V(A). Planned Program (Summary)

1. Name of the Planned Program

Improving Human Health and Wellbeing through Food Function and Food Safety

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

<table>
<thead>
<tr>
<th>KA Code</th>
<th>Knowledge Area</th>
<th>%1862 Extension</th>
<th>%1890 Extension</th>
<th>%1862 Research</th>
<th>%1890 Research</th>
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<tbody>
<tr>
<td>501</td>
<td>New and Improved Food Processing Technologies</td>
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<tr>
<td>502</td>
<td>New and Improved Food Products</td>
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<td>503</td>
<td>Quality Maintenance in Storing and Marketing Food Products</td>
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<td>701</td>
<td>Nutrient Composition of Food</td>
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<td>702</td>
<td>Requirements and Function of Nutrients and Other Food Components</td>
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<td>703</td>
<td>Nutrition Education and Behavior</td>
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<td>711</td>
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<td>712</td>
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</table>

Total: 100%

V(C). Planned Program (Inputs)

1. Actual amount of professional FTE/SYs expended this Program

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<tr>
<td>Actual</td>
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2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

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<th></th>
<th>Extension</th>
<th>Research</th>
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</table>
V(D). Planned Program (Activity)

1. Brief description of the Activity
Conduct research and produce refereed publications in the scientific literature. Hold international scientific symposia.

2. Brief description of the target audience

V(E). Planned Program (Outputs)

1. Standard output measures

<p>| Target for the number of persons (contacts) reached through direct and indirect contact methods |</p>
<table>
<thead>
<tr>
<th>Direct Contacts Adults</th>
<th>Indirect Contacts Adults</th>
<th>Direct Contacts Youth</th>
<th>Indirect Contacts Youth</th>
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</thead>
<tbody>
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<td>Target</td>
<td>Target</td>
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<td>2007</td>
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</table>

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

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<thead>
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<td>2007:</td>
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Patents listed
5 patents were submitted through the University of Massachusetts of which two are at the U.S. Patent Office.

3. Publications (Standard General Output Measure)

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<thead>
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<th>Number of Peer Reviewed Publications</th>
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V(F). State Defined Outputs

Output Target

Output #1

Output Measure
- # of refereed publications

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</thead>
<tbody>
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</table>

Output #2

Output Measure
- # of international symposia

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## V(G). State Defined Outcomes

<table>
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<tr>
<th>O No.</th>
<th>Outcome Name</th>
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<tbody>
<tr>
<td>1</td>
<td>Accurate research on functional foods made available and shared</td>
</tr>
<tr>
<td>2</td>
<td>Accurate research on food safety made available and shared</td>
</tr>
<tr>
<td>3</td>
<td>Accurate research in production, characterization and application of nanostructured food</td>
</tr>
<tr>
<td>4</td>
<td>Accurate research on interactions and consequences of lipid and protein oxidants in muscle foods</td>
</tr>
<tr>
<td>5</td>
<td>Accurate research on the effect of animal proteins on iron uptake</td>
</tr>
<tr>
<td>6</td>
<td>Accurate research in food safety training and certification for undereducated, limited english proficient school food service personnel</td>
</tr>
<tr>
<td>7</td>
<td>Accurate research on antimicrobial delivery systems to improve food safety</td>
</tr>
<tr>
<td>8</td>
<td>Accurate research on characterization of transfer of <em>listeria monocytogenes</em> between processing surfaces and foods</td>
</tr>
<tr>
<td>9</td>
<td>Accurate research on physiology and control of foodborne disease agents</td>
</tr>
</tbody>
</table>
Improving Human Health and Wellbeing through Food Function and Food Safety

Outcome #1

1. Outcome Measures
   Accurate research on functional foods made available and shared

2. Associated Institution Types
   • 1862 Research

3a. Outcome Type:
   Change in Knowledge Outcome Measure

3b. Quantitative Outcome

<table>
<thead>
<tr>
<th>Year</th>
<th>Quantitative Target</th>
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<tbody>
<tr>
<td>2007</td>
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</table>

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Novel techniques to stabilize lipids will be developed which would in turn provide new technologies for food manufacturers to incorporate bioactive lipids such as omega-3 fatty acids into their products. Omega-3 fatty acids incorporated into foods will provide products with improved health benefits.

What has been done

The antioxidant activity of proteins in oil-in-water emulsion systems is thought to encompass both free radical scavenging by amino acid residues and chelation of transition metals. To determine the role of free scavenging amino acids on inhibition of lipid oxidation, proteins were added to oil-in-water emulsions and oxidation of both lipid and amino acids were monitored. In addition to native proteins, heat modified proteins and protein hydrolysates were also tested.

Results

While cross linking proteins at the emulsion droplet interface made them more cohesive and viscoelastic, they were not able to inhibit the metal-promoted decomposition of lipid hydroperoxides. This could be due to the fact that while the protein layer was more cohesive and viscoelastic, it was still porous enough to allow metals to diffuse through the protein layer and interact with the omega-3 fatty acid core. Development of novel antioxidant technologies would be instrumental in producing foods with nutritionally important lipids such as omega-3 fatty acids. This project has shown that proteins in the continuous phase of the oil-in-water emulsions are effective antioxidants that can protect emulsified omega-3 fatty acids. These ingredients could be very useful for producing omega-3 fortified foods that could benefit individuals at risk for heart disease, mental illness and immune response disorders.

4. Associated Knowledge Areas

   KA Code  Knowledge Area
   501      New and Improved Food Processing Technologies

Outcome #2

1. Outcome Measures
   Accurate research on food safety made available and shared

2. Associated Institution Types
   • 1862 Research

3a. Outcome Type:
   Change in Knowledge Outcome Measure

3b. Quantitative Outcome

<table>
<thead>
<tr>
<th>Year</th>
<th>Quantitative Target</th>
<th>Actual</th>
</tr>
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<tbody>
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<td>0</td>
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</tbody>
</table>

3c. Qualitative Outcome or Impact Statement
Improving Human Health and Wellbeing through Food Function and Food Safety

Issue (Who cares and Why)
Outbreaks of listeriosis derived from consumption of fish contaminated with L. monocytogenes still occur annually in the U.S. The development of new methods for inhibiting the refrigerated growth of the organism and destroying L. monocytogenes on seafood in addition to optimizing sanitary practices of seafood processing plants will assist in greatly reducing the numbers of this organism in processing plants and on fish tissue and in eliminating or reducing further seafood derived outbreaks. The purpose of these studies is to reduce the public health hazard of human pathogenic bacteria associated with seafood by reducing the number of human pathogenic bacteria in processing plants, identifying optimized plant sanitation practices, and by reduction of psychrotrophic human pathogenic bacteria on seafood.

What has been done
The seaweed Porphyra yezoensis was grown, harvested, and fed to rainbow trout at a level of 30%. Results indicated that the growth rate of the trout was similar to the reference diet. Seaweeds were also found capable of taking up and metabolizing various organic aquatic toxicants. Isolates of the human pathogenic bacteria Plesiomonas shigelloides from various environmental sources were found to exhibit significant genetic diversity via RAPD analysis. These studies also indicated that seafood may be a serious source of potential risk of human infection by this bacterium. A quantitative PCR assay developed for P. shigelloides in shellfish was found capable of detecting 60 CFU/g. Phenolics from oregano and cranberry extract were found to inhibit L. monocytogenes synergistically. This inhibition was enhanced by lactic acid. The establishment of Listeria monocytogenes on environmental surfaces was found not to occur in the presence of competing biofilms microflora. Among a total of 62 strains of Bacillus cereus isolated from seafood, 33 were found to produce enterotoxin.

Results
The seaweed Porphyra yezoensis was found capable of taking up and metabolizing various organic aquatic toxicants. The development of a rapid quantitative PCR assay for P. shigelloides in shellfish capable of detecting 60 CFU/g of tissue greatly facilitates the rapid detection of this human pathogenic organism in shellfish. The ability of oregano and cranberry extracts to synergistically inhibit Listeria monocytogenes has potential for significantly reducing the public health risk of this organism associated with seafood. Our studies on the surface development of L. monocytogenes have significantly contributed to our insight into the occurrence and development of this organism on processing surfaces. The observation that strains of Bacillus cereus from seafood are capable of producing enterotoxin indicates the potential hazard involved with this organism when seafood is subjected to storage temperature abuse.

4. Associated Knowledge Areas

<table>
<thead>
<tr>
<th>KA Code</th>
<th>Knowledge Area</th>
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</thead>
<tbody>
<tr>
<td>712</td>
<td>Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins</td>
</tr>
</tbody>
</table>

Outcome #3

1. Outcome Measures
Accurate research in production, characterization and application of nanostructured food

2. Associated Institution Types
• 1862 Research

3a. Outcome Type:
Change in Knowledge Outcome Measure

3b. Quantitative Outcome

<table>
<thead>
<tr>
<th>Year</th>
<th>Quantitative Target</th>
<th>Actual</th>
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<tbody>
<tr>
<td>2007</td>
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3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Food antimicrobials are compounds that can greatly improve the safety of foods, but their activity in foods is very low and large concentrations are required which impacts flavor and taste. The purpose of this study is to develop new encapsulation methods based on modern nanotechnology approaches to improve the effectiveness of food antimicrobials and to ultimately improve the safety of the US food supply.
What has been done

Base support (materials and supplies) were used to support research of five Ph.D. students and three M.S students of which one Ph.D. student and two M.S. students completed their respective degrees. One Ph.D. thesis and two M.S. thesis were prepared. Results were presented at the Institute of Food Technologists Annual Meeting, the International Association of Food Protection Annual Meeting, the American Oil Chemists’ Society, the Institute of Life Sciences North America Meeting, the National Academy of Sciences, the National Research Council (as part of the Food Nanotechnology inquiry) and the Delivery of Functionality in Complex Food Systems: Physically-Inspired Approaches From Nanoscale To Microscale Conference. 12 articles were published in peer-reviewed journals such as Food Biophysics, International Journal of Food Protection, and the Journal of Food Safety and 5 articles have been accepted for print.

Results

The results have important implications for the design and fabrication of stable SLN suspensions. Overall Impact/Outcomes of the Research Project. Results show that solid lipid particles have significant potential to act as novel carrier systems for bioactive ingredients, but that formulation with GRAS ingredients is not an easy task. Physical stability of the compound appears to be improved, but more experiments will be needed to verify the degree of increased stability. This enables the design of new shelf-stable food products and food products that carry bioactive ingredients (e.g. functional foods). The research results directly contribute to the enhanced safety and well-being of the US consumer by delivering bioactive components in foods to the consumer and by inhibiting and inactivating food pathogens.

4. Associated Knowledge Areas

<table>
<thead>
<tr>
<th>KA Code</th>
<th>Knowledge Area</th>
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<tbody>
<tr>
<td>501</td>
<td>New and Improved Food Processing Technologies</td>
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</table>

Outcome #4

1. Outcome Measures

Accurate research on interactions and consequences of lipid and protein oxidants in muscle foods

2. Associated Institution Types

• 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

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<tr>
<th>Year</th>
<th>Quantitative Target</th>
<th>Actual</th>
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3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

This research grant shall evaluate the effects on the quality and shelf-life of fish muscle by the simultaneous oxidation of lipids and proteins in a series of model systems of increasing complexity. The role of the specific compounds in the muscle tissue that cause the oxidation shall be determined to allow the best strategy for antioxidation treatments. The distribution, polarity and efficacy of natural antioxidants will then be tested on the model systems and the muscle tissue of fatty fish.

What has been done

Our procedures in the presence or absence of added oil produced extremely high antioxidant concentrations in the membrane preparation with minimal uptake into the oil fraction. Recoveries of antioxidants among the membranes, oil and aqueous phases was good except in the cases of octyl and lauryl gallate where only 50% of the added antioxidant was recovered in the three fractions.

Results

This research will determine the best conditions for adding antioxidants to maximize their effectiveness against the highly oxidation-prone membrane lipids, thus lowering the amounts that need to be added. It will also identify those antioxidants which are most acceptable to the consumer for their effectiveness and their contribution to health and well-being.
4. Associated Knowledge Areas

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<tr>
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Outcome #5

1. Outcome Measures

Accurate research on the effect of animal proteins on iron uptake

2. Associated Institution Types

• 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

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3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Iron deficiency anemia is a major nutritional problem due, largely, to poor absorption of dietary iron. This project examines the effect of animal proteins on iron uptake.

What has been done

Our experimental approach will be to digest animal proteins (from muscle and milk) in the presence of iron and determine the extent of iron binding, iron reduction, and production of dialyzable iron. Uptake of iron will be tested using cultured human caco -2 cells. Isolation of iron binding peptides will be attempted using iron-chelate affinity chromatography and the ability of separated peptides to enhance iron uptake will be tested with the caco -2 cells. Chemical determinants of iron binding/uptake will be tested by chemical modification of key amino acid residues in the peptides.

Results

The findings of this research help us understand the nutritional impact of food choices among animal protein foods. The findings of this research showed that digestion of chicken muscle proteins increased the production of bioavailable forms of iron and that both soluble (sarcoplasmic) and insoluble (myofibrilar) muscle proteins contribute nearly equally at equivalent protein levels. Soluble, low molecular weight non-protein components had a measurable but minor effect. In contrast, other non-muscle animal proteins such as egg white had no effect or in the case of whey protein concentrate—a negative effect. Muscle proteins produced dialyzable ferrous iron species, which are the most bioavailable, whereas other animal proteins produced hardly any ferrous iron. There was an excellent correlation between ferrous iron production and sulfhydryl content of proteins from all sources suggesting that these are, at least partly, responsible. Histidine content was not similarly correlated. We found differences in the size of the dialyzable iron species produced by digestion of animal proteins. With non-muscle proteins all of the dialyzable iron was smaller than 1KDa, whereas with muscle proteins there was a range of sizes (1-10KDa) with most in the range 2-3 KDa, illustrating that the peptides from muscle which enhance iron uptake are quite different and unique to muscle. Detailed study of whey proteins indicated that there were differences according to the method of preparation and that increasing purification led to less dialyzable iron. Both of the major whey proteins-alpha lactalbumin and beta lactoglobulin were slightly inhibitory compared to an egg white reference. Whole whey produced a large amount of dialyzable ferric iron which was attributed to its citric acid content. Mycoprotein, which is sold as an alternative to meat produced about as much dialyzable iron as chicken muscle, whether digested or not, due to its content of siderophores rather than to its amino acid composition. However it is unlikely that this would be bioavailable so mycoprotein does not appear to have the same effect as meat on iron uptake.
Outcome #6

1. Outcome Measures
Accurate research in food safety training and certification for undereducated, limited English proficient school food service personnel

2. Associated Institution Types

• 1862 Research

3a. Outcome Type:
Change in Action Outcome Measure

3b. Quantitative Outcome

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3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
UMass Extension, in cooperation with the Universities of Connecticut and Rhode Island, and national partners in food safety training and certification will improve opportunities for under-educated and limited English proficient school food service personnel to successfully complete the food manager certification examination. This integrative approach responds to the increased diversity of the food service trainees and declining exam passing rates.

What has been done
To date, over 2,000 copies of the Word List have been distributed. In Phase III, 58 trainers, with an average of 8.4 years experience teaching food manager certification courses, completed an online survey with 89.7% reporting food safety training experience, and 63.8% completing a food safety trainer course. Most difficult aspects of being a trainer were language barriers, keeping information interesting, and dealing with diverse learner backgrounds and needs. Forty-nine percent described the text used as accommodating of different learning styles; 16.0% felt it was understandable to non-English speakers. Fifty-seven percent felt that supplemental materials were culturally appropriate and 26.5% felt they were understandable to non-English speakers. A final outcome of the project was the development of a research-based website [http://www.umassone.net/ete/index.html].

Results
This project has the potential to improve food safety comprehension, efficacy, training and assessment for under-educated and limited English proficient school food service workers who participate in food manager certification training programs and examinations. The novel approach of this project provides insight to addressing the needs of diverse audiences on issues critical for food safety and protection. These data suggest a need for further study of exam policies, exam construction, and item testing.

4. Associated Knowledge Areas

<table>
<thead>
<tr>
<th>KA Code</th>
<th>Knowledge Area</th>
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<tbody>
<tr>
<td>712</td>
<td>Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins</td>
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Outcome #7

1. Outcome Measures
Accurate research on antimicrobial delivery systems to improve food safety

2. Associated Institution Types

• 1862 Research
Improving Human Health and Wellbeing through Food Function and Food Safety

3a. Outcome Type:
Change in Knowledge Outcome Measure

3b. Quantitative Outcome

<table>
<thead>
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<tbody>
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3c. Qualitative Outcome or Impact Statement

**Issue (Who cares and Why)**

In this project we will develop new food preservation strategies based on nanotechnological approaches to produce nanometer sized antimicrobial systems in the form of particles that improve antimicrobial activity in food formulations and food process operations. Three different encapsulation systems have shown promise. These include: (1) natural phenolic compounds encapsulated in surfactant-based micelles for application in liquid/semi-fluid food systems (2) phospholipid liposomes for encapsulation of polypeptide antimicrobials and application in liquid or solid systems and (3) natural phenolic and polypeptide antimicrobials encapsulated in emulsion droplets for delivery in liquid/semifluid and solid food systems. We expect that the new systems will have either substantially higher antimicrobial activity or higher stability than free antimicrobials. Because of the small size of capsules, no change in appearance and texture of foods should be observed. This research has the potential to dramatically improves the safety of processed foods and may have counter-bioterrorism as well as military applications.

**What has been done**

During the project funding period we developed, characterized and validated the activity of antimicrobial carrying capsules as novel preservation systems for foods. 1. Liposomes as Antimicrobial Carrier Systems. Ability of liposomes to maintain integrity was tested by encapsulation efficiency (EE), zeta potential, and vesicle size. PC, PC/PG 8/2, and PC/PG 6/4 (mol fraction) liposomes retained between ~70-90% EE despite exposure to elevated temperature or extreme pH. Liposome size averaged 100-240 nm. L. monocytogenes inhibition depended slightly upon dose, but was heavily dependent upon phospholipid constituents of liposomes. Near complete inhibition of E. coli O157:H7 with liposomal antimicrobial and chelator at concentrations below those required for unencapsulated antimicrobial and chelator was found. In milk, liposomal nisin was inhibitory to L. monocytogenes strains, and effects on strains were equivalent, regardless of milksfat level. 2. Microemulsions as Antimicrobial Carrier Systems. Eugenol was solubilized into cationic-nonionic (Mirenat-N-T-Maz80K or LAE-TM) and nonionic surfactant mixtures (T-Maz80K-Surfynol485W or TM-S485). Physicochemical characterization included surface tension, particle size, charge and solubilization capacity.

**Results**

The antimicrobial efficiency of cationic-non-ionic micelles was high since LAE alone inhibited the growth of E. coli O157:H7 and Listeria. Micelles inhibited all microbial growth with exception of TM:LAE (5:1) ratio. Addition of eugenol at 3mM inhibited the growth of Listeria and 7 mM inhibited the growth of E. coli O157:H7. When microemulsions were tested in a food system (milk), the antimicrobial efficiency varied depending on the fat level. 3. Emulsions as Antimicrobial Carrier Systems. Emulsions containing eugenol and a carrier lipid were kinetically stable depending on eugenol and lipid mixing ratios. Corn-oil emulsions loaded with eugenol were the most stable and inhibited the growth against E. coli O157:H7 strains depending on loading ratio but failed to inhibit growth of Listeria strains. Specific Impacts/Outcomes: Colloidal carrier systems can prolong activity of a large number of antimicrobials in model microbiological and model food systems. Some carrier systems can enhance the activity of antimicrobials against selected microorganisms and in some cases not only inhibit but inactivate pathogens. Overall, less antimicrobial is needed to retard activity of pathogen if an encapsulation system is used compared with the simple addition of the antimicrobial to the food. Products can be microbiobally stabilized for a significantly enhanced period. This enables the design of new shelf-stable food products and nanoencapsulation is therefore clearly an enabling technology for the food industry. The research results directly contribute to the enhanced safety and well-being of the US consumer by introducing a new control measure for food pathogens in the market.

4. Associated Knowledge Areas

<table>
<thead>
<tr>
<th>KA Code</th>
<th>Knowledge Area</th>
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<tbody>
<tr>
<td>712</td>
<td>Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins</td>
</tr>
</tbody>
</table>

**Outcome #8**

**1. Outcome Measures**

Accurate research on characterization of transfer of listeria monocytogenes between processing surfaces and foods
L. monocytogenes contamination is responsible for the majority of Class I recalls of processed foods. The presence of L. monocytogenes in processed foods is thought to be due to post-processing contamination from established organisms in the processing environment. Although research has focused upon adhesion and biofilm formation by Listeria monocytogenes, no one has studied the potential of bacterial transfer from food processing surfaces to foods, and from foods to processing surfaces. The overall purpose of this research is to obtain a more precise understanding of the potential for Listeria monocytogenes transfer and the influence of moisture on this transfer. Ultimately, the results of this research will answer the question: should food safety advice specify drying of food contact surfaces after cleaning and sanitizing?

For this objective, the influence of surfaces, inoculation method, hydration level, and food upon transfer was evaluated. Our results strongly suggest that stainless steel (mean EOT= 0.52) transferred more Listeria to food surfaces than HDPE (mean EOT= 0.21) (P=0.05). Overall, L. monocytogenes transferred more efficiently to bologna (mean EOT= 0.44) than cheese (mean EOT= 0.29) (P<0.05). These results indicate that inoculation method; food product and moisture level can influence bacterial transfer. The impact of the hydration level on the transfer was significantly higher for dried biofilms growing on stainless steel (P<0.05). No significant differences in hydration level were seen under other conditions (P>0.05). To study the influence of moisture, prior to transfer to bologna and hard salami, biofilms were equilibrated over saturate salts to control water levels in biofilms. Our results showed that more bacteria were transferred to bologna (mean EOT=3.0) compared to hard salami (mean EOT= 0.35, P<0.01). As biofilms became drier, the transfer of Listeria from stainless steel to both foods increased (P<0.05).

Results showed that the maximum pull-off force and retraction work needed to retract the cantilever for glass (-85.42 nN and 1.6x10-15 J respectively) were significantly lower than those of polyethylene (-113.38 nN and 2.7x10-15 J respectively) (P<0.001). The results of this study suggest that Listeria biofilms adhere more strongly to hydrophobic surfaces than hydrophilic surfaces. We hypothesize that weakened cell-to-cell interactions and cell-to-surface interactions of biofilms and the presence of capillary forces in the food are involved in the increased transfer upon drying.

### 4. Associated Knowledge Areas

<table>
<thead>
<tr>
<th>KA Code</th>
<th>Knowledge Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>712</td>
<td>Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins</td>
</tr>
</tbody>
</table>

### Outcome #9

1. **Outcome Measures**

   Accurate research on physiology and control of foodborne disease agents

2. **Associated Institution Types**

   • 1862 Research
Improving Human Health and Wellbeing through Food Function and Food Safety

3a. Outcome Type:
Change in Knowledge Outcome Measure

3b. Quantitative Outcome

<table>
<thead>
<tr>
<th>Year</th>
<th>Quantitative Target</th>
<th>Actual</th>
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</thead>
<tbody>
<tr>
<td>2007</td>
<td>(No Data Entered)</td>
<td>0</td>
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</tbody>
</table>

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Foodborne illness continues to be a significant and preventable public health issue in the U.S. This project will determine the cellular events leading to the production of an enterotoxin responsible for foodborne disease as well as possible use of plant (natural) products to inhibit growth of selected bacteria which are causes of such illnesses

What has been done
Three hundred and forty seven fresh and processed seafood samples were examined for the presence of the foodborne pathogens Bacillus cereus, Clostridium perfringens, and Clostridium botulinum. The presence of C. perfringens and C. botulinum was confirmed in one and zero samples respectively. On the other hand 62 B. cereus isolates were confirmed at levels from 3.6 to >1100/gm. Thirty of the isolates produced the two enterotoxins known to be associated with this organism. As determined by PCR the presence of at least one of the three genes of the NHE enterotoxin complex was detected in 99% of isolates while 71% possessed at least one of the three genes of the HBL enterotoxin complex. Fifty of the 62 isolates were from imported seafood. A majority of enterotoxin-producing isolates were resistant to two of 10 antibiotics tested.

Results
The presence of toxigenic B. cereus in seafood has never been determined. Our results show that not only is this organism present in this commodity but can be present at relatively high levels. Most of the isolates were from imported seafood including those producing the highest concentration of enterotoxin.

4. Associated Knowledge Areas

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</table>

V(H). Planned Program (External Factors)

External factors which affected outcomes
- Competing Public priorities

Brief Explanation

V(I). Planned Program (Evaluation Studies and Data Collection)

1. Evaluation Studies Planned
- Other (scientific peer review)

Evaluation Results

Key Items of Evaluation