carbon dioxide is vital for leavening and texture of bread while the ethanol bakes off, whereas fermenting with similar ingredients to produce beer retains the ethanol component.



**Figure 3:** Yeast glycolytic pathway and catabolism of pyruvate.

Image adapted from: (Doyle et al., 2013)

Fermentation is rarely the effort of one microorganism, but several acting concurrently or sequentially, owing to the genetic diversity in microbiological ecosystems. Select microorganisms thrive in favored environmental conditions, including salinity level, temperature, pH, oxygen concentration, water activity, and nutrient

content (Battcock & Azam-Ali, 1998). LAB are social microorganisms, and fermenting the substrate is part of the practical relationship to foster a suitable environment for bacterial colony growth and development. There are three main stages of bacterial sequencing, as one bacteria starts to slow down due to increased acidity, conditions become favorable for the next in sequential colonization, yet enzymes still function. In the example of sauerkraut production, shredding the cabbage bruises the plant cell walls, which draws out fermentable sugars and water. Adding salt for brine preparation will increase salinity, while decreasing water activity and available oxygen, as well as inhibiting pathogenic microorganisms. These early conditions, when maintained at room temperature (64.4-71.6°F), favor colonization of present smaller, salt-loving, heterofermentative *Leuconostoc mesenteroides* bacteria which produce carbon dioxide and lactic acid. These metabolic end-products lower the pH to an acidic level and decrease oxygen content creating a selective environment for homofermentative *Lactobacillus plantarum*. LAB succession continues, lactic acid production increases, and pH drops to a safe level for acidic preservation (Battcock & Azam-Ali, 1998).

### ***Benefits***

Fermentation transforms agricultural substrates into new and often sensory pleasing products (Mothershaw & Guizani, 2007). Fermentation has its roots as a means of producing safe foods and beverages with enhanced health benefits using low energy expenditure (Battcock & Azam-Ali, 1998). It was his direct observation of centenarians in the Balkans that led Russian scientist Élie Metchnikoff, world-renowned for his immunity research, to suggest human longevity could be attributed to beneficial effects of fermented milk products (Metchnikoff & Mitchell, 1908). Qualities of fermented foods and beverages differ due to factors including substrate, available

microorganism ecology, attention to variables for cultivation, and final end product, but in general, many fermented foods and drinks have health attributes such as:

- Improved shelf life and safety of products, including prevention of pathogenic contamination (van Boekel et al., 2010),
- Living microorganisms that confer health benefits to the consumer, including those classified as probiotic organisms, and prebiotics availability (Stanton, Ross, Fitzgerald, & Van Sinderen, 2005),
- Reduced anti-nutrients, such as phytic acid bound to minerals in grains, and increased bioavailability of certain nutrients through enzyme activity (Poutanen, Flander, & Katina, 2009; Raes, Knockaert, Struijs, & Van Camp, 2014),
- Enhanced nutrient availability, including B-vitamins and antioxidant activity (Burgess, Smid, & van Sinderen, 2009; Paško et al., 2009),
- Reduced lactose in dairy and increased lactase enzyme for improved digestibility (Smith, Kolars, Savaiano, & Levitt, 1985),
- Chemical compounds produced, including organic acids, and other altered compounds that may positively impact our gut microbiota, thus in turn beneficially influencing health outcomes like mental health, and risk of chronic disease or cancer (Dufresne & Farnworth, 2000; McGovern et al., 2010; Selhub, Logan, & Bsted, 2014), including the hypothesis by Petyaev and Bashmakov (2012) that aged, mold ripened cheese is a factor in the decreased cardiovascular disease risk of the “French paradox.”

Consumers are becoming increasingly aware of attributes of certain fermented products associated with digestive and immune health, such as probiotics in functional dairy foods

(Kapsak, Rahavi, Childs, & White, 2011). Consumers and health professionals in health discussions and product marketing commonly use the term probiotic. Yet the term and what it encompasses is still confusing even to scientists. A recent panel of experts revised the 2002 accepted definition to be “live microorganisms that, when administered in adequate amounts, confer a health benefit on the host” (Hill et al., 2014). The panel recommends that fermented foods and drinks, with unspecified microbial strains, should not be labeled as probiotic food sources, but instead that they contain live and active cultures. Exceptions include cultured dairy products, such as yogurt, containing *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus salivarius* subsp. *thermophilus* shown to facilitate lactose digestion.

Fermentation, from a global perspective, serves an important role in improving food security, especially in developing countries. This is through the benefits already listed, but also the added ability for communities to minimize food waste and utilize more of the harvested products, reduce cooking fuels and cooking times needed to make foodstuffs consumable, increase individual economic opportunities through production and sales, and practice traditional usage for perceived medicinal attributes (Battcock & Azam-Ali, 1998).

### **Consumer Behavior and Educational Opportunities**

Countless traditional fermented foods and beverages, such as yogurt, cheese, pickles, bread, beer, and wine, have grown in presence in the Western diet and are manufactured for their desirable sensory characteristics. Small to large-scale industrial application of fermentation techniques are increasing fermented product market availability, to supply consumer demands for the revival of living functional foods.

Regrettably, lifestyle diseases (e.g. obesity, diabetes, cardiovascular disease, cancer) are increasing in prevalence in part due to the decline of traditional food practices and decreasing quality of American dietary behaviors. For example, sprouting, soaking, and souring grains and beans has moved out of standard practice as a food preparation technique despite the ability to improve product healthfulness without reformulation (Rowe et al., 2011). Dietitians and food scientists are on the front-line of public health, tasked to redirect consumer behavior towards desirable products supporting positive health outcomes. Ares, Giménez, and Gámbaro (2008) report a decrease in willingness to try some foods with perceived health benefits, including yogurt, among those with limited nutrition knowledge. A survey of students at a university in Canada indicated that most of respondents were unfamiliar with fermented or probiotic dairy products and stated they may consume more if they were aware of potential health benefits (Hekmat & Koba, 2006). Wansink, Westgren, and Cheney (2005) further clarify this from a study on food consumption in relation to knowledge of food attributes, which shows a correlation between knowledge of consumption consequences, and consumption. They state that consumers need two types of nutrition education in order to choose a food based on functional characteristics; they need to have knowledge on what the benefits are for eating the food and why those benefits are attributed to the food. They describe a consumption hierarchy of consumer knowledge starting with no knowledge, moving to attribute knowledge on why a specific food is beneficial, then consequences knowledge on what the actual benefits are of consuming that specific food, and subsequently, food consumption. Fermenting takes time and effort; commercial availability relieves that barrier to potentially bolster a national dietary resurgence.

Consumer demand for local foods is on the rise (Martinez et al., 2010). Although “local” is not clearly defined, for many consumers it is a preference for foods procured geographically nearby, especially supporting smaller farms and often those committed to sustainable practices. For some, this means gardening or directly supporting a farm, which may result in a surplus of seasonal products at a given time. As a result, this local foods movement has revitalized food preservation practices. Education on fermentation as a safe, low energy preservation technique that does not depend on specialized equipment, is in demand by community outreach educators, as evidenced by personal communication with outreach educators. In addition, interest in university-level fermentation science programs is seeing growth in order to meet national industrial demand for safely producing diverse fermented consumables (Department of Food Science and Human Nutrition at Colorado State University, 2015).

## **Teaching and Learning**

### ***Teaching***

A responsibility of an instructor is to construct a suitable environment for encouraging cognitive development in learners, or the skills on how to learn and construction of intelligence including remembering, problem-solving, and decision-making (Weinstein, Meyer, Husman, McKeachie, & King, 2011). Instructors in higher education are tasked with creating a safe learning space to engage adult learners representing varied learning styles, interests, abilities, and demographics; a teaching and learning environment that helps students take responsibility for their learning (Schmidt, 2014). The focus of the teaching and learning environment should be on the students not the educators, steered by the critical engagement, thought processes, and feelings, desired by the educator (Davis, 2009).

Use of various learning theories and developmental approaches are appropriate to guide the process of creating a curriculum for nurturing learning. Understanding by Design (UbD), as a curricular planning approach, is applicable for the industry-driven needs of an introductory food fermentation course (Wiggins & McTighe, 2011). The UbD framework is essentially a backwards design model; plan curriculum with the end in mind. First the instructor identifies desired results or objectives, then determines acceptable evidence including both formative (monitor) and summative (evaluate) assessment techniques, and then plans learning experiences and instruction accordingly.

Within the curricular plan, intentional use of mixed modes of delivery and assessment can often engage a diverse audience of students with a broad representation of learning styles and modes. Mixed instructional methods, such as direct instruction and experiential learning, should be considered for advantages and disadvantages based on confines of the learning environment. In a hands-on laboratory-focused class, students are actively learning, learning by doing, and problem-solving with application to different forms of intelligence. This includes opportunities for advancing greater cognitive development through social learning, as students work with a laboratory partner or small group to provide dialogue, interaction, peer teaching and learning, and collaboration.

Differentiation for ability levels recognizes that not all students start with the same base knowledge in a course. The developmental approach is to predict students' initial knowledge level, and target the gaps to reach a deeper understanding of the subject matter (Svinicki & McKeachie, 2011). Undergraduates are of age to be considered adults, and as Halx posits (2010), should be regarded as such in the classroom. Andragogy, or adult learning theory, as introduced by Knowles assumes adult learners have self-concept, experience, a readiness to learn,

orientation to learning, and motivation to learn (Smith, 2002). Students interested in fermentation curricula cover the spectrum for initial knowledge and attitudes; some students are avid home brewers interested in deepening their understanding, some students are taking the course simply to fill a microbiology requirement, and the rest of the students align somewhere in between.

Intentional compilation and integration of data from multiple evaluation techniques, provides evidence for progression of high-quality instructional methods (Lattuca & Domagal-Goldman, 2007). Quantitative end-of-course survey results and qualitative student group interview sessions represent effective methods of student evaluation for curriculum assessment and drawing study conclusions. In combination with student outcome grades and pre-course and post-course questionnaire data, assessment information provides the basis for mixed methods research, allowing for a more accurate picture of successful instruction (Creswell & Plano Clark, 2007).

### ***Learning***

A study on student perceptions of learning gains in an introductory nutrition and food science course reported that students ranked class activities, including lecture, discussion, and in-class materials, as the highest reflection on what contributed to their individual learning (Anderson, 2006). Researchers at the University of Illinois implemented an experiential learning activity in two of the four sections of a large introductory food science and nutrition course (Bohn & Schmidt, 2008). Student-assessed impact included improved comprehension and motivation. Students personalized their learning, which in turn showed improved cognition and overall investment in the course, in comparison to the control sections. Experiential learning, as defined by the authors, occurs when a learner participates in an activity, reflects and analyzes the

experiential content to create new knowledge, and incorporates it into their comprehension. Experiential learning, as an active learning technique, can make the information more meaningful to students and improve retention for better summative assessment performance (Yoder & Hochevar, 2005). Use of situated learning involves student exposure to tools of the trade and collaboration with local industries, granting access for learning to take place in the authentic context. This, in combination with functional knowledge approaches, makes the learning relevant to the “real world.”

The Institute of Food Technologists (IFT) established Core Competencies in Food Science as a guidance for undergraduate program development, to afford exceptional educational experiences, as preparation for professional application (Institute of Food Technologists, 2011). Beyond knowledge measures in the field of study, “Success Skills” deemed vital for accomplished food science graduates includes communication skills, critical thinking skills, professionalism skills, life-long learning skills, and interaction. Critical thinking is an approach to cognition, in order to cultivate skills for the thinker, or learner, to engage in better thinking. It goes beyond topic focus, it is self-guided, and it encourages thinkers to reach high quality solutions. At Purdue University, researchers Hayes and Devitt (2008) incorporated planned student-led discussions in a large freshman food science course in order to encourage student development of critical thinking skills. Student-led discussions also introduce students, especially those early in their academic path, to professional situations of working collaboratively with others. Although difficult to fully evaluate critical thinking skills, researchers Iwaoka, Li, and Rhee (2010) tested the Cornell Critical Thinking Test in an Experimental Foods course and found significant gains in deduction and assumption aspects. The authors state the value of use of classroom journaling for students to improve skills in reasoning,

analysis, and problem solving. This along with take-home exams, open-ended questions, experiments with multiple objectives, writing lab reports, and use of problem-based learning were indicators of critical thinking skills gained while putting emphasis on transformational learning, or the process of structuring meaning from an experience.

### **Colorado State University**

The Carnegie Classification of Institutions of Higher Education classifies Colorado State University (CSU) as a large, four-year, primarily residential university with balanced arts and sciences instructional programs, high undergraduate enrollment that is selective in admissions, with a higher rate of transfer students ("The Carnegie Classification of Institutions of Higher Education," 2015). CSU is listed as a Carnegie Research University (very high research activity) including STEM dominant graduate instructional programming. Colorado boasts a strong history in agricultural industries, including contributions to livestock, organic foods, specialty crops, and dairy production. Colorado, notably Fort Collins, is a top producer of beer, including craft breweries ("Colorado Food and Agriculture," 2015).

The Department of Food Science and Human Nutrition (FSHN) at CSU boasts three unique undergraduate degree programs: Nutrition and Food Science, with concentrations in Nutrition Sciences, Food Safety and Nutrition, Nutrition and Fitness, and Dietetics and Nutrition Management; Fermentation Science and Technology; and Hospitality Management. In addition, the graduate programs of study are specializations in Human Nutrition, Food Science, Functional Foods for Health, and Food Science/Safety. The diverse majors and specializations each correlate with food and beverage fermentation; it is a field of study that draws together strengths across the disciplines in a transdisciplinary approach.

CSU Extension and university outreach educational efforts, in general, extend research and education from the university to consumers. CSU was established as a Land Grant University under the Morrill Act of 1862, which enacts the college to be:

“...without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts, in such manner as the legislatures of the States may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life” ("Act of July 2, 1862 (Morrill Act)").

The Smith-Lever Act of 1914 advanced outreach efforts for dissemination of current, research-based agricultural information from land-grant universities through the establishment of Cooperative Extension Services. CSU Extension provides a wide array of programs and resources to educate all ages and income levels of rural and urban populations throughout Colorado counties (Colorado State University Extension, 2014). Family and Consumer Science (FCS) Extension agents provide programs and resources on health related topics, including safe food preservation and nutrition. FCS agents are often local community members, trained by faculty specialists for content information and delivery. They participate in continuing education efforts to provide current, research-based information sought after in their local communities. In addition, Extension publications are an online resource, written and updated by CSU faculty and students, and available to a global audience.

## **Summary**

A review of the literature substantiates the need for scholarly, up-to-date research on fermented consumables. In order to advance such research, academic institutions are needed to provide apt conditions for teaching and learning that engage critical thinking, drive research questions, and therefore contribute to new knowledge. CSU is well suited to provide an

innovative foundational fermentation course that addresses gaps in research and instruction already ongoing and translational science disseminated to the public. Successful student scholarship and undertakings corroborates with emerging consumer awareness and curiosity, that fermentation studies are valuable for CSU undergraduate students and will bring value to the Food Science and Human Nutrition Department at CSU.

This curriculum development was unique, first as a stand-alone university course driven by demand and then as a core introductory course in the Fermentation Science and Technology major. The delivery and evaluation of the curriculum have informed refining the curriculum and can cultivate furthering the education mission of the major and department. The objectives for this doctorate study were to develop a learner-centered university course on fermented foods and beverages, augment outreach education messaging based on demand by way of the developed university curriculum, and evaluate and continually amend these materials for advancing investigation and instruction on the subject of fermented foods and beverages.

## CHAPTER 3: SCIENCE OF FOOD FERMENTATION: DEVELOPMENT OF A UNIVERSITY CURRICULUM<sup>1</sup>

### Summary

While food and beverage fermentation is rooted in thousands of years of global traditions, today we are experiencing a surge in interest by consumers aware of its health benefits and organoleptic qualities. Interdisciplinary instructors at Colorado State University developed a research-based, learner-centered, introductory-level, undergraduate academic curriculum to increase fermentation education availability. FTEC 210, *Science of Food Fermentation*, was implemented and evaluated for outcomes in Year 1 (n=15) and Year 2 (n=22).

Curriculum development was designed around students' initial knowledge level, then gaps were addressed for deeper understanding of natural and social fermentation sciences. Learning events alternated layers of direct instruction and experiential learning to engage diverse learners in problem-solving and application, and inspire cognitive growth through evaluation and creation.

Student change in knowledge, attitudes, and behaviors was assessed via pre-course and post-course questionnaire compared to a control group. Qualitative interviews, conducted mid-semester in Year 1, and course survey comments from Years 1 and 2, clarified quantitative data and provided feedback on curriculum usefulness and course satisfaction. Areas of analysis included student demographics and grades, for reflection on content delivery and assessments.

Students enrolled in FTEC 210 significantly increased knowledge from pre to post course ( $P < .0001$ ), and their mean increase in knowledge was significant in comparison to the control group ( $P < .005$ ). All students reported increased consumption of fermented food and drinks, and

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<sup>1</sup> Manuscript to be submitted to the *Journal of Food Science Education*.

indicated that active learning in laboratory exercises such as self-studies and home practices enhanced their education.

This curriculum is relevant for cognitive development of university students and food knowledge application across disciplines, including integration of cultural diversity education and incorporation of biochemical processes.

## **Introduction**

Fermentation has historical and cultural significance predating current awareness of science, safety, and nutritional attributes of fermented food and drinks. Food and beverage fermentation is a biochemical process whereby microorganisms metabolize carbohydrates and transform the existing raw agricultural substrate into a uniquely flavored desirable food product via production of metabolic end-products including lactic acid, ethanol, and carbon dioxide. Fermentation, as a means of producing safe foods and beverages with enhanced health benefits, originated thousands of years ago as a food preservation technique and maintains substantial importance in indigenous cultures globally (Battcock and Azam-Ali 1998; McGovern and others 2004). Many fermented foods and drinks have healthful benefits such as improved shelf life and safety of products (van Boekel and others 2010), probiotics and prebiotics availability (Stanton and others 2005), anticancer properties (McGovern and others 2010), degradation of anti-nutritional factors that hinder absorption of nutrients which improves bioavailability of certain minerals (Raes and others 2014), reduced lactose in dairy (Smith and others 1985), and improved sensory properties (Mothershaw and Guizani 2007). Moreover, consumers are becoming increasingly aware of attributes of certain fermented products associated with digestive and immune health, such as probiotics in functional dairy foods (Kapsak and others 2011).

Additionally, many traditional fermented foods and beverages, such as yogurt, cheese, pickles, bread, beer, and wine, have grown in usage in the Western diet and are manufactured for their desirable sensory characteristics. Small to large-scale industrial application of fermentation techniques are increasing fermented food product market availability and helping to meet consumer demands for functional foods.

Increased consumer interest in fermentation warrants development of a research-based curriculum in higher education. A learner-centered curriculum, in a science that harnesses the activities of microorganisms for beneficial results, feeds outreach potential. Setting the course learning outcomes based on industry standards directs course assessment development, which in turn guides learning events, benefiting student performance and professional preparation (Hartel and Gardner 2003). The Institute of Food Technologists (IFT) established Core Competencies in Food Science as guidance for undergraduate program development, to afford exceptional educational experiences, as preparation for professional application (Institute of Food Technologists, 2011). Competencies cover application and integration within food safety and microbiology, food processing and engineering, applied food science, and success skills, which includes communication skills, critical thinking skills, professionalism skills, life-long learning skills, and interaction skills. Imbedding direct instruction with student-led discussions introduces students to professional situations of working collaboratively with others as well as developing critical thinking skills (Hayes and Devitt 2008). Applying experiential learning, via laboratory exercises and product development, places expectations on students to construct new knowledge through integrating the base knowledge from lecture, social interaction with a laboratory partner, and active hands-on practices (Kolb and Kolb 2005). Students enrolled in FTEC 210, *Science of Food Fermentation*, participated in a unique experiential curriculum to learn-by-eating.

Specific aims for this study were to 1) Develop an undergraduate level course to guide the development of critical food science skills and address existing gaps in fermentation science education in the Rocky Mountain region, 2) Evaluate materials for meeting fermentation curricular needs of the distinct audience, undergraduate students, and amend for future course delivery.

## **Materials and Methods**

Interdisciplinary instructors in Food Science/Safety, Hospitality Management, and Community Nutrition, housed in the Department of Food Science and Human Nutrition (FSHN) at Colorado State University (CSU) developed, implemented, and evaluated the introductory-level lecture and laboratory course, FTEC 210, *Science of Food Fermentation*. FTEC 210 is a three-credit, lower division course, offered annually in fall semester, with an enrollment limit of 20 students. It was first offered experimentally to 15 registered undergraduates representing diverse disciplines during Fall 2012, and then as a permanent course offering to 22 registered students in Fall 2013. Student demographics collected from the university information system included gender, academic major, classification, and grade point average (GPA) after spring semester. In Year 1, the interdisciplinary instructors delivered direct instruction and guided laboratory activities; in Year 2, the Community Nutrition doctoral student was the main instructor and coordinated efforts with outside assistance from the supervising faculty.

The course description in the university catalog is as follows: “Science, history, culture, gastronomy, safety, health, and nutrition aspects of fermented foods and beverages” (Colorado State University 2014). Instructional aims were to provide hands-on, student-centered, and developmentally appropriate educational materials for diverse audiences, in order for enrolled

students to gain an appreciation of the science, nutritional attributes, cultural significance, and desirability of fermented food and drink products, and to advance student application of the science of fermentation. Course objectives were set to fit with the industry-driven objectives of the newly established Fermentation Science and Technology (FST) major and the philosophy of CSU to graduate leaders in research, education, service, and outreach. The course is a sophomore-level foundation class within the FST major, which was launched in Fall 2013. Instructional delivery was on-campus two-hour lecture and two-hour laboratory, meeting one day per week, over a 16-week semester.

### ***Development***

This course curriculum was designed and formatted to focus on weekly exposure to fermented products through hands-on activities and multiple guest educators, and the application of microbiology while following a food-group based syllabus. Curriculum development progressed after consideration of the few similar course offerings at other institutions, including personal communication and review of syllabi. An extensive review of the literature on food related education at the collegiate level, specific food or beverage fermentations to be investigated in class, as well as human cultural and historical contexts, informed content and delivery. The course instructors reviewed content and delivery for meeting course and major objectives for the target audience.

Throughout curriculum development, course instructors reviewed the limited available textbooks on the subject matter for applicability to the target audience and curriculum goals. Instructors chose “The Art of Fermentation” by Sandor Katz, published three months before the start of Year 1, for the required course textbook because of the breadth of thoroughly researched

subject matter, with attention to the universal human context of fermentation, written in a user-friendly mode.

Instructors used the university online learning system, Blackboard Learn 9.1, (Blackboard Inc. 2012) for general course management. Online requirements included participating in a weekly discussion board based on assigned readings, posting one article from lay literature on a fermentation topic, as well as commenting on a classmate's posted article. In Year 2, the instructor added a research component to increase scholarly awareness in food and beverage fermentation. Students performed library research on the week's topic and then informally presented their selected peer-reviewed journal publication. This peer-learning opportunity was included to broaden information transfer of often-complex concepts and research studies.

### ***Delivery***

Instructors employed mixed instructional strategy methods, including direct instruction, student-directed instruction, and experiential learning in the laboratory exercises, to create a classroom environment to foster students' responsibility for their learning, represent occupational situations, and engage students with diverse learning styles and modes. In addition, local and university experts were invited to guest lecture and/or lead laboratory exercises to facilitate engagement with local industries and university departments, and broaden students' educational experiences.

The curriculum was divided into five units: non-alcoholic beverages, meats and legumes, dairy, vegetables, and grains. The five units were established to create a culinary experience of an entire meal made from products developed over the course of the semester. Each unit's

objectives incorporated natural and social sciences, such as the importance globally in cultural cuisine, as well as the application of technique in the corresponding laboratory unit. Each unit included readings, online discussions, lectures, guest experts, hands-on laboratories with lab report assignments, and an exam. In addition, for their final projects, student groups developed and formally presented on a fermented food or beverage product with two or three distinct variations, and developed a related 1-page fact sheet. Content areas for student evaluation included lecture, laboratory, textbook readings, information from guest experts, and articles shared. Student evaluation included unit exam performance, laboratory unit reports, online discussion participation, fulfillment of both article assignments, and final project achievement.

### ***Evaluation***

The second research objective was to evaluate, particularly the experimental offering (Fall 2012), for attaining educational outcomes and emendations for future delivery. Evaluation of the second offering and an added control group afforded a richer data set for statistical analysis extrapolation. Curriculum evaluation methods, listed in Table 1, used an explanatory sequential mixed methods design and underwent expert review for internal validity (Creswell 2015). Grades from unit laboratory reports, unit exams, and the final project and presentation were amalgamated into the data set obtained after course completion and grades were reported, explicitly for research purposes only, to protect student confidentiality. CSU Institutional Review Board (IRB) granted approval of research materials for student subject participation. After researchers' verbal explanation of the study, student consent was obtained by signature, and by voluntary participation for those in the control group.

**Table 1:** FTEC 210 Evaluation methods for attaining educational outcomes

	Year 1	Year 2	Control
Internal and external expert review	✓	✓	
Student unit and project outcome performance grades	✓	✓	
<b>Confidential student participant completion of:</b>			
Pre and post-course fermented foods and drinks questionnaire assessing knowledge, attitudes, and behavior	✓	✓	✓
Mid-semester Course Survey@CSU	✓		
Mid-semester group interviews designed for qualitative discussions on student perceptions, to determine usefulness and satisfaction with course content and resources	✓		
End-of-semester Course Survey@CSU	✓	✓	

The primary instructor entered all quantitative research data and course outcomes assessment data into Excel spreadsheets and Blackboard, and checked for accuracy. Data were analyzed using SAS software, Version 9.3 of the SAS System for Windows. (Copyright © 2002-2010 SAS Institute Inc., Cary, NC). Covariate analysis of research data and individual grades were conducted with student demographics in the model.

In Year 1, students were randomly assigned to participate in one of two group interviews, moderated externally, during class time. Each group interview involved seven or eight students in a structured discussion on curriculum satisfaction and effectiveness, with space for reflection and inquiry. To ensure accurate reporting of fermentation-related main themes for immediate use, researchers selected a note taker with direct knowledge on fermented food production. Students who were not participating in an interview attended the lecture and lab portion of the class. After both groups were complete, the moderators, note taker, and primary instructor met to review main themes that arose as most imperative for application in the remaining half of the semester. Sessions were audio recorded, yet to protect student confidentiality, recordings or

transcripts were not evaluated by researchers until after final grades were submitted. External researchers transcribed the interview recordings. The primary instructor confirmed the transcripts and summarized. Internal researchers then reviewed the transcripts and summary data for main themes. Embedding interview main themes into the quantitative results bolstered the data set for triangulation of findings.

## **Results and Discussion**

All 37 students enrolled in The Science of Food Fermentation over two years, participated in the curriculum study (See Table 2). Main themes that arose from mid-semester group interviews were encouraging and constructive. Overall, students stated they enjoyed the course, especially the hands-on laboratory components and trying new foods. The students gave overwhelming support for curricular opportunities to learn-by-eating. Instructors were aware ahead of time that most of the students declared taking the course as a replacement for the required microbiology course in the Hospitality Management (HM) degree program. As such, knowing through experience and past studies that learning styles often differ across disciplines, instructors established outcomes and educational approaches suitable for empowering diverse learners that will be appropriate with the impending increase in Fermentation Science and Technology (FST) majors to develop industry-desired skills (Hartel & Gardner, 2003; Wolfe, Bates, Manikowske, & Amundsen, 2005).

Students stated a unique interest in choosing to attend and participate in class, where they not only learned but were excited to learn. As revealed by a senior Criminal Justice major, “so I’m learning stuff I’ve never learned before, and it’s going to make me, you know, just have a broader span of knowledge, better in life.” In the hands-on laboratory-focused class, students

**Table 2:** Demographics of students enrolled in FTEC 210 (n=37)

<b>Characteristics</b>	<b>Year 1 (n=15)</b>	<b>Year 2 (n=22)</b>
<b>Gender</b>		
Female	9	15
Male	6	7
<b>College Major</b>		
Hospitality Management (HM)	11	8
Nutrition and Food Science (NFS)	3	4
Fermentation Science and Technology (FST)	-	4
Sociology	1	1
Microbiology	-	2
Agricultural Economics	-	1
Environmental Health	-	1
Interior Design	-	1
<b>Class Level</b>		
Sophomore	3	2
Junior	5	6
Senior	7	10
Senior - Second Bachelor	-	3
Masters	-	1
<b>GPA range (out of 4.00)</b>		
Minimum	1.88	2.19
Maximum	3.88	4.00
Mean	2.85	3.16

were actively learning, learning by doing, problem-solving, and advancing their cognitive development through community learning; students worked with a laboratory partner or small group to discuss, interact, peer educate, and collaborate. Experiential learning engaged students to increase their transfer of knowledge through application, inquiry, and reflection (Svinicki & McKeachie, 2011; Yoder & Hochevar, 2005). A junior in Food Science expressed at the end of the group discussion,

“I was just going to say that I think this class is more helpful cuz it’s more hands-on and I feel like people learn a lot better when they, like, actually see it as opposed to, like, they tell you about it, like, “yeah, this is what happens.” Then you actually do it, then you’re like “Oh alright, I understand it better.”

Independent analysis from Year 1 resulted in no difference in exam or laboratory grades due to the student major or class. This did change with the addition of Year 2 data. Out of the five exams, significant differences in scores adjusted for student GPA across majors emerged on the beverages, meat and legumes, and dairy exams (See Table 3). Students with a declared FST major earned a significantly higher grade than classmates in Nutrition and Food Science (NFS), Hospitality Management (HM), and Other earned, most notably in comparison to HM majors (beverages:  $p < 0.0164$ ; meat and legumes:  $p < 0.0099$ ; dairy:  $p < 0.001$ ). This appears consistent with major requirements, potential previous education and experience, as well as disclosed student interest in content. The decrease in major effect, or decreased diversity in grade distribution, on the two remaining exams, vegetables and grains, demonstrates importance in providing diverse opportunities for student outcomes assessment due to differentiation in student achievement. The Vegetables Exam was a written essay initiated in small groups, instructors provided feedback, and then students individually revised their exams before final grading. The Grains Exam was the only exam administered using the online Blackboard course technology. In addition, higher scores on each of the five exam scores correlated significantly with earning a higher grade on the final project, while three of the five laboratory scores significantly correlated with final presentation scores. These correlations of individual exam scores with laboratory scores and final project scores indicate an overall trend that students either did well on exams or in laboratory activities, displaying the need for diverse approaches to engage learners and assess outcomes.

The main effect comparison by year revealed significantly higher grades in Year 2 compared to Year 1 on Beverages, Meat and Legumes, and Dairy exams; Beverages and Meat

**Table 3:** Combined FTEC students ( $n=37$ ) average assessment grades adjusted for student GPA, with declared major as covariate

Major	FST ( $n=4$ )	NFS ( $n=7$ )	HM ( $n=19$ )	Other ( $n=7$ )
least square mean (SE)				
<b>Exam scores (out of 100)</b>				
Beverages <sup>1</sup>	94.21 (3.5) <sup>a</sup>	87.95 (4.1) <sup>b</sup>	77.67 (2.5) <sup>a,b</sup>	82.63 (4.7)
Meat and Legumes <sup>1,2</sup>	90.13 (4.9) <sup>a</sup>	83.37 (3.5) <sup>b</sup>	74.93 (2.1) <sup>a,b,c</sup>	86.93 (4.0) <sup>c</sup>
Dairy <sup>1</sup>	95.97 (4.8) <sup>a,b</sup>	89.40 (3.4) <sup>b</sup>	76.63 (2.1) <sup>a,c</sup>	92.65 (3.9) <sup>c</sup>
Vegetables* <sup>1,2</sup>	89.08 (3.3)	94.35 (2.4)	86.67 (1.5)	87.43 (2.7)
Grains* <sup>1</sup>	92.65 (3.6)	90.69 (2.5)	85.26 (1.6)	93.28 (2.9)
<b>Lab scores (out of 50)</b>				
Beverages* <sup>2</sup>	46.73 (1.5)	48.12 (1.1)	46.85 (0.6)	45.18 (1.2)
Meat and Legumes* <sup>2</sup>	48.89 (0.8)	49.78 (0.6)	48.02 (0.3)	48.74 (0.6)
Dairy* <sup>2</sup>	45.15 (2.8)	42.92 (2.0)	42.63 (1.2)	42.25 (2.3)
Vegetables*	50.17 (1.1)	49.72 (0.8)	48.62 (0.5)	48.85 (0.9)
Grains*	48.73 (1.5)	47.32 (1.1)	47.76 (0.7)	48.32 (1.2)
<b>Final scores</b>				
Project (out of 250)*	231.00 (9.3)	236.83 (6.6)	223.01 (4.0)	226.37 (7.5)
Presentation (out of 100)*	91.00 (2.0)	90.77 (1.5)	88.80 (0.9)	87.86 (1.7)
<b>Overall percent</b>	92.84 (2.4) <sup>a</sup>	91.92 (1.7) <sup>b</sup>	85.88 (1.0) <sup>a,b</sup>	89.86 (1.9)

Mean scores may exceed total due to GPA in model (major effect of GPA was not significant)

\* = Major effect was not significant

<sup>1</sup> = Mean scores are significantly correlated (Pearson correlation coefficient) with Final Project Score

<sup>2</sup> = Mean scores are significantly correlated (Pearson correlation coefficient) with Final Presentation Score

Mean scores with the same superscript letter are significantly different ( $p < 0.05$ )

and Legumes lab scores; as well as final presentation grade. There was no significant effect from class status on grades.

The combined Year 1 and Year 2 experimental group change in knowledge, as evaluated from the pre and post-course questionnaire, increased 44.7% ( $p < .0001$ ). In addition, the improved knowledge of the experimental group resulted in a 30.7% increase ( $p < .0001$ ) in comparison to the control group. Table 4 compares experimental group behavior and knowledge

mean changes from pre to post-course with that of the control group. Specific topics of significant behavior changes and knowledge gain from pre to post-course (see Table 5) are useful in order to revise direct and experiential instruction on non-significant, or related, concepts in future course offerings.

Clarification of the experimental group questionnaire results on fermented food and beverage consumption and production behavior changes, using the qualitative responses, confirmed students' increased trial, usage, and familiarity with new foods and beverages. All of the students reported increased consumption of fermented food and drinks, as well as positive impacts on their learning including self-studies and home practices. Students were able to list specific products that they were including in their diet or undertaking at home because of exposure in the class.

Student discussion about the required textbook was positive; at least half of the students stated it was a useful course tool and personal reference for fermentation education and that they often read beyond the assigned readings. Students who took the course during Year 1 did not necessarily plan to pursue fermentation related careers, but all stated benefits of the course for personal knowledge and were able to identify specific application for their professional ambitions in hospitality management, food safety, and mission work.

Student suggestions for enhancing instruction were implemented as appropriate for the duration of Year 1 or incorporated in Year 2. Recommendations put in place included providing a study guide for future exams, assigning a written paper instead of one traditional exam, having a lecture on beer production, intentional structuring of class time to alternate between lecture and laboratory, and reserving products for use in future years. Recommendations implemented in Year 2 included more objective measurements of products, increased scientific research and

literacy expectations, a general microbiology overview early in the semester, as well as expected progression of primary instructor experience and education.

**Table 4:** Student behavior and knowledge questionnaire results of significance comparing mean change from pre to post course of FTEC 210 students (n=37) to control group students (n=62)

	<i>estimate (SE)</i>			
	<b>FTEC 210</b>	<b>Control</b>	<b>% difference</b>	<b>p value</b>
<b>Consuming*</b>				
Tempeh	1.64 (0.09)	1.38 (0.08)	18.8%	0.0099
Salami	2.45 (0.13)	2.07 (0.11)	18.4%	0.0274
Summer sausage	2.35 (0.11)	1.84 (0.10)	27.7%	0.0008
Sauerkraut	2.22 (0.11)	1.65 (0.10)	34.5%	0.0002
Kimchi	1.56 (0.11)	1.26 (0.10)	23.8%	0.0341
Sourdough bread	2.61 (0.11)	2.27 (0.10)	15.0%	0.0235
Wine	3.30 (0.14)	2.78 (0.11)	18.7%	0.0049
<b>Making*</b>				
Pepperoni	1.11 (0.03)	1.01 (0.03)	9.9%	0.0188
Sauerkraut	1.32 (0.05)	1.09 (0.05)	21.1%	0.0013
Kimchi	1.19 (0.05)	1.01 (0.04)	17.8%	0.0052
Sourdough bread	1.45 (0.08)	1.22 (0.07)	18.9%	0.0429
Beer	1.53 (0.10)	1.12 (0.08)	36.6%	0.0010
<b>Knowledge combined: % correct (SE)</b>	<b>53.24% (2.24)</b>	<b>40.74% (1.92)</b>	<b>30.7%</b>	<b>0.0025</b>
<b>Questions and answers:</b>				
Which of the following products is NOT traditionally made through fermentation processes:				
<i>Tofu</i>	74.7%	39.3%	91.0%	<.0001
The microorganisms responsible for fermenting cabbage and other seasonings for sauerkraut or kimchi are:				
<i>Wild or existing lactic acid bacteria (LAB) found on the vegetable</i>	37.4%	13.8%	171.8%	0.004
Criteria for classification as a PROBIOTIC include all of the following, except:				
<i>Must function in the same way as other probiotics</i>	44.0%	21.2%	107.5%	0.0031

\*Scale: 1=never, 2=a few times per year, 3=a few times per month, 4=a few times per week, 5=daily

**Table 5:** Student behavior and knowledge questionnaire results of significance from pre to post-course for Year 1 and Year 2 combined FTEC 210 students (n=37)

	<i>estimate (SE)</i>			
	pre	post	% change	p value
<b>Consuming</b>				
Kefir	1.30 (0.16)	1.91 (0.16)	45.8%	0.0022
Tempeh	1.38 (0.12)	1.89 (0.12)	37.0%	0.0026
Sauerkraut	1.96 (0.14)	2.47 (0.14)	26.0%	0.0012
Kimchi	1.26 (0.14)	1.86 (0.14)	47.6%	<.0001
Yeast breads, not sourdough <sup>^</sup>	3.65 (0.20)	3.04 (0.20)	-20.1%	0.0063
<b>Making</b>				
Kefir	1.11 (0.11)	1.40 (0.11)	26.1%	0.0273
Sauerkraut	1.03 (0.08)	1.62 (0.09)	57.3%	<.0001
Kimchi	1.09 (0.09)	1.28 (0.09)	17.4%	0.0406
Sourdough bread	1.18 (0.12)	1.71 (0.12)	44.9%	0.0016
<b>Knowledge combined: % correct (SE)</b>	43.60% (2.30)	63.10% (2.33)	44.7%	<.0001
<b>Questions and answers:</b>				
Fermentation of carbohydrates results in the major end-products of _____ using yeasts, bacteria, or a combination, under anaerobic conditions.				
<i>Lactic acid, carbon dioxide, ethanol</i>	61.05% (0.09)	93.02% (0.04)	52.4%	0.0032
Yogurt is produced by inoculating milk with the lactic acid bacteria <i>Streptococcus thermophilus</i> and <i>Lactobacillus delbrueckii</i> subsp. <i>bulgaricus</i> .				
<i>TRUE</i>	72.04% (0.08)	95.37% (0.03)	32.4%	0.0169
Fermentation of beer utilizes a different species of yeast than what is used to make bread.				
<i>FALSE</i>	34.21% (0.08)	62.16% (0.08)	81.7%	0.0224
The microorganisms responsible for fermenting cabbage and other seasonings for sauerkraut or kimchi are:				
<i>Wild or existing lactic acid bacteria (LAB) found on the vegetable</i>	13.16% (0.05)	64.86% (0.08)	393%	0.0002

\*Scale: 1=never, 2=a few times per year, 3=a few times per month, 4=a few times per week, 5=daily

<sup>^</sup>Consuming sourdough, though not significant, rose 12.2% from pre (2.46) to post (2.76)

A differentiating attribute of food and beverage fermentation as a food science and human nutrition curriculum, is the amalgamation of human cultural reflection with biological and chemical studies. Fermentation metabolism is often taught in natural science labs, by way of yeast and yogurt experiments in microbiology courses (Drake & McKillip, 2000; Knabb & Misquith, 2006). Food and Agriculture Organization (FAO) reports verify the long-standing importance of fermentation in global diets (Marshall & Mejia, 2012). This curriculum is distinct as an undergraduate semester-long hands-on course strictly on food and beverage fermentation that also ties in cultural education by means of exploring cuisine rooted in tradition.

## **Conclusion**

Education, like fermentation, is a transformative process taking time, cultivation, diversity, a sustainable environment, and give-and-take between the ready substrate and change agent. Offering the course, *Science of Food Fermentation*, addresses a gap in education at CSU and regionally. Information has not been previously gathered on fermentation curriculum evaluation. A research challenge was predicting student knowledge in a topic without previous classroom exposure. Students representing diverse demographics provided an opportunity for educators to employ techniques that empowered varied backgrounds, interests, and skills in a far-reaching field of study. The lecture and hands-on laboratory course design provided opportunities for students of multiple learning styles and differential abilities to be engaged in the material and learn-by-eating. The distinct assessment techniques (exams, laboratory activities, final project) evaluated separate outcomes, and were beneficial to meet the needs of diverse student populations while providing multiple opportunities for student success in a multidisciplinary environment. As Yoder and Hochevar (2005) observed, experiential learning,

as an active learning technique, can make the information more meaningful to students and improve retention for better summative assessment performance.

The use of multiple evaluative measures corroborated results and substantiated indirect instructor observations. Compared to the mid-semester Course Survey@CSU, use of mid-semester qualitative group discussion provided a confidential means for students to groupthink and express relevant constructive feedback for curriculum implementation in a timeframe appropriate for putting into practice. Although not always feasible, educators may find value in replicating this step, especially in the case of a new and unique course. Gaps in anticipated knowledge change, as measured by the pre and post course questionnaire, enforced the need to continue to construct and provide multiple approaches to teaching main concepts as well as coach learners in effective study skills (Schmidt, 2014). In future years, as students come into the course with increased fermentation knowledge, repeating the mixed research methods and including follow-up measures or industry feedback will aid in maintaining an innovative curriculum.

This curriculum serves a distinct purpose at this land-grant university situated in an agricultural region, which is supporting a growth of available fermented consumables. Students majoring in FST at CSU will have diverse fermentation learning exposure in FTEC 210 that will prepare them for future major courses and industry prospects. Student and course outcomes will benefit student career potential, personal confidence and understanding, and greater community outreach dissemination. With the use of experiential and situated learning techniques in the curriculum, students directly applied learning for use in fermented food and beverage production enterprises, food service, food science, food safety, nutrition, animal science, microbiology, social science venues, as well as personal practices.

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## CHAPTER 4: FERMENTATION: LIVING IN SYNERGY WITH MICROBES<sup>2</sup>

### **Summary**

Consumer desires to enjoy and learn more about fermented foods and beverages are increasing across the country, which is cultivating the need for related Extension education and outreach material development. Instructional barriers may exist for the most desirable audience to provide reliable consumer education, Extension food safety educators, due to the unfamiliar approach of welcoming and promoting the growth of microorganisms in the process of making food. Those who practice and teach fermentation will need a mindset shift to embrace collaborating with these unseen “partners.” This article describes how observations from an academic course guided the structural design, and a workshop for Extension educators provided data for the development of outreach educational classes and materials on food and beverage fermentation.

### **Fermentation**

The relationship between humans and microbes is complicated. The human desire to avoid disease sometimes gets transformed into the idea that microorganisms need to be completely eradicated, especially in terms of food preparation, but microscopic species are responsible for fermentation processes (See Table 6). The growth of the fermented food and beverage market, well demonstrated by the demand for Greek yogurt (Berry, 2014) and craft beer (Brewers Association, 2014), is a clear sign that consumers are interested in the flavors and products developed from synergy with microorganisms. Yet consumers may not even be aware that delighting in spoonfuls of creamy dairy or sips of a cool brew is thanks to an extensive

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<sup>2</sup> Manuscript to be submitted to the *Journal of Extension*.

history of synergy with microorganisms, originating as a food preservation technique and rooted across world cultures. The fermented foods and beverages buffet is vast, including sauerkraut, salami, old-style pickles, cheese, sourdough bread, kimchi, kombucha, tempeh, hard cider, and even chocolate and coffee.

Fermentation is a synergistic process that utilizes bacteria, yeast, and/or fungi to transform an agricultural substrate into a unique end-product. This collaborative progression requires interaction with a specific set of microbial cultures for a desirable result. Yogurt was once just milk. Beer was once just barley. The addition of bacteria to the milk and yeast to the barley, allows simple ingredients to be elevated via fermentation to a new platform, creating very different products that enliven our senses.

### **Outreach Engagement**

Fermentation, one of the oldest recognized food preservation techniques, has recently become an emerging issue in nutrition, health, and food safety for Extension educators throughout Colorado and other regions of the United States. However, resources including research-based training, hands-on activities, and online publications focused on safe practices and health benefits of fermentation, are limited. Information can be found for fermented pickles and sauerkraut, for example at the National Center for Home Food Preservation Safety (2009), but very little pertaining to kimchi, kombucha, kefir, hard cider, and other new arrivals to local tables.

Extension Family and Consumer Sciences (FCS) agents provide educational programs for community members throughout their respective regions, which often includes food preservation classes and information. These outreach professionals are well-positioned as educators to deliver

evidence-based information on fermentation as a preservation technique with health attributes yet they may need to first jump that hurdle of what they know and practice for food preservation and food safety.

Unlike some areas of food preservation, fermentation does not have a long list of what not to do, but requires a different approach that includes promoting the growth of beneficial organisms and often the ability to “mindfully explore.” For example, in the process of fermentation, shredded cabbage and salt are facilitated to progress toward sauerkraut, while canning vegetables requires following very precise steps to maintain safety. Educating agents to use their knowledge and skill to mindfully explore may contradict preceding familiarity with the microbial world. Certainly many types of bacteria, yeast, and molds can cause harm (Food and Drug Administration, 2015) but not all microorganisms need to be eradicated for food safety and health. The characteristics of microorganisms extend across a spectrum, from pathogenic to beneficial with many species benignly existing in the environment and our intestinal systems. Although good hygienic technique and proper temperature control are critical principles of both food safety and fermentation, one of the primary roles of the fermenter is to provide a suitable environment for the growth and survival of beneficial microorganisms, which may in turn allow them to predominate and produce acidic or alcoholic byproducts thereby outcompeting and/or creating an environment that inhibits the growth of undesirable microorganisms. Living in synergy with the microscopic world in terms of fermentation entails attention and adaptation; attainment will reap benefits that include achieving the desired sour taste of success.

The practice of fermentation bridges the science and art of food preparation with a goal of achieving balance in favor of the growth of “good microorganisms.” Opportunities to interact with microorganisms in a culinary lab setting, driven by diverse educational outcomes, has been

evolving and growing over the past three years for Colorado State University students. An academic course, Science of Fermented Foods, engaged learners in the science, history, culture, gastronomy, safety, health, and nutrition aspects of fermented food and drinks, with intentions for spreading beyond the classroom (*Citation to be added: Bauer 2015*). The teaching and learning setting is active and alive; not unlike the students' objectives to establish suitable environments for the enzymatic processes to initiate a conformational change from basic ingredients into food and beverages with living cultures. Even students unfamiliar with fermented foods, eagerly sampled food and drinks produced in cooperation with microscopic lab partners. Observations from the development and delivery of this academic course contributed to a better understanding of the unique constructs associated with fermentation skills which can be applied in an outreach setting:

1. Knowledge is vital. Misinformation and myths inundate our pursuit for credible information. How does one comprehend that yogurt can be healthful and not only provide nutrients but also active cultures? How does one realize that sauerkraut is easy to make or progressing normally? How does one appreciate that kimchi can be a healthy meal addition and enliven flavor? The answer, education.
2. A personal succession from knowledge and practice, to perseverance and confidence, can develop into understanding and consumables.
3. The starting point for each person's succession can be unique, yet the process of making yogurt, ginger ale, and sauerkraut may be most easy to grasp and appreciate before delving into complex projects like cheese and salami production.
4. Learners often come to fermentation with one experience that sparked a desire to engage in more: a home brewer who wants to break away from the recipe, a yogurt producer who wants to

expand into cheese, or maybe someone who is ready to stop paying for kombucha and try brewing it instead. Thus begins the first chapter of their personal fermentation story, the process.

5. Skills garnered in one topic area of fermentation, can be applied throughout the field for diverse competency development and production of a well-balanced meal.

6. Food educators have a unique opportunity to expand on the love of the fermentation process and introduce community learners to a wide array of products, consequently expanding consumers' breadth of knowledge, awareness, interest, and opportunities to ferment.

7. Fermentation education starts with respect for our role in the balance of life and has potential to lead to an awareness of microbial impacts and understanding of microbial processes.

If the public is to be educated about fermented foods and how to prepare them in safe ways, we need a cadre of outreach food educators who are prepared to instruct others on the processes of fermentation, and how to integrate into the local cuisine. Learning skills for producing safe and high quality consumables in one topic area of fermentation can be applied across food groups for practical knowledge on fermentation techniques. The aim of this study was to adapt outcomes of a successful university fermentation curriculum to create complementary, Extension educator-driven, outreach materials on related fermentation topics for use among diverse audiences.

## **Methods**

In order to meet consumer demands for research-based materials on current topics, we conducted and evaluated an online-training and preliminary fermentation workshop for Extension agents that were developed to identify areas of interest and inform the production of

educational materials for outreach dissemination. The concurrent development and evaluation of an undergraduate introductory course on the science of food fermentation helped inform the formulation of outreach trainings and materials.

Context: Colorado Extension educators were invited to participate in a four-hour-long workshop during which they participated in classroom presentations and laboratory-based activities.

Resources developed for an undergraduate course on fermentation science were incorporated into workshop materials.

Participants: Twelve Extension educators participated in the study. They were all female and experienced Family Consumer Science agents from a range of urban and rural regions.

### ***Forum Workshop: Food Fermentation Workshop***

A learner-centered workshop was organized to provide FCS agents with hands-on practice teaching food fermentation topics as well as pilot test lab activities for the university curriculum. Participants were welcomed with a complimentary breakfast, featuring fermented products, such as yogurt and kefir. Concurrently, agents participated in a PowerPoint presentation providing cultural and contextual information on the history of fermentation, metabolic pathways, introduction to some of their microscopic lab partners, and then specifics on production methods for the hands-on component. Participants were broken into small groups that each created a unique product: yogurt, a soft cheese, sauerkraut, or kimchi. Then they observed a condensed demonstration of ginger ale made traditionally by cultivating the microorganisms present on fresh gingerroot. Agents conversed about their experiential learning while being able to taste test fresh and fermented varieties of the fermented products created.

### ***Data Collection***

Prior to the workshop, Extension FCS agents were invited to participate in an interactive presentation delivered electronically referred to as a Desktop Training. Our evaluation efforts modeled previous desktop trainings, by state specialists on pertinent topics, to capture situational information for follow-up and overall satisfaction. In this study, users came in and out of the presentation, and anonymously reported pre and post training. Therefore, user data could not be linked, nor could we ascertain time spent in the training by participants. As such, a limitation of the quantitative results is that they are less generalizable. However, as this was an exploratory study, we argue that the findings are still informative for our stated purpose.

We collected two types of data from the workshop: observational field notes and written evaluation. The two co-authors were both involved in the workshop and made observations regarding 1) participant engagement in the workshop activities; 2) participant interest in learning more about fermented foods; and 3) opportunities for improved delivery of content for subsequent workshops. We asked participants to rate on a Likert scale overall assessment of the workshop, comfort with teaching the practiced recipes, adequacy of information provided, and additional similar questions. Participants were also asked to describe their perceived level of consumer interest in fermentation in their region. In addition, all participants were informally interviewed (no interview protocol or audiorecording devices were used) during the workshop. Participant comments were used to triangulate our observational and evaluation survey findings.

### ***Data analysis***

Desktop training evaluation comments from nine participants were reviewed separately and themes identified, followed by comparisons to support or refute our themes. Workshop

instructors debriefed after the workshop and shared respective observational notes. These were discussed until complete agreement was reached (Creswell, 2015).

### ***Findings***

Extension agents stated at the online training, hands-on workshop, and in personal communication their concern with appropriately addressing consumer questions on how to make yogurt, especially troubleshooting, and why to consume yogurt. Comments provided feedback on the desktop training delivery and content, which informed workshop development needs. Out of nine participants who completed the desktop training post evaluation, five made comments: three stated the presentation was very informative, two of the three added that there was quite a lot of information for the time given. After the training, agents requested a follow-up hands-on workshop, and materials authorized for their own teaching events.

### ***Fact Sheet Development: Making Yogurt at Home, and Yogurt: Probiotic and Health Benefits***

Findings led to further exploration of home yogurt production for consumer material development. Variables in home yogurt production were informally tested at altitude and analyzed for sensory characteristics prior to developing two Extension fact sheets. Variables included incubation technique and starter culture type. Incubation methods examined included an electric home incubator, water bath in oven, water bath in hard-sided insulated cooler, heating pad, thermos, and slow cooker. Incubation methods included at least two jars of milk to become yogurt, one inoculated with plain, whole milk yogurt containing live and active cultures, and the other inoculated with Yógourmet freeze-dried yogurt starter culture (Lyo-San inc., Lachute, Québec, Canada). The heating pad only used one jar inoculated with freeze-dried starter because

of heating pad size. Mean results from the taster panel showed an equal flavor, texture, and overall preference for yogurt made with the freeze-dried starter culture and incubated in the cooler, with that made with a freeze-dried starter culture and incubated the heating pad (See Figure 4). Yogurts made with the thermos and slow cooker did not set and were not evaluated. Interestingly, taster panelists did not rate yogurts incubated in the home incubator any higher than other incubation methods and raters consistently included comments on undesirable sourness. Home incubators may be desirable for ease of incubation, but this informal evaluation indicates consumers may not need to make the supplemental purchase of a home incubator for sensory qualities.

Students enrolled in the corresponding academic course performed additional yogurt experiments each semester to expand on the previous exploration of variables in home yogurt production. Sensory comparisons included use of non-fat dry milk, milk fat levels, non-homogenized milk, length of hold time while initially heating milk, and length of incubation time. With a greater diversity of palates, undergraduate student tasters did not agree on preferred characteristics of yogurt, making the overall preferred process difficult to establish. In general, yogurts made with non-fat dry milk, held at upper temperature for longer, made with higher milk fat, and incubated longer yielded thicker results, with the opposite variables yielding thinner results. One variable that did consistently yield improved mouthfeel and flavor was use of milk with higher milk fat, and addition of the non-fat dry milk was regarded as unnecessary for sensory characteristics.

Results from these informal variable evaluations were beneficial to integrate in comprehensive fact sheets on home yogurt production. Two separate fact sheets were produced

to provide succinct resources on yogurt production at home. One fact sheet details instructions on yogurt production and a separate fact sheet provides information on health attributes.

## **Conclusions**

Food and health professionals need training to be prepared to coach community members through fermentation processes. In addition, Extension agents have the opportunity to provide consumers with university research-based information regarding fermented food safety, handling, and contributions to human health. As we found in our previous study with undergraduate students, experiential learning integrated with research-based information enhanced training opportunities targeted to outreach educators (*Citation to be added: Bauer 2015*). Fermentation extends the meaning of culture beyond both the microbial ecology and human beliefs or customs to a transformational discipline of thriving with microorganisms. We found that Extension participants were open-minded to learning about both types of *cultural* integration.

Community-driven, outreach materials extend educational efforts to a broader population of consumers. These materials are relevant for diverse rural and urban audiences who are interested in fermentation as a food preservation technique, for its cultural and historical significance, as an application of food microbiology, for entrepreneurial food product development and gastronomy interests, as support for local agriculture, and for research-based information on potential health attributes.

The original scope of outreach material dissemination had unexpected impact (measured by observations, personal communications, and formal evaluations) and has created demand for further outreach engagement, beyond Extension, for additional audiences, including university

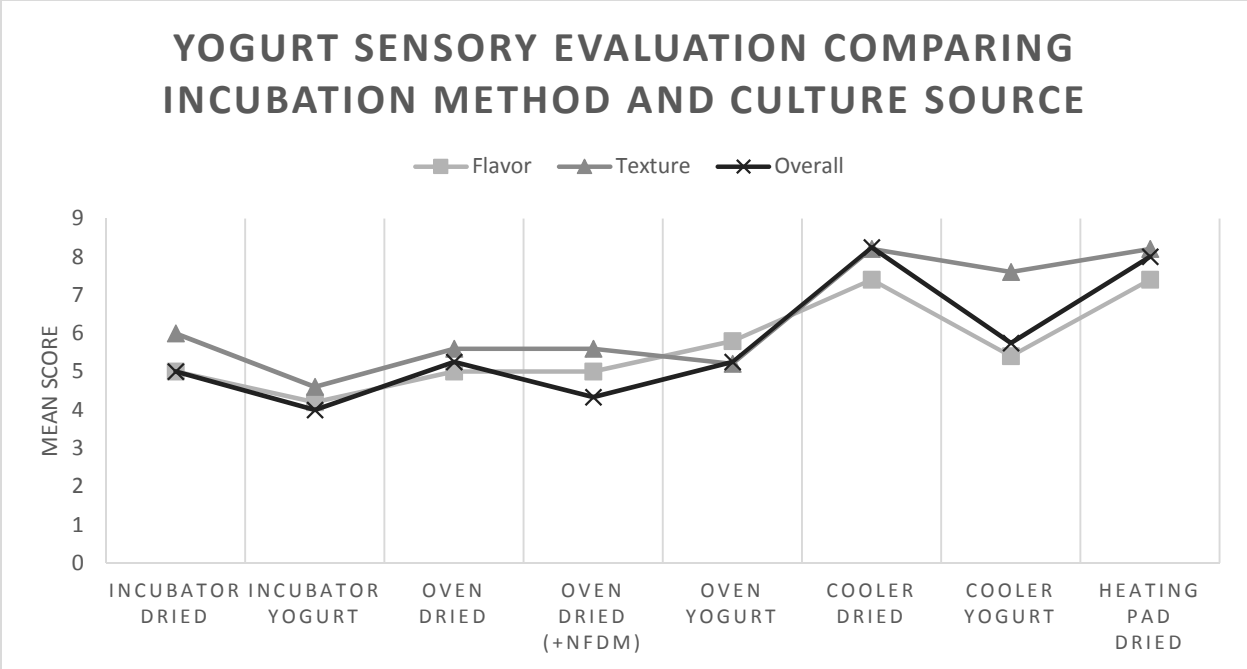
students and instructors, public health professionals, food professionals, and consumers.

Although this study described an intervention with a small set of participants, we are encouraged by our findings. There is currently a growing interest in producing and consuming fermented foods and beverages and we urge our colleagues to consider how to educate Extension agents in the field of fermentation science so they are prepared to disseminate the value of “cultural integration” and to take advantage of the collateral benefits of improved understanding of the existence and impact of microorganisms.

**Table 6:** Common microorganisms in food and beverage fermentation processes categorized by agricultural substrate classification

<b>Substrate classification</b>	<b>Substrate</b>	<b>Product</b>	<b>Microorganisms Commonly Involved</b>
<b>Grain &amp; Fruit</b>	Grapes, grain (barley, wheat, corn, sorghum, buckwheat), hops	Wine, beer	Yeast: <i>Saccharomyces cerevisiae</i> ; Lactic acid bacteria or LAB
	Wheat, rye, other grains	Bread	Yeast: <i>Saccharomyces cerevisiae</i> , other yeasts; LAB
<b>Vegetable</b>	Cabbage	Sauerkraut	LAB: <i>Leuconostoc (mesenteroides, fallax)</i> , <i>Lactobacillus (brevis, plantarum, curvatus, sake)</i>
	Soybeans and wheat	Soy sauce	<i>Aspergillus oryzae</i> or <i>soyae</i> , lactobacilli, and <i>Zygosaccharomyces rouxii</i>
	Cabbage, vegetables, sometimes seafood, nuts	Kimchi	LAB: <i>Leuconostoc</i> , <i>Lactobacillus</i> , <i>Lactococcus</i>
	Soybeans	Tempeh	<i>Rhizopus oligosporus</i>
	Cucumber	Pickles	LAB: <i>Leuconostoc mesenteroides</i> , <i>Lactobacillus (plantarum, brevis)</i> , <i>Pediococcus pentosaceus</i>
	Green olives	Olives	<i>Leuconostoc mesenteroides</i> , <i>Lactobacillus (plantarum, brevis)</i>
	<b>Animal-source</b>	Milk	Cheddar cheese
	Milk	Swiss-type cheese	<i>Lactobacillus (delbrueckii, bulgaricus, helveticus)</i>
	Milk	Mold and smear-ripened cheeses	<i>Carnobacterium piscicola</i> , <i>Brevibacterium linens</i>
	Milk	Yogurt	<i>Streptococcus thermophilus</i> , <i>Lactobacillus delbrueckii</i> subsp. <i>Bulgaricus</i>
	Milk	Kefir	Lactococci, <i>Lactobacillus kefir</i> (and others); yeast
	Pork, beef	Fermented sausages	LAB: pediococci, lactobacilli, staphylococci
	Fish	Fish	<i>Carnobacterium (piscicola, divergens)</i>

Sources: Caplice & Fitzgerald (1999); and Ross, Morgan, & Hill (2002)



**Figure 4:** Mean flavor, texture, and overall acceptability scores from expert sensory panel evaluation of eight homemade yogurts consistently prepared applying distinct variable modifications in incubation method and starter culture source.

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## CHAPTER 5: DISCUSSION

Every fermenter has a story. The story of the author of the textbook for FTEC 210, Sandor Katz, started with a sour pickle in urban New York, and has led to him writing two books on fermentation, teaching events worldwide, and living in community with a diverse assortment of microorganisms in rural Tennessee (Katz, 2012). The story of each of the students enrolled in FTEC 210 during Year 1 and Year 2 started as humbly, most likely due to the lingering pleasure of home-brewing, but over 16 weeks, began a new chapter involving an open invitation to beneficial bacteria, yeasts, and molds to be on journey with them. The story behind FTEC 210 curriculum development is part of CSU's response to a growing industry and student interest. The story at CSU is just beginning. There will be twists and turns, as health trends and interpretations come and go, but the historical roots, cultural application, and broad gastronomical appeal of fermented consumables offers assurance that this story of fermentation education at CSU will continue and thrive.

The project analysis frame was situational and contextual; the goal was to seek ways to improve, versus prove. This makes data less generalizable, but that was beyond the needs for the intended scope of practice. The driving force of course evaluation efforts was for decision-making at the time, to guide overall curriculum development and delivery. The interdisciplinary team approach to teaching the curriculum, during the experimental offering in Year 1, provided an internal expert panel for constant content review. Mixed research tools, both quantitative and qualitative, were designed for process evaluation, in order to provide useful information that could intersect with the academic evaluation tools to inform the practice and gauge impact. From the researcher framework, the goal was to expand on the knowledge of the instructors on

teaching methods for the demographic, gain knowledge on fermented products for course instruction as well as dissemination into Extension materials (for example, results from student modification of variables in yogurt production as a laboratory experiment, were used for training Extension professionals.) Research helped justify development of materials. Research techniques also included efforts to obtain student feedback and gain insight to drive development of the curriculum within the mission of the major, department, and university. From the evaluation framework, the goal was to assess the scholastic process to meet the educational goals, or facilitate decision-making in curriculum development at the time. Course assessment materials, including exams, assignments, and participation data were used in formative evaluation for constant adjustments. Outcome data was assessed for summative evaluations, with the overarching goal of improving for future classes. The overlap of these distinct frameworks allowed for better generalizability of data. It helped to inform instructors of areas to make positive changes for the sake of the class at hand and potentially the evolution of curriculum in general for impending changes in demographics. The evaluation process would not have been complete without each method, in order to provide pieces of the profile for each student. Yet, although resource-costly, qualitative group interviews during mid-semester, repeated after the course, and once again as a follow-up could grant comprehensive understanding for curriculum development and delivery that isn't captured quantitatively, in this and other university courses.

This research of curricular impact on student knowledge, attitudes, and behavior in relation to course educational materials was unique. The development of the course filled a gap, which evolved from an area of interest, to a required course within a major. This in itself, guided the progression of the course design and intended outcomes for students interested in personal use to those with career goals in fermentation industries. Results comparing students in Year 1 to

Year 2 displayed difference simply due to acknowledged student interest and ambitions, yet minor statistical differentiation does support that what was being evaluated by the research methods, was the curriculum and not the students. As explored across the mixed methods literature (Creswell & Tashakkori, 2008), contributions from this mixed methods research analysis has the potential to advance the field of study in food science undergraduate education beyond simply quantifying student achievement or qualifying student remarks.

As a student stated in the second group for the qualitative interview session, during Year 1, "...the other thing I really like is trying stuff in labs. I haven't really had any of that stuff before." Student questionnaire responses to varying behavior for consumption or production of products introduced in laboratory activities did not adequately quantify the increased trial, usage, and familiarity with new foods and beverages. Students were able to list specific products that they were including in their diet because of exposure in the class. The students gave overwhelming support for curricular opportunities to learn-by-doing and learn-by-eating.

Assessment of any course has challenges but possibly more so for one that bridges science, art, and technology. Test grades and student observation are useful as formative assessment measures, yet useful student perceptions for course development are difficult due to confounding factors when involving students with grading their instructors. Student input is important, even necessary, for curricular and instructor evaluation, yet the often anonymous, required, student evaluation of teaching (SET) is controversial as the most effective tool (Spooren, Brockx, & Mortelmans, 2013). Although SET feedback can be valuable for instructional strengths and weaknesses, it should not be the only source for course and organizational assessment. Current media, including The New York Times and NPR, have presented the discussion from faculty nation-wide (Kamenetz, 2014; "Professors and the

Students Who Grade Them," 2012). Faculty recommended solutions to apparent concerns include such tactics as those used during Year 1 to assess satisfaction with FTEC 210 curriculum, such as mid-semester evaluations, qualitative feedback, reflection from instructors, decreased student anonymity on SET, and accepting the evaluations at face value strictly for satisfaction of this course. Application of mixed research methods provided the data desired for a full picture of the curriculum impact.

In addition to performing a mixed methods study, utilizing more than one approach to instruction creates a learning environment that diversifies the instructor and student roles, and considers factors outside of what is taught but also how it is taught. A benefit is the potential for engaging a diverse audience of students with multiple learning styles and modes. In the classroom, introduction of new material was through direct instruction. This approach was teacher-directed, and although beneficial for content delivery, was not sustainable or reasonable for the four-hour class duration. Students were also expected to apply learning to homework assignments and the final project, engaging in student-directed instruction opportunities. Students were expected to construct new knowledge through integrating the base knowledge from lecture, collective interaction with a lab partner, and active hands-on practices. Students were often innately challenged beyond strictly following a recipe and invoked the brain's natural drive to learn, as discussed by Gunn, Richburg and Smilkstein (2007), by simply needing to "see if you can figure this out."

A key theme we found from our qualitative group discussions with the students, was the unique interest in the class. Not only did students learn, but they were excited to learn. An illustration of this unique interest in the subject area could be observed from the demographics of students enrolled in FTEC 210, which placed many students as non-traditional undergraduates.

Students were changing majors as upper classmen, completing a second bachelor's degree, or coming back to school after a hiatus. Some students were married or had children. Pedagogical methods directed for adult learners, or andragogy, were more practical due to this broad range of demographic factors. For example, the experiences that built each student as well as the self-assured professional goals that drove each student, were assumed as part of the teaching and learning framework. This also encouraged a community of learners and embraced the unique classroom cultures present.

To fulfill the mission of a Land Grant Institution, research-based materials are shared with the public. The decision was made to produce two separate fact sheets related to yogurt in order to condense applicable information in a unique publication. A unique publication on health attributes of yogurt balances out a publication focused on home production for consumer educational needs. Yogurt was an obvious first step in creating Extension publications on fermented consumables, due to reported growth in sales and consumption from Dairy Management Inc. (2011), but it is simply the launch of publications now in demand.

Implications in training Food and Consumer Science (FCS) Extension agents to educate the Colorado public in fermentation techniques and attributes, involved providing a safe space for transfer of knowledge from a “war on bacteria” approach, to one that cultivates growth of beneficial microorganisms. Transitioning from traditional home food preservation outreach materials to fermentation guidance is a significant change from incorporating ingredients and following exact process steps to guiding a process dependent on microorganisms sensitive to time and temperature parameters. The original scope of this project understandably had impact, and has created demand for further outreach dissemination of fermentation information beyond Extension. The demand for fermentation education is currently outpacing the research and

content available, reinforcing need for university and outreach materials development and research facilities for a transdisciplinary fermentation team.

## CHAPTER 6: CONCLUSIONS AND IMPLICATIONS FOR FUTURE RESEARCH

Education, like fermentation, is a transformative process taking time, cultivation, diversity, a sustainable environment, and give-and-take between the ready substrate and change agent. Offering the course, *Science of Food Fermentation*, fills a gap in education at CSU and regionally. The course is relevant for university students in many disciplines to apply food science knowledge across diverse fields of study, including integration of cultural diversity education. Representation of diverse demographics provided an opportunity to employ techniques that empowered varied backgrounds, interests, and skills in a far-reaching field of study. The lecture and hands-on lab course design provided opportunities for students of multiple learning styles and differential abilities to be engaged in the material. The distinct assessment techniques (exams, laboratory activities, final project) evaluated separate outcomes, and were beneficial to meet the needs of diverse student populations while providing equal opportunities for student success in a multidisciplinary environment.

This food fermentation curriculum increased knowledge of a historic, yet reemerging, food preservation technique with diverse cultural roots, which developed student confidence and understanding and created material for outreach dissemination. A limitation of deciphering results from the study is the impending change in major demographics from Year 1, mostly Hospitality Management (HM) majors, to successive years that will increase in students majoring in Fermentation Science and Technology (FST). A benefit of identifying this limitation is the opportunity for intentionally employing instructional techniques that encourage differentiating background, interests, and skills to succeed in a far-reaching field of study. In addition, the data are not longitudinal, which does offer a potential research opportunity for a

future graduate student to follow-up with the students from Year 1 and Year 2 to find out more about where they are now or the impact the course has had, now that they are further removed.

Information has not been previously gathered on fermentation curriculum evaluation. Because of this, a research limitation was predicting student knowledge in a topic without previous classroom exposure. Development of the curriculum content, format, and delivery needed to be unique for the topic needs, therefore research methods needed to be able to capture wide-ranging data. Methods were approached collaboratively from departmental experts representing diverse disciplines, yet suggestions from industry would have improved the assessments.

An unforeseen advantage from the enrollment of Year 1 as substantially HM students, was that this course taught HM students some science and brought the science into their field. During the mid-semester qualitative interviews, all HM students could readily state how they would use the course information beyond the semester, in their field. They were knowledgeable of consumer demand and interest, and knew that including fermented consumables (beyond beer and wine) in the industry could be a marketing tool. This demonstrates applicability of the course to a diverse audience. A limitation in the curriculum developed for Year 1 is that in subsequent years, students will be entering the course with stronger science and fermentation background, and the curriculum will need to meet new needs and address new gaps in knowledge. This is an exciting limitation for the growth of the FST program and future of research in fermented consumables.

On the post questionnaire given to students in Year 1 and 2, students were asked, “Do you think that taking the course FTEC 280a1: *Science of Food Fermentation* helped your personal education on the subject of food fermentation any more than if you had selected to not

take the course and learn the subject on your own?” Student responses were all yes, with brief explanation on why. A student from Year 2 summarized student-perceived benefits of the curriculum, in response to this question, as:

“Taking this course was more helpful to my education on fermentation because we learned about what microorganisms are fermenting the foods, their history, culture, and most importantly how to ferment them. Then after learning all of this we made it and interacted with what we learned and applied it hands-on in the kitchen. Much more beneficial than doing fermenting on your own.”

### **Implications for Future Research**

The curriculum is unlike others in the nation, setting the stage for CSU to be leaders in fermentation education to university students and consumers. Many traditional fermented foods and beverages, have grown in usage in the Western diet, and are being manufactured for their desirable sensory characteristics. Small to large-scale industrial application of fermentation techniques are increasing fermented food product market availability, in order to supply consumer demands for functional foods. Students are better poised for diverse industrial experiences through a greater understanding and appreciation of fermentation. Students who came into the course simply aware of the brewing industry, now have hands-on experience in the broad practice of fermentation. This effective exposure, to open their minds and engage their passion, will benefit student career potential, personal confidence and understanding, and in turn lead to greater community outreach dissemination from the rise in educated individuals.

In addition to student benefit, with fermentation as a topic of study, CSU is better poised to address research opportunities in diverse fermentation topics. The results inferred from this mixed methods design could be taken one step further to formulate a follow-up instrument that would continue curriculum analysis and emendation to continue to improve the educational opportunities for FST students. This third phase of study would have the advantage of supporting

evaluation efforts of the FST major. FSHN faculty have bridged multiple disciplines to form a FSHN fermentation transdisciplinary team, which will afford the opportunity for faculty and graduate students to design research projects and formulate questions to address gaps in the literature, specifically on production, microbiology, safety, health attributes, and culinary application.

Knowledge of health attributes of fermented consumables as well as the benefits to the producer on reduced energy expenditure can also have a role in dissemination to lower income audiences. Steinkraus (1995) identified five functions of fermentation especially significant for developing societies,

- “1. Enrichment of the diet through development of a diversity of flavors, aromas, and textures in food substrates
2. Preservation of substantial amounts of food through lactic acid, alcoholic, acetic acid, and alkaline fermentations
3. Enrichment of food substrates biologically with protein, essential amino acids, essential fatty acids, and vitamins
4. Detoxification during food fermentation processing
5. A decrease in cooking times and fuel requirements”

With a growing global population, safe, traditional preservation practices that not only maintain, but also in some cases amplify health attributes of agricultural products, will be important.

Canning and freezing are high energy-usage preservation techniques requiring specialized equipment. Outreach education initiatives and food assistance programs may value from teaching fermentation practices, to diverse urban and rural audiences, which address food security by practicing sustainable food practices, such as safe food preservation of a local harvest. Scientific research and empowering education are essential for a global food system, while focusing on developing a local food system. The transdisciplinary FST major sets CSU apart as a potential leader in this effort.

This research project opened the door for research in fermentation education. When the course was first offered, it was a stand-alone course, and now it is required in a major that is supported with faculty and new research labs. Countless print and online sources exist for information, but CSU is now prepared to provide the evidence-based information that has been lacking. It was quite rewarding to be a part of this project, and I look forward to participating in the growth of fermentation studies at CSU and dissemination to the community.

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APPENDIX A: RESEARCH PROJECT RECRUITMENT SCRIPT

## **Recruitment script – 1<sup>st</sup> day of class**

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*[Read aloud after introducing the course and instructors, but prior to reviewing the syllabus.]*

We are eager to have this widely growing topic of interest in food fermentation as a course option, and because FTEC 280A1 is a new course, we will be taking some class time to evaluate it for meeting the course objectives and fitting in with the curriculum of the Food Science and Human Nutrition Department. We want to make this course the best that it can be for students, and we want your help in assessing that. It will be your choice to participate in the research study, and your choice to participate or not to participate will not affect your grade in any way. We hope that all of you will choose to take part in the research study, because with our small number of students in this class, the more participants we can have the more useful your information will be for our research. So before we go over the course syllabus, we would like to go over the basics of what is involved with taking part in the research, and then we can answer any questions you may have at the end.

The research will mostly be asking for your opinions about the class and observing the progress of all of you in the class – so nothing invasive (no blood draws or body scans or anything like that!). But we understand that it can be intimidating to talk to your instructors about either positive or negative comments you might have, so we will set it up so that the information you give will not be linked directly to you. We will be giving participants a brief questionnaire today in class and again on the last day of class. This will give us an idea of initial knowledge of the subject matter and information gained from taking the class. We will do the regular course evaluation at the end of the semester, but in addition we will do the same evaluation during the middle of the semester. This will give us an idea of how things are going before the course is over. We will also do small group discussions to answer questions we have and for you to state feedback on the course. For each of these research methods, we will use a code to identify you instead of your name so that you never feel like you cannot be fully honest because all of your responses are important.

The information you share as an individual will be valuable, but we will not trace comments or answers directly back to a person or ever share your comments linked with your name. This is why we are using a code. If we use the data for public purposes (like publishing in a journal) we will report the information from the class as a whole and use code identifiers as necessary. The data will be kept confidential, and will be used to make amendments to the course for future semesters, or even this semester as available. We want to best fit the needs of our students!

We ask that as a participant you be as complete as possible on the pre and post questionnaires, course evaluations, and group discussions. Be honest with your answers. By being a part of this research, you will be helping us to make this course better – for you now, and for future students. Isn't that kind of neat to think that we not only want your opinion but will be taking it very seriously to help direct the curriculum? I hope you realize what a valuable opportunity being a part of this research project is for you. CSU is on the cutting edge with offering a course of this type while striving to be a leader in food fermentation education – you will be able to let future students know that you helped influence the development of this course!

To be a part of the research project, we need you to read and sign this consent letter.

*[Distribute consent form]*

If you agree to be a part of the research, please initial and date at the bottom of each page, and sign and print your name and date on the last page. Today's date is August 21. No matter what your choice is, we will collect all the forms so we don't single out people that do not want to take part in the study. We will pass out a second form that is for you to keep. It will be your reminder for what I have just told you about what is involved with the research project, plus it lists people to contact if you have any questions about the research project. Please keep in mind that this is different from questions or concerns about the course, only contact Janell Barker if your concern is in relation to the research. Before we collect the forms from you, do any of you have any questions in regard to what I just explained about the research project?

APPENDIX B: CONSENT FORM

## **Consent to Participate in a Research Study Colorado State University**

**Title of Study:** Science of Fermentation: the Development of a University Course and Outreach Educational Materials

**Principal Investigator:** Jeffrey Miller, PhD, Associate Professor, Dept. of Food Science and Human Nutrition, 970.491.6705, [jeffrey.miller@colostate.edu](mailto:jeffrey.miller@colostate.edu)

**CO-Principal Investigator:** Marisa Bunning, PhD, Assistant Professor, Dept. of Food Science and Human Nutrition, 970.491.7180, [marisa.bunning@colostate.edu](mailto:marisa.bunning@colostate.edu)

**CO-Principal Investigator:** Laura Bauer, MS, PhD student, Dept. of Food Science and Human Nutrition, [laura.bauer@colostate.edu](mailto:laura.bauer@colostate.edu)

**Study Location/Duration:** Gifford building / during FTEC 280A1 fall semester 2012

### **WHAT IS THE PURPOSE OF THE RESEARCH?**

The purpose of this research is to evaluate and improve a newly developed undergraduate level course that has been created to meet existing gaps in food fermentation science education at Colorado State University. The course, FTEC 280A1, Science of Food Fermentation, has been approved by the University Curriculum Committee.

### **WHY AM I BEING INVITED TO TAKE PART IN THIS RESEARCH?**

We would like your feedback on FTEC 280A1, as a student currently enrolled in the course.

### **WHO IS DOING THE STUDY?**

This study is being conducted as part of the doctoral dissertation research for Laura Bauer, who will be administering the surveys and group discussions for this study.

### **WHAT WILL I BE ASKED TO DO?**

Complete a pre/post questionnaire at the beginning and end of the semester  
Participate in a group discussion with other class members at mid-semester  
Fill out a mid-semester evaluation using the CSU course survey  
Classroom assignments and exams will be analyzed for research purposes

Your status and course grade will not be affected by your participation in this research.

### **ARE THERE REASONS WHY I SHOULD NOT TAKE PART IN THIS STUDY?**

You should not take part in this study if you are not enrolled in FTEC 280A1 fall semester 2012.

### **WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS?**

There are no known risks associated with participation in this research. It is not anticipated that any of the questions asked in the focus group will lead to distress but if you are uncomfortable for any reason, you have the option to leave the focus group at any time.

The researcher is not aware of any potential physical or psychological risk associated with participating in this study. However, it is not possible to identify all potential risks in research procedures, but the researchers have taken reasonable safeguards to minimize any known and potential, but unknown, risks.

### **ARE THERE ANY BENEFITS FROM TAKING PART IN THIS STUDY?**

There are no direct benefits to you for participating in this research, but we hope that you may gain some satisfaction from having input in improving a course at CSU.

Page 1 of 2 Participant's initials \_\_\_\_\_ Date \_\_\_\_\_

**DO I HAVE TO TAKE PART IN THE STUDY?**

Your participation in this research is voluntary. If you decide to participate in the study, you may withdraw your consent and stop participating at any time without penalty or loss of benefits to which you are otherwise entitled.

**WHO WILL SEE THE INFORMATION THAT I GIVE?**

We will keep private all research records that identify you, to the extent allowed by law.

Your information will be combined with information from other people taking part in the study. When we write about the study to share it with other researchers, we will write about the combined information we have gathered. You will not be identified in these written materials. We may publish the results of this study; however, we will keep your name and other identifying information private. The researcher will be assigning each participant a code. This code will be used for course evaluation materials including the pre/post questionnaire and group discussions. Questionnaire data will inform the group discussions as a whole. Once your group discussion is transcribed, your name will no longer be associated with the transcript. Keys to the code will be kept separate from the transcribed group discussions. The course instructors will not be able to link comments from a student’s course evaluation materials directly to him or her by name. Data collected, including course assignments and exams, will be linked using this code.

We will make every effort to prevent anyone who is not on the research team from knowing that you gave us information, or what that information is. For example, your name will be kept separate from your research records and these two things will be stored in different places under lock and key.

You should know, however, that there are some circumstances in which we may have to show your information to other people. For example, the law may require us to show your information to a court.

**WHAT HAPPENS IF I AM INJURED BECAUSE OF THE RESEARCH?**

The Colorado Governmental Immunity Act determines and may limit Colorado State University's legal responsibility if an injury happens because of this study. Claims against the University must be filed within 180 days of the injury.

**WHAT IF I HAVE QUESTIONS?**

Before you decide whether to accept this invitation to take part in the study, please ask any questions that might come to mind now. Later, if you have questions about the study, you can contact the researcher, Laura Bauer at [laura.bauer@colostate.edu](mailto:laura.bauer@colostate.edu). If you have any questions about your rights as a volunteer in this research, contact Janell Barker, Human Research Administrator at 970-491-1655. We will give you a copy of this consent form to take with you.

This consent form was approved by the CSU Institutional Review Board for the protection of human subjects in research on (Approval Date).

\_\_\_\_\_  
Signature of person agreeing to take part in the study

\_\_\_\_\_  
Date

\_\_\_\_\_  
Printed name of person agreeing to take part in the study

\_\_\_\_\_  
Name of person providing information to participant

\_\_\_\_\_  
Date

\_\_\_\_\_  
Signature of Research Staff

APPENDIX C: PARTICIPANT COVER LETTER



Department of Food Science and Human Nutrition  
1571 Campus Delivery  
Fort Collins, Colorado 80523-1571  
(970) 491-3663  
FAX: (970) 491-3875  
[www.fshn.cahs.colostate.edu](http://www.fshn.cahs.colostate.edu)

Dear FTEC 280A1 Student,

My name is Laura Bauer and with the assistance of my advisors, Dr. Marisa Bunning and Dr. Jeff Miller, I am working on a doctoral research project for my dissertation entitled, *Science of Fermentation: the Development of a University Course and Outreach Educational Materials*. We are asking students currently enrolled in the course FTEC 280A1: Science of Food Fermentation, to participate in course evaluation efforts for this research project. The course is unique in that it is new to Department of Food Science and Human Nutrition curriculum and it has been created to provide new learning opportunities for multiple disciplines to be engaged in the art, science, and culture of harboring beneficial microorganisms for food preservation and product development.

We hope that you choose to participate in this research project by sharing your feedback and opinions with us through confidential questionnaires and group interviews that will take place during class time. Your choice to participate or not to participate will not affect your grade in the course in anyway. Course instructors will have access to your responses as a group, but responses will not be linked to an individual person. Every student participant will be valuable to this research project; it will guide improvement of this course and potentially other courses. There will be no direct benefit to participating in the research project, but you will have an important role in ensuring CSU continues to provide exceptional learning opportunities for current and future students. The group interviews will be audio recorded to thoroughly collect your feedback data. We will maintain your confidentiality throughout the process by not making the tape recordings available to instructors until after course grades have been submitted.

While we are not able to provide you with compensation for participating in the project, you will be enjoying samples of homemade and commercial fermented foods and drinks as well as the experience in this unique opportunity to improve a course at CSU.

Thank you for your time and attention and I hope you will decide to participate in this study.

Laura M. Bauer, MS, RD  
PhD student  
Dept. of Food Science and Human Nutrition  
Colorado State University  
311 Gifford Building  
[laura.bauer@colostate.edu](mailto:laura.bauer@colostate.edu)

APPENDIX D: PRE AND POST QUESTIONNAIRE

To maintain confidentiality, you will use the same code for all FTEC 280A1 research documents:  
First letter of your middle name with the last two digits of your telephone number.

Pre Post Questionnaire

1. Which of the following products is NOT traditionally made through fermentation processes:
  - a. Beer and wine
  - b. Tofu
  - c. Sauerkraut
  - d. Cheese
  - e. Bread
  
2. What is historically significant about fermentation as a food processing technique?
  - a. Oldest method of food preservation
  - b. Initiated awareness of beneficial microorganisms
  - c. Unique to only one region of world and its culture
  - d. Both A and B
  - e. All of the above
  
3. Fermentation of carbohydrates results in the major end-products of \_\_\_\_\_ using yeasts, bacteria, or a combination, under anaerobic conditions.
  - a. Lactic acid, water
  - b. Citric acid, carbon dioxide
  - c. Lactic acid, carbon dioxide, ethanol
  - d. Citric acid, water, ethanol
  
4. Yogurt is produced by inoculating milk with the lactic acid bacteria *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*.
  - a. True
  - b. False
  
5. Fermentation of beer utilizes a different species of yeast than what is used to make bread.
  - a. True
  - b. False
  
6. Lactic acid bacteria have a role in improving the health benefits of fermented products by:
  - a. Killing pathogenic bacteria
  - b. Providing lactase enzymes for breakdown of lactose
  - c. Feeding probiotics present in the gut
  - d. None of the above
  - e. All of the above

7. The microorganisms responsible for fermenting cabbage and other seasonings for sauerkraut or kimchi are:
  - a. Yeasts added as a starter culture
  - b. Lactic acid bacteria (LAB) added as a starter culture
  - c. Both yeasts and LAB added as a starter culture
  - d. Wild or existing yeasts found on the vegetable
  - e. Wild or existing LAB found on the vegetable
  
8. Criteria for classification as a PROBIOTIC include all of the following, except:
  - a. Must be alive
  - b. Must provide a health benefit to the host
  - c. Must function in the same way as other probiotics
  - d. Must be identified to the genus, species, and strain level
  - e. None of the above
  
9. PREBIOTICS are all of the following, except:
  - a. Indigestible and not sensitive to gut secretions
  - b. Fermented by probiotics
  - c. Naturally occurring in a variety of plant foods
  - d. Mostly consisting of short-chain fatty acids
  - e. Able to stimulate growth of beneficial gut microflora
  
10. How likely would you be to increase, decrease, or change the variety of fermented food or drinks in your diet if you knew these products provide a health benefit?
  - a. I would definitely increase the amount or change the variety that I consume
  - b. I would consider increasing the amount or changing the variety that I consume
  - c. I would not plan to make any changes to my diet
  - d. I would decrease the amount or variety that I consume
  - e. I am not sure

1. How often on average do you **EAT OR DRINK** the following? (put an X in the appropriate box)

	Daily	A few times per week	A few times per month	A few times per year	Never
Yogurt, with live and active cultures					
Yogurt, heat treated after culturing					
Cheese					
Kefir					
Buttermilk					
Milk (any fat level)					
Tempeh					
Tofu					
Miso					
Salami					
Summer sausage					
Pepperoni					
Sauerkraut					
Kimchi					
Salsa					
Sourdough bread					
Any other yeast bread					
Quick breads or muffins					
Beer					
Wine					

2. How often on average do you **MAKE** the following? (put an X in the appropriate box)

	Daily	A few times per week	A few times per month	A few times per year	Never
Yogurt, with live and active cultures					
Yogurt, heat treated after culturing					
Cheese					
Kefir					
Buttermilk					
Milk (any fat level)					
Tempeh					
Tofu					
Miso					
Salami					
Summer sausage					
Pepperoni					
Sauerkraut					
Kimchi					
Salsa					
Sourdough bread					
Any other yeast bread					
Quick breads or muffins					
Beer					
Wine					

APPENDIX E: GROUP INTERVIEW SCRIPT

## **FTEC 280A1 Focus Groups Script and Questions**

*Objective: Further evaluate viability of FTEC 280A1 as FSHN course.*

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### **Introduction**

Welcome and thank you for being here! [Introductions of moderator and assistant.]

Each of you is here because you are all currently taking FTEC 280A1. We are interested in learning more about student perceptions of the course FTEC 280A1.

The results from our discussion will be helpful for CSU's growing presence as a leader in food fermentation education. Students who will take this course in the future will benefit from your honest and open conversation today.

It is your choice to be a part of this discussion, and your standing in the course will not be affected, either negatively or positively, by your choice. We are seeking more information about the class and we are not testing you. There are no right or wrong answers, nor will you offend us by your opinion. You do not need to agree with your classmates, and we encourage you to share your comments even if they differ from what has been said, but please listen attentively and be respectful to your peers. Please remember that we are just as interested in negative comments as we are interested in positive comments.

We ask that you respect this time together just like you would a class period. That means please turn off your phones, have only one person speaking at a time, and choose to use appropriate language that will be helpful and not disrespectful to others. We will be recording this discussion because we want it to be conversational and do not want to miss anything while taking notes. When we report results from these discussions, we will not use your names and your comments will be kept confidential.

For all questions, remember to probe as needed, i.e.:

"Would you explain further?"

"Would you give an example?"

"I don't understand."

1. Let's begin by going around the table for this first question. Even though we know each other from class, let's start by each person stating his or her name, what year you are in school, your intended major if you have one, and what led you to decide to take FTEC 280A1 this semester.

For the remaining questions you do not need to answer in order around the table, but again remember that we are recording this discussion and just ask that you speak one at a time.

## **FTEC 280A1 Focus Groups Script and Questions**

*Objective: Further evaluate viability of FTEC 280A1 as FSHN course.*

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2. What would you say has been the most productive way for you to learn the course material? (i.e. attending lecture, taking notes, performing experiments in the lab, weekly readings, working through homework problems, taking exams, course website, etc.)
  - a. How do you think each of the teaching and learning methods correlate or fit together? (i.e. lecture, lab, course website, readings, homework, exams, etc.)
3. What are your views on the guest speakers that presented so far in FTEC 280A1?
  - a. What has been most helpful about having guest speakers?
  - b. What has been least helpful about having guest speakers?
4. What are your views on the exams you have taken so far in FTEC 280A1?
  - a. How do you prepare for exams?
5. Do you feel that you were adequately prepared, through the required prerequisites, for FTEC 280A1?
  - a. If not, what do you think would have been helpful?
6. In what ways have the course sessions affected your understanding or interest in fermented foods and beverages?
7. In what ways do you see your experience of taking FTEC 280A1 impacting your future? (i.e. providing with marketable skills, preparing for upper division classes, eliminating this subject as intended major, skills for home fermenting, general new knowledge.)
  - a. Tell us more about the skills and/or knowledge that you have developed through FTEC 280A1 and how they will impact your future.
8. In our first question, many of you responded that you took this course because...*[fill in question based on theme of responses from #1 – interest in topic, chance to take course in department, interest in brewing, etc.]* Tell us if you feel FTEC 280A1 is meeting your expectations.
  - a. If not, what would you like to see added or removed from the course in order to meet your expectations?
  - b. If so, please tell us more about how the course is meeting your expectations.

## **FTEC 280A1 Focus Groups Script and Questions**

*Objective: Further evaluate viability of FTEC 280A1 as FSHN course.*

---

9. Suppose a friend asked if you would recommend taking this course. What would you tell your friend?
  - a. Tell us about positive things about this course.
  - b. Tell us about negative things about this course.
  
10. We have discussed a lot today, but we know that you might still have other input about the course. Is there anything you would like to say about FTEC 280A1 that hasn't been brought up already?

Thank you for your time today. We take your feedback very seriously and really appreciated being able to have this conversation with each of you.

APPENDIX F: IRB APPROVAL LETTER

**NOTICE OF APPROVAL FOR HUMAN RESEARCH**

**DATE:** June 17, 2013  
**TO:** Müller, Jeffrey, 1571 Food Sci and Human Nutrition  
Auld, Garry, 1571 Food Sci and Human Nutrition, Bauer, Laura, 1571 Food Sci and Human Nutrition, Bunning, M., 1571 Food Sci and Human Nutrition  
**FROM:** Barker, Janell, Coordinator, CSU IRB 2  
**PROTOCOL TITLE:** Science of Food Fermentation: Development of a University Course and Outreach Educational Materials  
**FUNDING SOURCE:** NONE  
**PROTOCOL NUMBER:** 12-3476H  
**APPROVAL PERIOD:** Approval Date: June 30, 2013 Expiration Date: June 29, 2014

The CSU Institutional Review Board (IRB) for the protection of human subjects has reviewed the protocol entitled: Science of Food Fermentation: Development of a University Course and Outreach Educational Materials. The project has been approved for the procedures and subjects described in the protocol. This protocol must be reviewed for renewal on a yearly basis for as long as the research remains active. Should the protocol not be renewed before expiration, all activities must cease until the protocol has been re-reviewed.

If approval did not accompany a proposal when it was submitted to a sponsor, it is the PI's responsibility to provide the sponsor with the approval notice.

This approval is issued under Colorado State University's Federal Wide Assurance 00000647 with the Office for Human Research Protections (OHRP). If you have any questions regarding your obligations under CSU's Assurance, please do not hesitate to contact us.

Please direct any questions about the IRB's actions on this project to:

Janell Barker, Senior IRB Coordinator - (970) 491-1655 [Janell.Barker@Colostate.edu](mailto:Janell.Barker@Colostate.edu)  
Evelyn Swiss, IRB Coordinator - (970) 491-1381 [Evelyn.Swiss@Colostate.edu](mailto:Evelyn.Swiss@Colostate.edu)

Barker, Janell



Barker, Janell

Approval is to recruit the remaining 25 participants with the approved consent form. This also reflects an approved amendment to increase the total approved to recruit from 20 to 40. With a total recruited of 15, the balance remaining to recruit is now 25. The above-referenced project was approved by the Institutional Review Board with the condition that the approved consent form is signed by the subjects and each subject is given a copy of the form. NO changes may be made to this document without first obtaining the approval of the IRB.

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**Approval Period:** June 30, 2013 through June 29, 2014  
**Review Type:** EXPEDITED  
**IRB Number:** 00000202

APPENDIX G: FTEC 280A1 COURSE SYLLABUS (YEAR 1)

## *FTEC 280A1/210: Science of Food Fermentation*

**Fall 2012, 3 credits:**

Tuesdays 4:00-7:50pm in Gifford 237 (& 239)

**Instructors:**

	<u>Laura Bauer, MS, RD</u>	<u>Marisa Bunning, PhD</u>	<u>Jeffrey Miller, PhD, CEC, CCE</u>
office:	Gifford 311	Gifford 200B	Gifford 214C
phone:	NA	491-7180	491-6705
email:	<a href="mailto:laura.bauer@colostate.edu">laura.bauer@colostate.edu</a>	<a href="mailto:marisa.bunning@colostate.edu">marisa.bunning@colostate.edu</a>	<a href="mailto:jeffrey.miller@colostate.edu">jeffrey.miller@colostate.edu</a>
office			
hours:	Tues & Fri 10am-12pm	Tues & Thurs 1-3pm	Mon & Wed 10am-12pm

**Prerequisite(s):** CHEM 107: Fundamentals of Chemistry, or CHEM 111: General Chemistry and  
LIFE 205: Survey of Microbial Biology

**Course Description:**

Science, history, culture, gastronomy, safety, health, and nutrition aspects of fermented foods and beverages.

**Required Text:**

Katz, Sandor Ellix (2012). *The art of fermentation: an in-depth exploration of essential concepts and processes from around the world*. White River Junction, Vt.: Chelsea Green Pub.

Additional required readings for FTEC 280A1 will be made available on RamCT.

**Additional Class Material:**

- Lecture notes and lab protocol will be posted on RamCT.
- Students will be required to purchase a three-ring binder to compile a lab manual.
- A course-specific online research guide from the library can be accessed at:  
<http://libguides.colostate.edu/FTEC>

**Course Objectives:**

1. Interpret cultural impact of fermentation in world cultures during previous historical periods.
2. Demonstrate ability to apply basic scientific principles to the study of food fermentation.
3. Analyze the role of common microorganisms used in the process of fermenting food and beverages.
4. Evaluate potential health advantages and disadvantages of fermented foods and beverages; including probiotics, nutrient bioavailability, food safety, and metabolic end products.
5. Integrate fermentation principles through biochemical conversion of food substrates into fermented consumable products within five categories: grains, vegetables, dairy, meat and soy, and beverage.

**Mode of Delivery:**

Classroom instruction will be split into approximately two hours of lecture and two hours of laboratory each week. Guest experts (CSU faculty and staff, and local experts) will be specialist instructors as noted on syllabus. Laboratory work will include hands-on fermented food and beverage preparation.

**Participation in Research Project:**

Students enrolled in FTEC 280A1 will have the opportunity to participate in a research project to evaluate the course for improvements. Participation is voluntary, and your choice to participate or not to participate will not affect your grade in the course in anyway. Project information and what will be asked of participants will be made available the first day of class and on RamCT.

**Methods of Evaluation:**

Students are expected to attend all classes, participate in laboratory, complete laboratory assignments, participate in online reading and writing assignments, take five unit exams, and complete and present one final project. Grading will be based on these requirements. Material from laboratory sessions is included in examinations. Late assignments will not be accepted.

**Evaluation:**

	<b>Points</b>	<b>Total</b>
5 unit exams	5 x 100	500
Lab assignments	5 x 50	250
Online discussion participation	10 x 10	100
Final project	250	250
Final project presentation	100	100
Total:		1200

**Grading criteria:**

<p>A = 90 – 100% (1080 – 1200 points)          B = 80 – 89% (960 – 1079 points)          C = 70 – 79% (840 – 959 points)          D = 60 – 69% (720 – 839 points)          F = 59% and below (&lt;720 points)</p>
---

**Explanation of Evaluation and Grading:**

5 unit exams: Each unit (beverages, meat and soy, dairy, vegetables, and grains) will have a separate unit exam. Please see syllabus for dates of these exams.

Lab assignments: Students will be responsible for maintaining their own lab manual and completing lab assignments. Assignments will be posted on RamCT. Students may work on lab assignments with their lab groups but must submit their own work.

**Lab assignment breakdown – 50 points per unit:**

- 30 points: unit assignment
- 10 points: unit lab performance (technique, quality, safe practices, participation)
- 10 points: oversee unit ferments outside of class time (participation)

Online discussion participation: Each week you will have a reading and writing (R&W) assignment due 24 hours before class (by Monday at 4pm). Each R&W assignment is worth up to 10 points. You must do 10 R&W assignments for full participation points (This allows you the flexibility to skip or miss up to 4 assignments. You can do more than 10 R&W assignments, but you will not be awarded extra credit. We will, however, keep that as a positive consideration in determining your final grade.).

1. **Read the assigned reading each week**, and ferment on the reading, even if you do not complete the R&W assignment. When the assigned section from the book includes a section on a food or beverage product we will not be making, you can skim that section. Please note that these sections may be useful for planning your final project.
2. **Write on the topic.** You will have specific questions to address or you will be asked to write a simple reflection on the reading.
3. **Post your writing** on our class webpage on RamCT Blackboard. There will be a folder for each week. Post your writing as a new topic under the appropriate week's folder.
4. **Read what your classmates have posted** and comment (reply) on at least one other person's posting.
5. **Find fermentation in the news** and popular information sources. As part of your R&W assignment, two times during the semester, each student must find, read and post a URL link to an article from a lay literature information source (newspaper, magazine, news website, etc.) that is related to the week's topic. Write a brief summary of the article (3-4 sentences). You will notice that fermentation is a hot topic! You will not sign up for a week, but we hope to have these well-balanced each week throughout the semester. Students are encouraged to read and comment on each other's articles, this can count as your participation comment.
6. **Guidelines for R&W:**
  - The readings will prepare you for the week's topic. Come to class prepared.
  - The online discussion will help guide our class discussion. Use this venue for this purpose only. If you need to contact an instructor or classmate for other reasons, use other contact methods.
  - Your writing will not be graded, but satisfactory completion of at least 10 R&W assignments is part of your overall class grade.
  - Write as you would for a graded paper. That means: no text talk, no foul language, use proper grammar and punctuation, and proofread your post for spelling and context.
  - The instructor will not make comments online, unless deemed necessary or directly asked to respond.

Final project and presentation: Each student will select a final project to complete. Presentations of the projects will happen during the final exam time slot on **Thursday, December 13<sup>th</sup> from 6:20-8:20pm.**

1. The **final project** will tie into what will be learned from weekly labs, lectures, and readings. Weekly lab activities follow a specific recipe to gain underlying fermentation concepts, but students will be expected to apply these skills and think critically beyond using a given recipe for their final project.
  - Students will work in groups of 2 or 3 (depending on class size).

- Each group will develop a fermented food or beverage (non-alcoholic) for class consumption.
  - The final product can be innovative based on class labs or a common product in an indigenous culture that we did not study.
  - Groups will be given a small amount of class time to work. Most of the work will need to be done outside of class time.
  - Groups will be required to complete and submit a project plan to receive approval to work on that project. This is to ensure your timeline is thought-out and will also ensure diverse products and fact sheets made across groups.
  - Each student will submit a log of his or her contributions to the group project to be considered for grading purposes.
  - Documents for the project plan, detailed project guidelines, and project log will be made available on RamCT.
2. The **developed product** will be evaluated by classmates, instructors, and possibly guest speakers based on:
- Sensory characteristics
  - Overall palatability
  - Safety and product analysis (pH)
  - Marketability
3. Each group will prepare a **presentation** on their final product. The final presentation must include information on production:
- Farm to plate: ingredients and equipment used, timeframe
  - Science: proposed mechanism of action, health benefits, side effects
  - Human perspective: historical and cultural connections
  - Proposed culinary use
4. Each group will create a **one page fact sheet** for brief but thorough product information directed to consumers. The final presentation will include presenting your fact sheet. A template for the fact sheet layout will be available on RamCT. The fact sheet will need to include information from the above presentation bullets with applicable photos.
5. **Important Dates for Final Project:**
- 8/21: Introduce topic options.
  - 9/11: Sign-up for group and topic.
  - 9/25: Project plan due.
  - 10/23: Draft 1 of fact sheet due.
  - 11/13: Draft 2 of fact sheet due.
  - 12/13: Final project due.

**Class Policies:**

*Please respect yourself, your fellow students, and your instructors:*

- All communication devices (cell phones, pagers, PDAs, iPods, etc – anything that beeps, buzzes, rings or makes noise) must be **turned off** during the class period.
- Refrain from text-messaging, reading newspapers, puzzles, or conducting personal conversations during the class period. Your complete attention helps us do a better job.

*Academic Honesty:* Group study is often an excellent way to further your understanding of course material, but all written material and examinations must reflect your personal knowledge and mastery of the topic only. Representing someone else's work (or "unoriginal work") is considered **academic dishonesty**. CSU, FSHN, and the instructors of this course have a zero tolerance policy for academic dishonesty. All suspected incidents of academic dishonesty such as cheating on exams, plagiarism on lab reports or the final project, having another student complete your assignment, etc. will be referred to the CSU Office of Conflict Resolution and Student Conduct Services. Be aware that depending on the severity of the incident, punishments range from failing the assignment or course to expulsion from the university.

*Exams:* We will not give early or late exams except in cases spelled out by university policies (i.e. participation in university-sanctioned events). Should you miss an exam due to illness or true emergency, it is your responsibility to contact one of us as soon as you know you will be unable to make the exam. This means a time stamped e-mail or phone call **prior** to the exam period. Requests for make-up exams after the fact will be viewed highly skeptical and will be considered on case-by-case basis.

*Assignments:* Assignments are due before class begins on the scheduled date. Late make-up assignments may be accepted up to two weeks past the due date with a 10% point penalty per week. No assignments will be accepted more than two weeks late.

*Attendance:* We expect everyone to be in class every day except when they have an infectious disease. For this reason you will not receive points for class attendance, but attendance will be considered when assigning course grades. You are responsible for all material distributed in class. Should you be unable to attend class on a given day, it is your responsibility to get the material covered during that period.

*e-ID:* We will communicate all matters of urgency and importance (i.e. a change of test date) via RamMail. You are responsible for all information we send via RamMail. Undeliverable messages due to a full mail box or outdated contact information is not our responsibility. If you use a smartphone for communication, ensure your CSU e-mail is forwarded to it.

*Use of RamCT Blackboard:* A RamCT webpage will be used in this course to post grades, course material including lecture notes, lab protocol, R&W assignments, and communicate vital information (i.e. date changes on the syllabus). Check the RamCT webpage frequently.

We reserve the right to modify this syllabus and schedule. Any changes will be announced in class and posted on the RamCT webpage.

**FTEC 280A1 Course Topic and Weekly Schedule:**

<b>Week (date)</b>	<b>Topic</b>
<b>1 (8/21):</b>	<p><b>Introduction</b></p> <p><i>Lecture:</i> Class overview and introduction to fermentation</p> <p><i>Laboratory:</i> Kitchen lab orientation and prep work. Ginger bug.</p> <p><i>Reading:</i> (optional: Introduction and Ch.1)</p>
<b>2 (8/28):</b>	<p><b>Unit 1: Beverages</b></p> <p><i>Lecture:</i> History/Culture</p> <p><i>Laboratory:</i> Ginger ale, water kefir</p> <p><i>Guest Instructor:</i></p> <p><i>Reading:</i> Ch. 6: p. 147-167 “kombucha”</p>
<b>3 (9/4):</b>	<p><b>Unit 1: Beverages</b></p> <p><i>Lecture:</i> Science of</p> <p><i>Laboratory:</i> Kombucha (ongoing: ginger ale, water kefir)</p> <p><i>Guest Instructor:</i> Dr. Tiffany Weir, FSHN</p> <p><i>Reading:</i> Ch. 6: p. 167 “kombucha”-179</p>
<b>4 (9/11):</b>	<p><b>Unit 1: Beverages</b></p> <p><i>Lecture:</i> Practice/Application</p> <p><i>Laboratory:</i> Beverages sensory assessment</p> <p><i>Guest Instructor:</i> Merinda McLure, CAHS Librarian</p> <p><i>Reading:</i> <b><u>5:50-7:50pm in Library Computer Classroom 174</u></b> Ch. 2 &amp; 3, all</p>
<b>5 (9/18):</b>	<p>➤ <i>Unit Exam: Beverages</i></p> <p><b>Unit 2: Meat &amp; Soy</b></p> <p><i>Lecture:</i> Start Meat &amp; Soy</p> <p><i>Laboratory:</i> Soy lab: Sweet miso</p> <p><i>Guest Instructor:</i></p> <p><i>Reading:</i> Ch. 11, all</p>
<b>*6 (9/25)*:</b>	<p><b>Unit 2: Meat &amp; Soy – <u>In Animal Sciences bldg., room 114</u></b></p> <p><i>Lecture:</i> Fermented meats</p> <p><i>Laboratory:</i> Meat lab (salami)</p> <p><i>Guest Instructor:</i> Dr. Dale Woerner and Curtis Pittman, Center for Meat Safety and Quality, Dept. of Animal Sciences</p> <p><i>Reading:</i> Ch. 12, all</p>
<b>7 (10/2):</b>	<p><b>Unit 2: Meat &amp; Soy</b></p> <p><i>Lecture:</i> Fermented soy products</p> <p><i>Laboratory:</i> Tempeh virtual lab with samples</p> <p><i>Guest Instructor:</i> <u>Group Interviews for research project participants</u></p> <p><i>Reading:</i> Ch. 10, all</p>
<b>8 (10/9):</b>	<p>➤ <i>Unit Exam: Meat &amp; Soy</i></p> <p><b>Unit 3: Dairy</b></p> <p><i>Lecture:</i> History/Culture</p> <p><i>Laboratory:</i> Kefir</p> <p><i>Guest Instructor:</i></p> <p><i>Reading:</i> Ch. 7: p. 181-186 “yogurt” &amp; 192 “kefir”-198</p>

**FTEC 280A1 Course Topic and Weekly Schedule:**

<b>9 (10/16):</b>	<b>Unit 3: Dairy</b> <i>Lecture:</i> Science of <i>Laboratory:</i> Yogurt <i>Guest Instructor:</i> <b>5-6pm: Tour at MouCo Cheese Co.</b> <i>Reading:</i> Ch. 7: p. 186 "yogurt"-192 "kefir"
<b>10 (10/23):</b>	<b>Unit 3: Dairy</b> <i>Lecture:</i> Practice/Application <i>Laboratory:</i> Soft and hard cheese <i>Guest Instructor:</i> <i>Reading:</i> Ch. 7: p. 199-209
<b>11 (10/30):</b>	➤ <i>Unit Exam: Dairy</i> <b>Unit 4: Vegetables</b> <i>Lecture:</i> History/Culture <i>Laboratory:</i> Kimchi <i>Guest Instructor:</i> Kimchi expert <i>Reading:</i> Ch. 5: p. 95-119
<b>12 (11/6):</b>	<b>Unit 4: Vegetables</b> <i>Lecture:</i> Science of <i>Laboratory:</i> Sauerkraut <i>Guest Instructor:</i> Marni Wahlquist, Vital Cultured Foods <i>Reading:</i> Ch. 13, all
<b>13 (11/13):</b>	<b>Unit 4: Vegetables</b> <i>Lecture:</i> Practice/Application <i>Laboratory:</i> Pickles (brined ferments). Start sourdough starter <i>Guest Instructor:</i> <i>Reading:</i> Ch. 5: p. 120 "brining"- 144
----- 11/20: No class. Fall Break -----	
<b>14 (11/27):</b>	➤ <i>Unit Exam: Vegetables</i> <b>Unit 5: Grains</b> <i>Lecture:</i> History/Culture and Science of <i>Laboratory:</i> Baking with sourdough starter. <i>Guest Instructor:</i> Callie Koch, Ingrained Bakery <i>Reading:</i> Ch. 8: p. 211-235
<b>15 (12/4):</b>	<b>Unit 5: Grains</b> <i>Lecture:</i> Practice/Application <i>Laboratory:</i> Fermented Feast! <i>Guest Instructor:</i> <i>Reading:</i> Ch. 8: p. 236-245
➤ <i>Take-Home Unit Exam: Grains – due by Friday 12/7 at 12noon</i>	
<b>16 (12/13) 6:20-8:20pm</b>	<b>Finals</b> ➤ <i>Presentations of final project</i>

APPENDIX H: FTEC 210 COURSE SYLLABUS (YEAR 2)

## *FTEC 210: Science of Food Fermentation*

### **Fall 2013, 3 credits:**

Tuesdays 4:00-7:50pm in Gifford 237 (& 239)

**Instructor:** Laura Bauer, MS, RD

**office:** Gifford 311

**email:** [laura.bauer@colostate.edu](mailto:laura.bauer@colostate.edu)

**office hours:** Tuesday or by apt.

**Prerequisite(s):** CHEM 107: Fundamentals of Chemistry, or CHEM 111: General Chemistry  
and  
LIFE 205: Survey of Microbial Biology

### **Course Description:**

Science, history, culture, gastronomy, safety, health, and nutrition aspects of fermented foods and beverages.

### **Required Text:**

Katz, Sandor Ellix (2012). *The art of fermentation: an in-depth exploration of essential concepts and processes from around the world*. White River Junction, Vt.: Chelsea Green Pub.

Additional required readings for FTEC 210 will be made available on RamCT.

### **Additional Class Material:**

- Lecture notes and lab protocol will be posted on RamCT.
- Students will be required to compile their own lab manual from posted assignments. A three-ring binder is recommended but not required.

### **Course Objectives:**

1. Interpret cultural impact of fermentation in world cultures during previous historical periods.
2. Demonstrate ability to apply basic scientific principles to the study of food fermentation.
3. Analyze the role of common microorganisms used in the process of fermenting food and beverages.
4. Evaluate potential health advantages and disadvantages of fermented foods and beverages; including probiotics, nutrient bioavailability, food safety, and metabolic end products.
5. Integrate fermentation principles through biochemical conversion of food substrates into fermented consumable products within five categories: grains, vegetables, dairy, plant and animal proteins, and beverages.

### **Mode of Delivery:**

Classroom instruction will be split into approximately two hours of lecture and two hours of laboratory each week. Guest experts (CSU faculty and staff, and local experts) will be specialist

instructors as noted on syllabus. Laboratory work will include hands-on fermented food and beverage preparation.

**Participation in Research Project:**

Students enrolled in FTEC 210 will have the opportunity to participate in a research project to evaluate the course for improvements. Participation is voluntary, and your choice to participate or not to participate will not affect your grade in the course in anyway. Project information and what will be asked of participants will be made available the first day of class and on RamCT.

**Methods of Evaluation:**

Students are expected to attend all classes, participate in lecture and laboratory, fulfill assignment requirements, take exams, complete and present one final project, and maintain products out-of-class. Grading will be based on these requirements.

**Evaluation:**

	<b>Points</b>	<b>Total</b>
5 unit exams	5 x 100	500
Lab assignments	5 x 50	250
Online discussion participation	5 x 10	50
Professional article presentation	40	40
Fermentation in the news	10	10
Final project	250	250
Final project presentation	100	100
Total:		1200

**Grading criteria:**

A = 90 – 100% (1080 – 1200 points) B = 80 – 89% (960 – 1079 points) C = 70 – 79% (840 – 959 points) D = 60 – 69% (720 – 839 points) F = 59% and below (<720 points)
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**Explanation of Evaluation and Grading:**

5 unit exams: Each unit (beverages, plant and animal proteins, dairy, vegetables, and grains) will have a separate unit exam. Material from laboratory sessions is included in examinations. Please see weekly schedule for dates of these exams. We will have an ungraded pre-test at the start of each unit that students may use as a study guide for the unit material.

Lab assignments: Students will be responsible for maintaining their own lab manual and completing lab assignments. Assignments will be posted on RamCT. Students may work on lab assignments with their lab groups but must submit their own work.

**Lab assignment breakdown – 50 points per unit:**

- 15 points: lab notebook (subjective and objective evaluations)
- 15 points: online assessment and guest instructor questions
- 10 points: unit in-lab performance and participation (technique, quality, safety)
- 10 points: unit out-of-lab performance and participation (oversee unit ferments)

Online discussion participation: Each non-exam week you will have an online discussion assignment due 24 hours before class (by Monday at 4pm). Each assignment is worth up to 10 points. You must do one assignment from each unit for full participation points. (This allows you the flexibility to skip or miss one assignment per unit. You can do more than the required assignments, but you will not be awarded extra credit.)

- Online discussion will be based on the weekly assigned reading. **You are expected to complete the assigned reading prior to class even if you do not do the online discussion.** The readings will prepare you for the week's topic. Come to class prepared.
- On the RamCT Blackboard webpage for the class, under the "Discussion Board" tab, there will be a new forum for discussion posted for each week. Please post your response as a new topic thread under the week's folder.
- Read what your classmates have posted and comment (reply) as appropriate.
- Grading rubric is posted. You need to write one original post and one reply to a classmate's post for full credit. Both of your posts should be well-thought, appropriate, and display your comprehension of the week's reading for full credit. Please do not simply say "I agree" for your reply post!
- Write as you would for a graded paper. That means: no text talk, no foul language, use proper grammar and punctuation, and proofread your post for spelling and context. The instructor will provide feedback only visible to the individual and will not make comments online, unless deemed necessary or directly asked to respond.
- Please remember: The online discussion will help guide our class discussion. Use this venue for this purpose only. If you need to contact an instructor or classmate for other reasons, use other contact methods.

Professional article presentation: Each student will select and informally present a peer-reviewed journal article to the class. Students may choose to work independently or with one partner. Students will sign-up at the beginning of the semester for a week and unit topic to present. Students will then research the topic of discussion for that week and find and read a relevant article. Students will post a pdf of the article and a brief statement on its relevance to the class on RamCT Blackboard BEFORE the class period they present. On the "Wiki Pages" link, under the correct heading, create a Wiki Page (Click "show more" icon to display the icon for inserting a file.). Students will informally present on their chosen article to the class, including the citation (author(s), title, journal, date) and addressing these three items:

1. Purpose of the article (audience, research goals)
2. Summarize article (methods, conclusions, results)
3. What you learned from the article and its relevance to this class

Grading will be based on article credibility, relevance to topic and class, and student preparation.

Fermentation in the news: Find fermentation in the news and popular information sources. Each student must find, read and post a URL link to an article from a lay literature information source (newspaper, magazine, news website, etc.) that is related to the week's topic. Write a brief statement about the article (3-4 sentences). On the "Wiki Pages" link, under the correct heading, create a Wiki Page. You will notice that fermentation is a hot topic! You will not sign up for a week, but we hope to have these well-balanced each week throughout the semester. Students are encouraged to read and comment on each other's articles. Due by December 10<sup>th</sup>.

**Final project and presentation:** Each student will select a final project to complete. Presentations of the projects will happen during the final exam time slot on **Thursday, December 19<sup>th</sup> from 2:00-4:00pm.**

1. The **final project** will tie into what will be learned from weekly labs, lectures, and readings. Weekly lab activities follow a specific recipe to gain underlying fermentation concepts, but students will be expected to apply these skills and think critically beyond using a given recipe for their final project.
  - Students will work in groups of 2 or 3 (depending on class size).
  - Each group will develop at least three variations on a fermented food or beverage (non-alcoholic) for class consumption.
  - The final product can be innovative based on class labs or a common product in an indigenous culture that we did not study.
  - Groups will be given a small amount of class time to work. Most of the work will need to be done outside of class time.
  - Groups will be required to complete and submit a project plan to receive approval to work on that project. This is to ensure your timeline is thought-out and will also ensure diverse products and fact sheets made across groups.
  - Documents for the project are available on RamCT.
2. The **developed product** will be evaluated by classmates, instructors, and possibly guest speakers based on:
  - Sensory characteristics
  - Overall palatability
  - Safety and product analysis (pH)
  - Marketability
3. Each group will prepare a **presentation** on their final product. The final presentation must include information on production:
  - Farm to plate: ingredients and equipment used, timeframe
  - Science: proposed mechanism of action, health benefits, side effects
  - Human perspective: historical and cultural connections
  - Proposed culinary use
4. Each group will create a **one page fact sheet** for brief but thorough product information directed to consumers. The final presentation will include presenting your fact sheet. A template for the fact sheet layout is available on RamCT. The fact sheet will need to include information from the above presentation bullets with applicable photos.
5. **Important Dates for Final Project:**
  - 8/27: Introduce topic options.
  - 9/17: Sign-up for group and topic.
  - 10/8: Project plan due. Discuss with instructor.
  - 10/29: Draft 1 of fact sheet due.
  - 11/19: Draft 2 of fact sheet due.
  - 12/19: Final project due.

**Class Policies:**

*Please respect yourself, your fellow students, and your instructors:*

- All communication devices (cell phones, pagers, PDAs, iPods, etc – anything that beeps, buzzes, rings or makes noise) must be **turned off** during the class period.
- Refrain from text-messaging, reading newspapers, puzzles, or conducting personal conversations during the class period. Your complete attention helps us do a better job.

*Academic Honesty:* Group study is often an excellent way to further your understanding of course material, but all written material and examinations must reflect your personal knowledge and mastery of the topic only. Representing someone else's work (or "unoriginal work") is considered **academic dishonesty**. CSU, FSHN, and the instructors of this course have a zero tolerance policy for academic dishonesty. All suspected incidents of academic dishonesty such as cheating on exams, plagiarism on lab reports or the final project, having another student complete your assignment, etc. will be referred to the CSU Office of Conflict Resolution and Student Conduct Services. Be aware that depending on the severity of the incident, punishments range from failing the assignment or course to expulsion from the university.

*Exams:* We will not give early or late exams except in cases spelled out by university policies (i.e. participation in university-sanctioned events). Should you miss an exam due to illness or true emergency, it is your responsibility to contact one of us as soon as you know you will be unable to make the exam. This means a time stamped e-mail or phone call **prior** to the exam period. Requests for make-up exams after the fact will be viewed highly skeptical and will be considered on case-by-case basis.

*Assignments:* Assignments are due before class begins on the scheduled date. Late make-up assignments may be accepted up to two weeks past the due date with a 10% point penalty per week. No assignments will be accepted more than two weeks late.

*Attendance:* We expect everyone to be in class every day except when they have an infectious disease. For this reason you will not receive points for class attendance, but attendance will be considered when assigning course grades. You are responsible for all material distributed in class. Should you be unable to attend class on a given day, it is your responsibility to get the material covered during that period.

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We reserve the right to modify this syllabus and schedule. Any changes will be announced in class and posted on the RamCT webpage.

**FTEC 210 Course Topic and Weekly Schedule:**

<b>Week (date)</b>	<b>Topic</b>	<b>Read before class</b>
<b>1 (8/27):</b>	<b>Introduction</b> <i>Lecture:</i> Class overview, introduction to fermentation and microbiology <i>Lab:</i> Kitchen lab orientation and prep work.	
<b>2 (9/3):</b>	<b>Unit 1: Beverages</b> <i>Lecture:</i> History / Culture <i>Lab:</i> Ginger bug <i>Guest:</i> Merinda McLure, CHHS Librarian <b>6-8pm in Library Computer Classroom 174</b> <i>Due:</i>	Introduction and Ch. 1
<b>3 (9/10):</b>	<b>Unit 1: Beverages</b> <i>Lecture:</i> Science / Microbiology <i>Lab:</i> Kombucha (ongoing: ginger ale) <i>Guest:</i> FSHN Graduate Students <i>Due:</i>	Ch. 6, all
<b>4 (9/17):</b>	<b>Unit 1: Beverages</b> <i>Lecture:</i> Practice / Application <i>Lab:</i> Water kefir demo <i>Guest:</i> <i>Due:</i> Sign-up for final project group and topic	Ch. 2 & 3, all
<b>5 (9/24):</b>	➤ <b>Unit Exam: Beverages</b> <b>Unit 2: Plant &amp; Animal Proteins</b> <i>Lecture:</i> Start Plant and Animal Proteins <i>Lab:</i> Plant lab (Indian ferment) <i>Guest:</i> <i>Due:</i>	Ch. 11, all
<b>6 (10/1):</b>	<b>Unit 2: Plant &amp; Animal Proteins</b> <i>Lecture:</i> Fermented meats <i>Lab:</i> Meat lab (salami) <i>Guest:</i> Dr. Dale Woerner, Dept. of Animal Sciences <i>Due:</i>	Ch. 12, all
<b>7 (10/8):</b>	<b>Unit 2: Plant &amp; Animal Proteins</b> <i>Lecture:</i> Fermented soy products <i>Lab:</i> Tempeh virtual lab with samples <i>Guest:</i> <i>Due:</i> Project plan. Discuss with instructor	Ch. 10, all
<b>8 (10/15):</b>	➤ <b>Unit Exam: Plant &amp; Animal Proteins</b> <b>Unit 3: Dairy</b> <i>Lecture:</i> History/Culture <i>Lab:</i> <i>Guest:</i> Robert Poland, MouCo Cheese Co. <b>Tour at MouCo, time TBD</b> <i>Due:</i>	Ch. 7: p. 181-186 "yogurt" and p. 201 "whey"-209

**FTEC 210 Course Topic and Weekly Schedule:**

<b>9 (10/22):</b>	<b>Unit 3: Dairy</b> <i>Lecture:</i> Science of <i>Lab:</i> Yogurt and Kefir (compare and contrast) <i>Guest:</i> <i>Due:</i>	Ch. 7: p. 186 "yogurt"-201
<b>10 (10/29):</b>	<b>Unit 3: Dairy</b> <i>Lecture:</i> Practice/Application <i>Lab:</i> Cheese <i>Guest:</i> <i>Due:</i> Draft 1 of fact sheet	Enjoy a break! (we skip ch. 4, 9, 14 – check those out if you want!)
<b>11 (11/5):</b>	➤ <i>Unit Exam: Dairy</i> <b>Unit 4: Vegetables</b> <i>Lecture:</i> History/Culture <i>Lab:</i> Kimchi <i>Guest:</i> Suki Warren, community Kimchi expert <i>Due:</i>	Ch. 5: p. 95-119
<b>12 (11/12):</b>	<b>Unit 4: Vegetables</b> <i>Lecture:</i> Science of <i>Lab:</i> Sauerkraut <i>Guest:</i> Marni Wahlquist, Vital Cultured Foods <i>Due:</i>	Ch. 13, all
<b>13 (11/19):</b>	<b>Unit 4: Vegetables (&amp; Grains)</b> <i>Lecture:</i> Practice/Application <i>Lab:</i> Start sourdough starter <i>Guest:</i> Callie Koch, Ingrained Bakery <i>Due:</i> Draft 2 of fact sheet	Ch. 5: p. 120 "brining"- 144
----- 11/26: No class. Fall Break -----		
<b>14 (12/3):</b>	➤ <i>Unit Exam: Vegetables</i> <b>Unit 5: Grains</b> <i>Lecture:</i> History/Culture and Science of <i>Lab:</i> Baking with sourdough starter <i>Guest:</i> Callie Koch, Ingrained Bakery <i>Due:</i>	Ch. 8, all
<b>15 (12/10):</b>	<b>Unit 5: Grains</b> <i>Lecture:</i> Practice/Application <i>Laboratory:</i> TBD <i>Guest:</i> <i>Due:</i> (fermentation in the news)	Epilogue
➤ <i>Take-Home Unit Exam: Grains – due by Friday 12/13 at 12noon</i>		
<b>16 (12/19)</b> <b>2:00-4:00pm</b>	<b>Finals</b> ➤ <i>Presentations of final project</i>	

## APPENDIX I: FOOD FERMENTATION WORKSHOP MATERIALS

- Yogurt Recipe
- Neufchâtel Cheese Recipe
- Sauerkraut Recipe
- Kimchi Recipe
- Fermenting Foods Workshop Participant Assessment

# Yogurt

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## QUICK FACTS...

- Yogurt was likely discovered by accident over 8000 years ago by nomadic herdsmen in present day Middle East.
- Yogurt is a semi-solid dairy product made by fermenting milk with a special bacterial culture.
- Flavored yogurt, strained yogurt, or yogurt drinks can be made from plain yogurt. Plain yogurt can be used as a tart, lower calorie substitute in cooking and baking.
- Yogurt can be made safely at home without specialized equipment.
- Yogurt is a good source of calcium, protein, potassium, phosphorous, magnesium, zinc, and B vitamins. Also, the lactose in yogurt is often more tolerable than the same amount of lactose in milk.

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## EQUIPMENT:

- *Thermometer.* Use a thermometer that accurately measures temperatures up to 220°F. It is helpful to have one that can be clipped on the side of the pan.
- *Large double boiler or regular saucepan.* The pan capacity should be 2-3 quarts, for 1 quart of milk.
- *Whisk or mixing spoon and measuring cups.*
- *Containers for yogurt.* This can be canning jars or cups with lids.
- *Incubator.* A temperature of 110°F must be maintained over several hours. Today we will use the following method:
  - *Oven.* Heat deep pan of water to 110°F. Place filled yogurt containers into pans; water should come at least halfway up the containers. Set oven temperature at its lowest point to maintain water temperature at 110°F. Monitor water temperature throughout incubation, making adjustments as necessary.

*Another easy to method to use at home: Cooler.* Warm water to 130°F and pour into a clean insulated (hard-sided) ice chest or picnic cooler. Carefully set filled yogurt containers in the cooler; water should come at least halfway up the containers. Check that the temperature of the water in the cooler is at least 110°F. Close the cooler, place in warm place and let sit undisturbed.

## INGREDIENTS – makes 4-5 cups of plain yogurt:

- 1 quart pasteurized milk (any level of fat or reconstituted dry milk)
- Nonfat dry milk (NFDM) powder: 1/3 cup when using whole or lowfat milk, or  
2/3 cup when using skim or reconstituted NFDM
- 1/4 cup commercial, unflavored yogurt with live and active cultures, **OR** dry starter (follow package instructions)

**PROCEDURE – RECIPE FOR PLAIN YOGURT:**

1. *Combine milk ingredients and heat.* Heating pasteurized milk is required to alter the milk proteins so that they set together instead of forming curds and whey. It also destroys competing spoilage microorganisms.
  - a. Put cold pasteurized milk into the top of a double boiler or heavy bottomed pot.
  - b. Stir nonfat dry milk into cold milk.
  - c. Heat milk to 185-200°F stirring gently.
  - d. Hold at temperature for 10 minutes for thin yogurt or 20 minutes for thicker yogurt.
2. *Cool and inoculate.* Use a thermometer to monitor temperatures. Introducing starter culture to very hot milk can kill the starter culture.
  - a. Place the pot or top pan of double boiler in cold ice water to cool rapidly to 115°F.
  - b. Remove one cup of the warm milk and blend it with the yogurt starter culture using a wire whisk.
  - c. Add this mixture to the rest of the warm milk. The temperature of the inoculated milk should now be 110-112°F.
3. *Incubate.* Carefully control temperature for lactic acid fermentation and coagulation of milk; too hot or too cold may hinder culture growth.
  - a. Pour immediately into clean, warm container(s). Cover and place in prepared incubator.
  - b. Close the incubator and incubate undisturbed for 4-7 hours at 110°F (plus or minus 5°F). Yogurt will set firm when the proper acid level is achieved (pH 4.6).
4. *Refrigerate.* Rapid cooling is necessary to stop acid development. Incubating yogurt for additional hours after the yogurt has set will produce a more tart or acidic flavor and eventually cause the whey to separate.
  - a. Once yogurt has set, refrigerate immediately. Yogurt will keep for about 10-21 days at 40°F or lower. Yogurt can also be kept frozen for several months.

# Neufchatel Cheese

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## QUICK FACTS...

- Cheese, like yogurt, was likely discovered by accident over 8000 years ago by nomadic herdsmen in present day Middle East.
  - Cheese is made by fermenting milk with a bacterial starter culture that is dependent on the intended final product.
  - There are thousands of types of cheeses made worldwide. The basic steps in making milk into cheese are quite similar, but variations in the steps are what yield different cheeses.
  - Using high quality pasteurized milk is recommended to limit pathogenic bacteria and spoilage organisms.
  - Cheese provides the same nutrients as milk, including calcium, protein, phosphorous, and zinc but most cheeses contain more saturated fat and sodium than milk. Choose lower fat cheese varieties most often and eat full-fat cheese in smaller portions.
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## EQUIPMENT:

- *Thermometer.* Use a thermometer that accurately measures temperatures up to 220°F. It is helpful to have one that can be clipped on the side of the pan.
- *Heavy stainless steel pot with lid or large double boiler.* The pan capacity should be 5 quarts for 1 gallon of milk.
- *Whisk.* Use to mix ingredients thoroughly, but not to create foam.
- *Metal spatula or long-bladed knife.*
- *Long handled spoon.*
- *Measuring cups.*
- *Cheesecloth or muslin.*
- *Large strainer or colander.* A pasta strainer or steamer that can hold additional weight works well to speed draining.
- *Large bowl.* Capacity of at least 1 gallon.
- *Forms or molds (optional).* For shaping the cheese.

## INGREDIENTS:

- 1 gallon pasteurized milk (any level of fat). It is not recommended to use UHT (Ultra High Temperature) pasteurized milk or reconstituted dry milk.
- ½ cup fresh cultured unsalted buttermilk **OR** ¼ cup fresh plain yogurt with live and active cultures
- 1 rennet tablet
- ¼ cup cold water
- 3 tsp salt (optional)

**PROCEDURE – RECIPE FOR NEUFCHATEL CHEESE:**

1. *Inoculate and heat milk.* Warm milk to be appropriate for active starter cultures.
  - a. Put cold pasteurized milk into the top of a double boiler or heavy bottomed pot.
  - b. Stir in buttermilk or yogurt and warm slowly to 92-94°F.
  - c. Maintain this temperature range through steps 2 and 3.
2. *Coagulate, or flocculate.* Enzymes are added for curd formation. Rennet is basically a broad term used to describe any enzyme used to coagulate milk, and rennin and chymosin are enzymes found in rennet.
  - a. Dissolve rennet tablet in  $\frac{1}{4}$  cup of cold water.
  - b. Stir dissolved rennet into inoculated milk for 2-3 minutes.
  - c. Allow inoculated milk to set undisturbed for a minimum of 30 minutes, up to overnight, until a gel forms. If letting set overnight, cover and keep at room temperature (65-70°F).
3. *Separate curd from whey.* To test for curd formation, cut a slit in the curd with a metal spatula or long knife, slip under the curd and lift slightly. If the cut curd breaks clean, continue with procedure. If not, allow milk to continue to set until it does break clean.
  - a. Cut the curd into approximately 1-inch cubes. Using a long handled spoon, stir gently and continuously for 20-30 minutes to help firm curds. Maintain the temperature range 90-94°F.
  - b. Line a large strainer with cheesecloth or muslin and place over a large bowl. Carefully ladle or pour curds and whey into cloth and allow whey to drain through.
  - c. After most of the whey has drained through, pick up the four corners of the cloth and tie around a long handled spoon to suspend over a bowl to continue to drain overnight in the refrigerator.

Or for faster draining: Keep cheese in the cloth lining the strainer, placed over a bowl. Cover cheese with additional cloth and apply pressure with a weight, such as a can of food. Use weight that can be supported by the strainer. Do this until the surface is smooth, 2-4 hours.
4. *Refrigerate.*
  - a. Remove cheese from cloth and mix in up to 3 tsp salt, depending on taste.
  - b. It may be eaten fresh or wrap cheese tightly in plastic or wax paper and store in refrigerator. It will keep for 7-10 days when properly refrigerated. It can be frozen for 4-6 months, but it will decrease the quality.

# Sauerkraut

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## QUICK FACTS...

- Sauerkraut, German for “sour herb” or “sour cabbage,” actually originated in China. It was introduced to Eastern Europe, and has become most associated with German cooking.
  - Sauerkraut is naturally fermented cabbage, made simply with cabbage and salt. The bacteria needed for fermentation are present on the cabbage leaves; a starter culture is unnecessary.
  - Sauerkraut is high in vitamin C and was eaten by sailors to prevent scurvy.
  - If it is kept cool and the top surface is not exposed to air, sauerkraut can keep indefinitely.
  - Sauerkraut is a common condiment, but can also be used in recipes from dips to desserts.
- 

## EQUIPMENT:

- *Shredder*. One of the following: large sharp knife and cutting board, food processor, mandolin, or special kraut cutter.
- *Tablespoon measuring spoon*.
- *Container(s)*. Use only food-grade ceramic crocks, wide-mouth glass jars, or plastic buckets. Do not use metal or containers with cracks or chips. Plan approximately one gallon for every five gallons of prepared cabbage.
- *Cover and weight*. To maintain anaerobic environment, keep cabbage submerged under brine. Cover snugly with a securely closed brine-filled food-grade plastic bag, a disk or plate that fits inside the container, or fit plastic wrap smoothly against sides of container. Place a clean weight on the disk, plate, or plastic wrap, such as a jar or brine-filled food-grade plastic bag. For a brine-filled bag, use: 6 Tbsp salt in 1 gallon boiled then cooled water.
- *Lid or cloth*. Help prevent contamination from insects, dust, or undesirable microorganisms by placing a clean towel or non-air tight container lid over weight.
- *Large mixing bowl or stock pot*. Use a non-reactive bowl, such as glass, plastic, or stainless steel.
- *Wooden tamper (optional)*.

## INGREDIENTS – makes about 1 gallon of sauerkraut:

- 5 pounds cabbage (about 1-3 heads)
- 3 Tbsp. **non-iodized** salt
- Add other ingredients, as desired, for variation in flavor. For example: red cabbage, grated carrots, hot peppers, onions, garlic, seaweed, greens, Brussels sprouts, turnips, beets, burdock roots, apples, caraway seeds, dill seeds, celery seeds, juniper berries, ginger, mustard seeds, peppercorns, and crushed red pepper.

#### **PROCEDURE – RECIPE FOR SAUERKRAUT:**

1. *Prepare cabbage.* Start with fresh, whole cabbage to limit introduction of other contaminants. Shredding the cabbage will release natural sugars for efficient fermentation.
  - a. Discard outer leaves and cut away any spoiled or damaged spots.
  - b. Rinse heads under cold water and drain.
  - c. Cut heads into quarters and remove core.
  - d. Slice or shred cabbage as desired.
2. *Salt cabbage.* Salt acts as a preservative and creates the brine. It disrupts the cell wall to release nutrients within the cabbage cells, including fermentable sugars. It also inhibits growth of undesirable yeasts, molds, and bacteria, while helping to select for the bacteria we want.
  - a. Layer cabbage and salt in container or large mixing bowl. Decrease or increase salt using the ratio of 3 Tbsp. of salt for every 5 pounds of cabbage.
  - b. Using your clean hands, thoroughly mix cabbage and salt.
  - c. Allow the salted cabbage to stand at least 5 to 10 minutes to begin wilting and pulling out juices.
  - d. Using your clean hands or other tamper, compress the cabbage firmly until the cabbage starts to get soft and enough juice, or brine, is drawn out to cover the cabbage.
3. *Pack container.* It is important to maintain an anaerobic environment and keep cabbage completely submerged under the brine.
  - a. Using your clean hands or other tamper, pack a small amount of the cabbage into the container. Pack it down as tightly as you can. Repeat this procedure, layer by layer, filling container.
  - b. Make sure cabbage is completely covered with brine, and keep at least one inch of air space above brine. If there is not enough brine from the cabbage, dissolve 1 ½ Tbsp non-iodized salt in 1 quart of boiled, cooled water and add necessary amount to cover cabbage.
  - c. Cover and weight down the cabbage using a method listed above.
4. *Ferment!*
  - a. Place container of cabbage on a tray or plate to catch overflowing brine that may leak out during fermentation. Do NOT pour leaked juice back into the jar.
  - b. Place container in a well-ventilated location (it will stink) with a relatively constant temperature of 68-72°F. The sauerkraut should be ready in about 2-3 weeks.
  - c. Check the container every day or two. Mold can appear on the surface. It can be scraped off and the sauerkraut is still safe and edible. Rinse off the cover and weight used each time mold or spoiled cabbage is removed. If the cabbage is no longer fully submerged in brine, add salted water as necessary (see 3b).
5. *Store and enjoy!*
  - a. If using a mason jar: remove cover and weight, tighten lid, wipe the outside of the jar, and store in refrigerator for several months.
  - b. If using a crock: if the surface is not exposed to air, it can be stored indefinitely in a cool storage area. Keep cover and weight down after removing portions. A small amount of spoilage may occur and can be skimmed off.

# Kimchi or Kimchee

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## QUICK FACTS...

- Kimchi is a traditional Korean fermented food, eaten at most mealtimes.
- There are nearly 200 known kinds of kimchi. The Codex standard for Kimchi was published in 2001 to be at a minimum: Chinese cabbage, and seasoning consisting of red pepper, garlic, ginger, onion, and radish. Optional ingredients include fruits, other vegetables, spices, fish, or nuts.
- The bacteria needed for fermentation are present in the raw materials; a starter culture is unnecessary.
- Kimchi consumption increased during the SARS (severe acute respiratory syndrome) outbreak in 2003. Koreans touted it as having a preventative role due to the lower incidence in South Korea.
- Kimchi provides similar health benefits as sauerkraut, along with additional nutritional attributes from the additional ingredients.

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## EQUIPMENT:

- *Large sharp knife and cutting board or food processor.*
- *Measuring spoons.*
- *Container(s).* Wide-mouth glass jars are recommended, but food-grade ceramic crocks or plastic buckets are also acceptable. Do not use metal or containers with cracks or chips.
- *Cover and weight.* To maintain anaerobic environment, keep kimchi submerged under brine. Cover snugly with a securely closed brine-filled food-grade plastic bag, a disk or plate that fits inside the container, or fit plastic wrap smoothly against sides of container. Place a clean weight on the disk, plate, or plastic wrap, such as a jar or brine-filled food-grade plastic bag.
- *Lid or cloth.* Help prevent contamination from insects, dust, or undesirable microorganisms by placing a clean towel or non-air tight container lid over weight.
- *Large mixing bowl or stock pot.* Use a non-reactive bowl, such as glass, plastic, or stainless steel.
- *Wooden tamper (optional).*
- *Rubber gloves (optional).* Protection from red peppers or chilies while packing kimchi.

## INGREDIENTS – makes about ½ gallon of kimchi:

- Approximately 1 quart of plain brine (dissolve 1 ½ Tbsp non-iodized salt in 1 quart of boiled, cooled water)
- 2 pounds of Napa cabbage (about 1 large head) or bok choy
- About 1 ½ Tbsp. non-iodized salt
- 1 ½ Tbsp dried, red pepper flakes, or use 6 to 8 hot red chilies, chopped
- 1 to 2 daikon radish or several red radishes
- 1 to 2 onions, leeks, scallions, and/or shallots
- 6 to 8 cloves of garlic
- 6 Tbsp fresh gingerroot
- Add other ingredients, as desired, for variation in flavor. For example: fruits (peeled cored, and thinly sliced) such as Asian pears or apples, fermented fish sauce, nuts, salted and fermented seafood such as shrimp, sesame seeds, or additional vegetables such as carrots.

#### PROCEDURE – RECIPE FOR KIMCHI:

1. *Prepare cabbage.* Start with fresh, whole cabbage to limit introduction of other contaminants.
  - a. Rinse heads under cold water and drain.
  - b. Cut away and discard any spoiled or damaged spots.
  - c. Coarsely chop cabbage.
2. *Salt cabbage.* Salt disrupts the cell wall to release nutrients within the cabbage cells, including fermentable sugars. It also inhibits growth of undesirable yeasts, molds, and bacteria, while helping to select for the bacteria we want. It is not necessary to measure the salt, as it will be rinsed away, but the amount is given as a guideline.
  - a. Place cabbage and salt in large mixing bowl.
  - b. Using your clean hands, thoroughly mix cabbage and salt.
  - c. Let the cabbage sit to wilt and allow the juices to be drawn out. This will take 1 to 3 hours. Prepare seasonings, listed in step #3, while waiting.
  - d. To test cabbage for doneness, take a sample, rinse it, and taste it. If it tastes salty after being rinsed, it is ready for the next step.
  - e. Rinse entire batch of salted cabbage and drain.
3. *Prepare seasonings.* Kimchi is spicy. Alter for taste.
  - a. Slice the radish, chop the onion, finely slice or grate the garlic and gingerroot, and prepare red pepper or chilies as necessary.
  - b. After the wilted cabbage has been rinsed and drained, add seasonings.
4. *Pack container.* It is important to maintain an anaerobic environment and keep cabbage completely submerged under the brine.
  - a. Using your clean hands (you may want to wear rubber gloves) or other tamper, pack a small amount of the cabbage mixture into the container. Pack it down as tightly as you can. Repeat this procedure, layer by layer, filling container.
  - b. Make sure cabbage is completely covered with brine, and keep at least one inch of air space above brine. If there is not enough brine from the cabbage, add prepared plain brine as necessary to cover cabbage.
  - c. Cover and weight down the cabbage using a method listed above.
5. *Ferment!*
  - a. Place container of cabbage mixture on a tray or plate to catch overflowing juice that may leak out during fermentation. Do NOT pour leaked juice back into the jar.
  - b. Place container in a warm, well-ventilated location (it will stink) with a relatively constant temperature. The kimchi should be ready in about 1 week.
6. *Store and enjoy!*
  - a. Remove cover and weight, tighten lid of jar, wipe the outside of the jar, and store in refrigerator for several months. It is best fresh, within two weeks.
  - b. If using a crock: if the surface is not exposed to air, it can be stored long-term in a cool storage area. Keep cover and weight down after removing portions. A small amount of spoilage may occur and can be skimmed off.

***Fermenting Foods Workshop Assessment***

1. Overall, the Fermented Foods workshop was:
  - Excellent
  - Good
  - Ok
  - Not so good
  - Unacceptable
2. I have an appropriate amount of information to ferment one or more of these products at home.
  - Strongly agree
  - Agree
  - Neutral
  - Disagree
  - Strongly disagree
3. I have an appropriate amount of information to field consumer questions on fermenting one or more of these products.
  - Strongly agree
  - Agree
  - Neutral
  - Disagree
  - Strongly disagree
4. How likely are you to ferment one or more of these products at home?
  - Strongly agree
  - Agree
  - Neutral
  - Disagree
  - Strongly disagree
5. How likely are you to educate consumers on fermenting one or more of these products at home?
  - Strongly agree
  - Agree
  - Neutral
  - Disagree
  - Strongly disagree
6. Please rate how easy or difficult it was to follow the recipe. On a scale from 1 to 10, with 1 = very difficult to follow, to 10 = very easy to follow: \_\_\_\_\_  
Comments on recipe ease of use (i.e. layout, wording, information, etc.):

7. Thank you for attending, do you have any additional comments about the workshop?

***Questions regarding consumers fermenting foods:***

1. Comment on the level of interest you see in consumers and fermenting foods. For example, do you think consumers are interested in fermenting foods? Do you think there has been a change (more or less) in interest in the last few years?

2. What, if any, educational programs or materials do you currently provide on any fermented food topic?

3. What, if any, educational program or material would you like to provide on any fermented food topic?

APPENDIX J: FACT SHEET (IN REVIEW): MAKING YOGURT

## Making Yogurt

By L. Bauer and M. Bunning

Colorado  
State  
University

Extension

### Key Facts...

- Yogurt is a semi-solid dairy product made by fermenting milk with a special bacterial culture.
- It can be used as a tart, lower calorie substitute in cooking and baking.
- Yogurt can be made safely at home without specialized equipment.
- Flavored yogurt, strained yogurt, or yogurt drinks can be made from plain yogurt.
- When stored at proper refrigeration temperature, yogurt should have a shelf-life of 10-21 days; yogurt can be frozen for several months.

Yogurt is a fermented dairy product made by adding live bacterial cultures to milk, which causes the conversion of milk sugar, lactose, into lactic acid. The name yogurt originates from Turkey but it is spelled yoghurt, or less commonly as yogourt, in some countries. Yogurt was likely discovered accidentally by nomadic tribesmen traveling across the Middle East. They stored the milk from their animals in pouches made from animals' stomachs. Bacteria present in the pouches produced acid, causing the milk to coagulate, and rennet enzymes lining the animal stomach resulted in further curdling of the milk. The acidity aided in preserving the milk from spoilage and harmful bacterial organisms, and resulted in a sour cream like product useful for making yogurt or cheese.

Yogurt is made by safely encouraging the growth of beneficial bacteria, which then limits the growth of harmful microorganisms. Yogurt can be made safely at home without specialized equipment. Thoroughly wash all equipment in hot soapy water, but due to the selectivity for beneficial bacteria it is not necessary to use a sanitizer, such as bleach. When refrigerated properly at a temperature of 40°F, yogurt made at home should keep for 10-21 days.

### Equipment for Making Yogurt

- *Thermometer.* Use a thermometer that accurately measures temperatures up to 220°F. It is helpful to have one that can be clipped on the side of the pan.
- *Large double boiler or regular saucepan.* The pan capacity should be 2-3 quarts, for 1 quart of milk.
- *Whisk or mixing spoon and measuring cups.*
- *Containers for yogurt.* These can be canning jars or cups with lids.
- *Incubator.* Traditional yogurt is made using a thermophilic, or heat-loving, culture. A temperature of 110°F must be maintained over several hours using one of the following methods:
  - *Yogurt maker/incubator.* Follow manufacturer's directions.
  - *Oven.* Heat deep pan of water to 110°F (a roasting pan works well). Place filled yogurt containers into pans; water should come at least halfway up the containers.

Set oven temperature at its lowest point to maintain water temperature at 110°F. Monitor water temperature throughout incubation, making adjustments as necessary.

- *Cooler.* Warm water to 130°F and pour into a clean insulated (hard-sided) ice chest or picnic cooler. Carefully set filled yogurt containers in the cooler; water should come at least halfway up the containers. Check that the temperature of the water in the cooler is at least 110°F. Close the cooler, place in warm place and let sit undisturbed.
- *Thermos.* Prewarm a clean thermos with boiling water. Empty water and pour in cultured milk. Add lid and let yogurt set. After incubation is complete, transfer yogurt to another container for refrigeration. A thermos placed directly into the refrigerator will not cool fast enough to stop further acid development.
- *Heating pad.* Use a heating pad without automatic shut off or closely monitor heating setting. Set pad on medium heat. Wrap pad around filled yogurt container(s) and cover with several towels. Let sit undisturbed but check often.

#### **Recipe for Plain Yogurt**

Plain yogurt can be used to make other flavors or varieties. Pasteurized milk from animal sources can be used, including cow, goat, and sheep. This process does not work for non-dairy milks, including soy, rice, almond, or coconut milk; additional procedures and thickeners are required to set effectively. Milk source and fat content will yield different consistencies and flavors. This recipe makes 4-5 cups of plain yogurt.

#### **Ingredients**

- 1 quart pasteurized milk (any level of fat or reconstituted dry milk)
- Nonfat dry milk (NFDM) powder: 1/3 cup when using whole or lowfat milk, or 2/3 cup when using skim or reconstituted NFDM
- 1/4 cup commercial, unflavored yogurt with live and active cultures, or dry starter (follow package instructions)

#### **Procedure**

1. *Combine milk ingredients and heat.* Heating pasteurized milk is required to alter the milk proteins so that they set together instead of forming curds and whey. It also destroys competing spoilage microorganisms.
  - a. Put cold pasteurized milk into the top of a double boiler or heavy bottomed pot.
  - b. Stir nonfat dry milk into cold milk.
  - c. Heat milk to 185-200°F stirring gently.
  - d. Hold at temperature for 10 minutes for thin yogurt or 20 minutes for thicker yogurt.
2. *Cool and inoculate.* Use a thermometer to monitor temperatures. Introducing starter culture to very hot milk can kill the starter culture.
  - a. Place the pot or top pan of double boiler in cold ice water to cool rapidly to 115°F.
  - b. Remove one cup of the warm milk and blend it with the yogurt starter culture using a wire whisk.

- c. Add this mixture to the rest of the warm milk. The temperature of the inoculated milk should now be 110-112°F.
3. *Incubate.* Carefully control temperature for lactic acid fermentation and coagulation of milk; too hot or too cold may hinder culture growth.
  - a. Pour immediately into clean, warm container(s). Cover and place in prepared incubator.
  - b. Close the incubator and incubate undisturbed for 4-12 hours at 110°F (plus or minus 5°F). Yogurt will set firm when the proper acid level is achieved (pH 4.6). Longer incubation usually results in thicker, more sour-tasting yogurt.
4. *Refrigerate.* Rapid cooling is necessary to stop acid development. Incubating yogurt for additional hours after the yogurt has set will produce a more tart or acidic flavor and eventually cause the whey to separate.
  - a. Once yogurt has set, refrigerate immediately. Yogurt will keep for about 10-21 days at 40°F or lower. Yogurt can also be kept frozen for several months.

### Yogurt Types

The following styles can be made from homemade plain yogurt:

- *Set yogurt:* cultured milk firms in individual container(s) rather than a large vat and is not disturbed. This results in an unstirred, thicker product.
- *Stirred yogurt:* after incubation yogurt is dispensed into smaller containers. The “set” is broken and the texture becomes less firm.
- *Fruit yogurt:* fruit, fruit syrup or pie filling is added to the yogurt. Fruit is placed on top, bottom, or stirred into the yogurt.
- *Drinkable or drinking yogurt:* stirred yogurt is blended with fruit and milk to make a drinkable product.
  1. Add fruit or fruit syrups to taste. Mix in milk to achieve the desired thickness.
  2. Some whey separation will occur and is natural. Shake before consuming. The shelf life shortens to 4-10 days since the pH is raised by fresh milk addition.
- *Strained yogurt or yogurt cheese:* liquid whey is strained from the yogurt to produce a thick, creamy, concentrated product.
  1. Line a colander or strainer with a double thickness of cheesecloth.
  2. Place colander over a bowl and pour in the yogurt. Do not use yogurt made with gelatin added. Gelatin will inhibit whey separation.
  3. Cover with plastic wrap and allow whey to drain 8 hours in refrigerator. Empty the whey from the bowl.
  4. Fill a plastic zip-lock bag with water, seal and place on top of the plastic wrap over the yogurt to weigh it down. Let it stand another 8 hours. The longer the yogurt is allowed to sit, the thicker the cheese will become.
  5. Two cups of yogurt will yield about 1 cup of strained yogurt. The shelf life is approximately 7-14 days when wrapped and refrigerated at less than 40°F.



### Trouble Shooting

- *Yogurt tastes or smells bad.*
  - Old milk or contaminated starter culture: use fresh milk or obtain a new starter culture for the next batch.

- Incubated too long (over-set): refrigerate immediately after setting to avoid continued acid production.
- Overheating or boiling of the milk: monitor temperatures when heating, as overheating or boiling milk can cause an off flavor.
- *Yogurt does not coagulate (set) properly.*
  - Poor incubation temperature control.
  - Inactive starter culture: contaminated, old, or killed by adding culture prior to milk cooling.
- *Whey collects on the surface of the yogurt, or a process known as syneresis.*
  - Some is natural, but excessive separation of whey can be caused by:
    - Incubating too long.
    - Agitating the yogurt while it is incubating.
    - Heating of milk inadequate: not heated to correct temperature or not held at temperature.

#### **Suggestions for using yogurt**

*Plain yogurt can be enjoyed as is, or flavored to taste.* Commercially available flavored yogurts are often higher in calories and sugar than what you can flavor on your own. Try adding fresh or cooked fruit, fruit canned in juice or low sugar, or low sugar preserves or sauces.

*Plain yogurt may be substituted for sour cream or mayonnaise in most recipes.* The final product may taste less rich and more tart; yet will be lower in calories and fat, and higher in protein and calcium. Try topping a baked potato or Mexican-themed dishes with plain yogurt. Try substituting plain yogurt for some or all of the mayonnaise in dips, dressings, or creamy salads.

*Plain or flavored yogurt may be substituted for some or all of the liquid in baking recipes.* The result will often be creamier in texture, and the yogurt flavor may also be imparted. If possible, adjust leavening by adding ½ teaspoon baking soda and reducing the baking powder by one teaspoon per cup of yogurt used.

*Be creative!* Plain or flavored yogurt can be used as a topping for fruit, pancakes, waffles, granola, desserts, vegetables, meats, or soups. Plain or flavored yogurt can be mixed with other ingredients to make a smoothie. Plain or flavored yogurt can be frozen as a cold treat or to enjoy thawed.

**See the following Extension fact sheet for information on the health benefits of yogurt:**

- Yogurt: Probiotics and Health Benefits

#### **Resources & References**

- Cascio, J. and Dinstel, R. R. (2011). Making yogurt at home. University of Alaska Fairbanks Cooperative Extension. Available online at: <http://www.uaf.edu/files/ces/publications-db/catalog/hec/FNH-00062.pdf>
- Nummer, B. A. (2002). Fermenting yogurt at home. The University of Georgia Cooperative Extension Service, National Center for Home Food Preservation. Available online at: <http://www.uga.edu/nchfp/publications/nchfp/factsheets/yogurt.html>

APPENDIX K: FACT SHEET (IN REVIEW):  
YOGURT: PROBIOTIC AND HEALTH BENEFIT

## Yogurt: Probiotic and Health Benefits

By L. Bauer and M. Bunning

Colorado  
State  
University

Extension

### Key Facts...

- Fermented dairy products, such as yogurt, combine the nutrient-rich attributes of dairy with the beneficial activities of probiotics to make a healthy food option.
- Yogurt, also known as yoghurt or yogourt, is made by fermenting milk with a bacterial culture containing the lactic acid-producing bacteria, *Lactobacillus bulgaricus* and *Streptococcus thermophilus*.
- The wide assortment of yogurt varieties available to consumers increases opportunities to include yogurt in a healthful diet.

### Probiotics

Not all bacteria are harmful, in fact, some bacteria can be helpful. The human body is estimated to have 10 times the number of microbial cells to human cells, and it is generally accepted that the digestive track contains 500 to 1000 different species of bacteria. Some of these microbes are beneficial, some cause disease, and some are neutral. Yogurt is a source of beneficial bacteria, or probiotics. The word probiotics means “for life” and they are defined as *live microorganisms which when administered in adequate amounts confer a health benefit on the host*. In order for a microorganism to be called a probiotic, the research on the health effect must be for genus, species, and strain level. Health claims on food products made with potentially beneficial bacteria need to have been tested for that specific strain. Part of the benefit of probiotics in the diet is to improve the intestinal bacterial balance which aids in keeping pathogenic bacteria from proliferating.

Research is ongoing to investigate effects that probiotics have on our health, but some of the strongest research-based benefits include:

- Ease digestion of lactose and symptoms of lactose intolerance
- Protect against acute diarrhea in children, and decrease diarrhea caused by antibiotics or rotavirus
- Boost immune health and prevent illness
- Decrease risk of allergy and eczema



Additional research is needed to provide information on the mechanisms of action of individual strains, or precisely how probiotics work, as well as microbe interactions in the gut, validation of safety and quality of strains, and required dosages and length of time needed to confer the health benefits.

Preliminary studies suggest the following potential benefits may be attributable to probiotics:

- Reduce risk of daycare infections, dental caries in children, complications due to *Helicobacter pylori* infection in the stomach, and certain cancers including bladder and colon cancers.

Treatment for certain diseases including: inflammatory bowel disorders (IBD), which includes ulcerative colitis and Crohn's disease; cystic fibrosis; *Clostridium difficile*

- Reduce risk of daycare infections, dental caries in children, complications due to *Helicobacter pylori* infection in the stomach, and certain cancers including bladder and colon cancers.
- Treatment for certain diseases including: inflammatory bowel disorders (IBD), which includes ulcerative colitis and Crohn's disease; cystic fibrosis; *Clostridium difficile* diarrhea; necrotizing enterocolitis, which primarily affects premature or sick newborns; and irritable bowel syndrome (IBS).

#### **Functional Foods**

A functional food goes beyond meeting nutritional needs to promote wellness and potentially reduce disease risk. Prebiotics differ from probiotics. Basically probiotics are the bacteria, and prebiotics feed the bacteria. Prebiotics are nondigestible substances that provide a beneficial physiological effect for the host by selectively stimulating the favorable growth or activity of a limited number of indigenous bacteria. They are mostly non-starch carbohydrates that we cannot digest, including:

- Fructooligosaccharides (FOS): Oligofructose, Inulin
- Galacto-oligosaccharides (GOS)
- Lactulose
- Breast milk oligosaccharides

Good food sources of prebiotics include: artichokes, asparagus, bananas, barley, chicory root, greens (dandelion, chard, kale), garlic, leeks, onions, rye, and wheat. Some foods or drinks contain both probiotics and prebiotics; they are referred to as synbiotics. Yogurt, or similarly cultured dairy products, can be developed as synbiotics. Probiotics, along with prebiotics and synbiotics contribute to classification of a food as a functional food.

#### **Benefits of Yogurt**

The production of lactic acid from fermenting milk into yogurt results in a more acidic end product by lowering the pH from 6.5 in the starting ingredient, milk, to around 4.6 in the finished product, yogurt. The higher acidity of yogurt aids in spoilage prevention by reducing the risk of pathogenic bacterial growth and extending the shelf-life of the end product.

Yogurt is a nutrient-rich protein source which has been shown to reduce the risk of osteoporosis and high blood pressure, increase the feeling of fullness, and improve tolerance of dairy for lactose intolerant individuals. As shown in Table 1, most types of yogurt are an excellent source (provides more than 20% of recommended daily amount) of protein, riboflavin, vitamin B-12, calcium, and phosphorus and a good source (provides between 10-19% of recommended daily amount) of potassium, pantothenic acid, magnesium, and zinc.

Table 1. Nutrients in yogurt, plain, per 8 oz container (227 g)\*

Nutrient	Units	Skim milk	%DV <sup>^</sup>	Low fat	%DV	Whole milk	%DV
Calories		127	-	143	-	138	-
Total Fat	g	0.4	1%	3.5	5%	7.4	12%
Saturated Fat	g	0.3	1%	2.3	12%	4.8	24%
Cholesterol	mg	5	2%	14	5%	30	10%
Sodium	mg	175	7%	159	7%	104	4%
Potassium	mg	579	17%	531	15%	352	10%
Total Carbohydrate	g	17	6%	16	5%	11	4%
Dietary Fiber	g	0	0%	0	0%	0	0%
Sugars	g	17	-	16	-	11	-
Protein	g	13	26%	12	24%	8	16%
Vitamin A	IU	16	0%	116	2%	225	5%
Vitamin C	mg	2	3%	1.8	3%	1.1	2%
Thiamin	mg	0.109	7%	0.1	7%	0.066	0%
Riboflavin	mg	0.531	31%	0.486	29%	0.322	19%
Vitamin B6	mg	0.12	6%	0.111	6%	0.073	4%
Vitamin B12	mcg	1.38	23%	1.27	21%	0.84	14%
Pantothenic acid	mg	1.455	15%	1.342	13%	0.883	9%
Folate	mcg	27	7%	25	6%	16	4%
Calcium	mg	452	45%	415	42%	275	28%
Iron	mg	0.2	1%	0.18	1%	0.11	0%
Magnesium	mg	43	11%	39	10%	27	7%
Phosphorus	mg	356	36%	327	33%	216	22%
Zinc	mg	2.2	15%	2.02	13%	1.34	9%

\* USDA National Nutrient Database for Standard Reference, Release 27 (2014).

<sup>^</sup> Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.

Good (orange) = 10-19%

High (yellow) = at least 20%

#### Why are these nutrients important?

*Potassium*: Key nutrient in cell signaling and muscle function; and reduces risk of high blood pressure.

*Protein*: Source of amino acids for energy and for making nearly all body components, including enzymes (or catalysts for body reactions), hormones, muscle, antibodies, and molecules for transporting nutrients in the blood.

*B Vitamins, especially Riboflavin, Vitamin B12, and Pantothenic acid*: Components of enzymes, especially important in metabolism of carbohydrates, protein, and fat.

*Calcium*: Vital for bone and dental health, including osteoporosis prevention; important for heart health, including reducing the risk of high blood pressure; key nutrient in cell signaling and muscle function; and reducing risk of colon cancer and obesity.

*Magnesium*: Vital for maintaining calcium status and functions; important in nutrient metabolism; role in cell signaling, synthesis, and activities; and associated with proper neuromuscular and cardiovascular function.

*Phosphorus*: Vital for bone and dental health; important in metabolism of nutrients for cellular energy; key nutrient in cell signaling, enzymatic activity, and cell structure; aids in pH balance and oxygen delivery.

*Zinc*: Vital role in many body processes as a component of several enzymes, including nutrient metabolism, growth and development, immunity, and hormone function.

### **Purchasing Yogurt**

Yogurt has gained popularity as a healthy food, and can be used as a meal, snack, or dessert. Yet the nutritional attributes of yogurt can differ widely across types, styles, and flavors. When buying yogurt for its qualities as a naturally fermented milk product, the following are items to look for on a yogurt label to make a delicious and nutritious choice:

- *“Live and active cultures”* indicates cultures are still alive and present. Heat treatment after being cultured will kill beneficial cultures. Manufacturers can voluntarily label with the National Yogurt Association’s Live & Active Cultures seal. The seal is available to all manufacturers of refrigerated yogurt whose products contain at least 100 million cultures per gram at the time of manufacture, and whose frozen yogurt contains at least 10 million cultures per gram at the time of manufacture. Some yogurt products may have live cultures but choose not to carry the seal on their label.
- *Short list of ingredients: Milk, live cultures, real fruit.* This helps minimize added sugars and additives including artificial flavorings or colors, and stabilizers (gelatins, gums). A naturally fermented product will have a thick gel-like consistency and should not need additives for texture – such as pectin, gelatins, or gums.
- *Nutrient-rich, especially calcium and protein.* In 6 oz. containers of regular yogurt, look for at least 5g protein and at least 20% daily value of calcium. In 5.3 oz. containers of Greek yogurt, look for at least 10 g of protein and at least 10% daily value of calcium. Some yogurts may be fortified with Vitamin D. This would be indicated on the label.
- *Expiration date.* Fresh is best, check the expiration date to ensure probiotics are at their peak. Heat treatment after culturing extends the shelf-life, but these yogurts do not have live beneficial cultures.

### **Varieties of Yogurt**

Yogurt comes in three types based on fat content, but a variety of styles with different forms, textures, and tastes.

#### **Types:**

- *Yogurt*: contains at least 3.25 percent milkfat.
- *Lowfat yogurt*: contains between 0.5 and 2 percent milkfat.
- *Nonfat yogurt*: contains less than 0.5 percent milkfat.

#### **Styles or Varieties:**

- *Balkan style or Set-style*: cultured milk is incubated in individual containers rather than a large vat. This results in an unstirred, thicker product.
- *Custard style, French style, or Swiss style*: consistency is custard-like, with fruit and yogurt mixed together and evenly distributed. A stabilizer, such as gelatin may be added for texture.

- *Fruit-on-the-bottom* or *sundae style*: yogurt is layered over fruit, which can be mixed together or turned upside down to look like a sundae.
- *Greek style, strained, or yogurt cheese*: liquid whey is strained to produce a thick, concentrated yogurt. Greek yogurt is higher in protein than standard yogurt, but lower in carbohydrates and calcium due to removal of the whey.
- *Skyr* (pronounced *skeer*) or *Icelandic style*: also a strained style yogurt, yet made from nonfat milk and actually a strained, skim-milk cheese. Icelandic yogurt is higher in protein than standard yogurt, but lower in carbohydrates and calcium due to removal of the whey.
- *Drinkable yogurt*: yogurt is blended with fruit to make a drinkable product. This is different from kefir. Kefir is a fermented dairy drink made from a different starter culture than yogurt.
- *Frozen yogurt*: a frozen dairy dessert that is not subject to federal standards such as other yogurt products. Frozen yogurt does not need to be fermented with live and active cultures, and is often nutritionally comparable to ice cream. Manufacturers can voluntarily label with the Live & Active Cultures seal if the product contains the required amount of cultures and is made by fermenting pasteurized milk with traditional yogurt cultures.

For information about making yogurt at home, please see CSU Extension Fact Sheet, Making Yogurt.

#### Resources & References:

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- U.S. Department of Agriculture, Agricultural Research Service. 2014. USDA National Nutrient Database for Standard Reference, Release 27. Nutrient Data Laboratory Home Page, <http://www.ars.usda.gov/nutrientdata>

<sup>1</sup> L. Bauer, CSU graduate student, M. Bunning, Department of Food Science and Human Nutrition, Extension food safety specialist and associate professor, 4/15.