Factor 1 - **Research Assignment** **28 August 2007**

A. Assigned Responsibility

Dr. Bower is a Research Food Technologist with the USDA-ARS Subarctic Agricultural Research Unit (SARU) located in Fairbanks, Alaska. Research is being conducted in Aquaculture (ARS National Program 106) in a project titled Converting Alaska Fish By-Products into Value Added Ingredients and Products. Research in this broad and complex subject area includes developing economical methods to stabilize discarded fish for later processing, as well as producing new value-added products for industrial uses, agricultural animals, domestic pets, and human consumption. This research is expected to have regional, national, and international impact.

B. Research Objectives and Methodology

Dr. Bower has been assigned to characterize the chemical and nutritional properties of by-products, develop high quality value-added products from salmon, evaluate raw material quality of fish meal and oils, and develop techniques for stabilizing and storing fish by-products. This will involve chemical, biochemical, and microbiological analysis of the process waste stream components to determine which by-products can be effectively converted into value-added ingredients. Fish by-product research remains a broad, poorly-defined area of study, necessitating technical expertise and considerable insight to identify significant problems and develop practical approaches for solving them. Additionally, since the products of this research may be used as aquaculture feeds, care must be taken to ensure that viral, bacterial, fungal, and prion diseases are not passed through the processing system. As one of only two SYs assigned to the CRIS project, the incumbent's research must encompass many diverse areas of by-product utilization rather than focus in depth on a single topic.

C. Expected Results

This research is expected to impact the sustainability and economics of fisheries in Alaska by providing fish processors with a selection of environmentally sound options for adding value to by-products currently discarded as waste. Feed ingredients from fish processing by-products can supplement or replace the fish meal currently produced from whole fish, thereby reducing pressure on wild fish stocks. The research is particularly relevant to markets where there is direct competition between humans and livestock for scarce marine protein. There is also a significant environmental component to this project. Over one million metric tons of fish by-products are discarded in Alaska each year. Shore-based processors often grind waste material and pump it into the ocean, disrupting the marine ecology and creating environmentally unfavorable conditions that impact tourism in Alaska.

D. Knowledge Required

Fish by-product research remains a broad, poorly-defined area of study, necessitating technical expertise and considerable insight to identify significant problems and develop practical approaches for solving them. Dr. Bower's research assignment requires in-depth knowledge and professional experience in food science and technology, fermentation techniques, and food engineering principles as they relate to the stabilization and processing of fish by-products. Knowledge of chemistry and biochemical testing methods are also essential, as is the ability to handle pathogenic bacteria in a Biological Safety Level 2 laboratory. Additionally, since only two SYs are assigned to this CRIS project, the incumbent must be able to continually develop the extra skills needed to explore diverse areas of by-product utilization and answer important questions in the field. Creating novels procedures for extracting and utilizing valuable omega-3 fatty acids will require the incumbent to attain the specialization of a lipid chemist. Taking advantage of the barrier properties displayed by fish-skin gelatin films will require developing an

increased expertise in protein chemistry and more extensive knowledge of food engineering. Employing fish by-products as a source of energy through biodiesel or gasification will require an expanded understanding of engineering principles and the acquisition of new technical abilities. The elusive problem of developing successful techniques for odor-less preservation of decomposing fish will also require ingenuity and new knowledge across a wide range of disciplines.

E. Supervisory Responsibilities
Provides technical and administrative supervision for one GS-7 Biological Science Laboratory Technician, and two GS-4 technicians. Is responsible for making selections for positions, assigning duties, reviewing work, approving/disapproving leave, and evaluating performance. Ensures equal opportunity is extended to all employees supervised and all candidates for employment without regard to race, color, religion, sex, national origin, age, or non-disqualifying handicapping condition. Ensures affirmative implementation of Equal Employment Opportunity plans of action and applicable Civil Rights provisions, which includes full consideration of eligible minority group members and women in filling vacant positions; providing career counseling and orientation; enhancing career opportunities through training and development, job redesign, and/or similar techniques; and ensuring full consideration of these employees in recommending promotions, awards, and other forms of special recognition.

Factor 2 – **Supervisory Controls**

A. Assigned Authority
Within the scope of the assignment and project plan, the incumbent is responsible for identifying research needs and problem areas and determining the appropriate research approach. The incumbent independently develops hypotheses, plans and conducts experiments, analyzes and interprets data, and reports results to scientific journals, citizens, and management agencies. The incumbent is authorized to act and speak for the ARS in dealing with groups or individuals on technical aspects within the research assignment.

B. Technical Guidance Received
Incumbent is a local authority in the field of fish by products utilization. Technical supervision is limited to reviewing project plans and hypotheses from a consultative standpoint.

C. Review of Results
Incumbent's reports and interpretations are reviewed by the Research Leader for relevance to CRIS Work Unit objectives and ARS research policy, but are generally accepted as accurate subject to judgment by the scientific community.

D. General Supervision
The incumbent is administratively supervised by the Research Leader of the Subarctic Agricultural Research Unit.

Factor 3 - **Guidelines and Originality**

A. Available Literature
Information on the functional and nutritional characterization of most cold-water fish tissues is not yet available in the scientific literature, and the studies that have been

conducted usually focus on whitefish. Salmon, unlike white fish, are anadromous (living in the ocean, but spawning in fresh water) and present wide ranges of maturity when harvested at sea. The resulting differences in biochemical constituents (proteolytic enzymes, lipids, moisture, etc...) produce wide batch-to-batch variations, which drastically influences standard stabilization processes. Additionally, methods of fish by-product stabilization, other than production of fishmeal and low-value silage, have not been widely investigated, and these techniques also tend to be tailored to whitefish. Alaskans harvest five different species of wild-caught salmon, all from a genus different than the more commonly studied Atlantic salmon. A significant component of this research is to increase the body of literature for species of Pacific cold-water fish such as salmon.

B. Originality Required

A high degree of creativity and originality is required to define problems, generate hypotheses, and devise practical methods for stabilizing large quantities of highly perishable fish by-products. Unlike whitefish, which are caught year-round, salmon are harvested seasonally, often in geographically-remote locations where lack of refrigeration and high transportation costs make fish by-product ventures unprofitable. Success in this research will require approaching the problem from many different angles. New techniques must be developed for handling large quantities of perishable fish by-products in an environmentally sound manner. Value-added commodities prepared from discarded fish components must be developed to offset transportation costs and increase the overall value of the catch. This broad research direction may involve studies that improve extraction protocols for high-value omega-3 fatty acids, or incorporate these lipids into novel products. Research opportunities also exist for working with specialty items such as fish-skin gelatin films, and expanding their function as food and industrial vapor barriers. Additional studies may be needed in previously unexplored areas such as using raw fish materials as a fuel source to provide energy through gasification.

Factor 3 - Guidelines and Originality

C. Demonstrated Originality

Dr. Bower became a leader in the area of antimicrobial protein adsorption after publishing the first-ever paper on the efficacy of adsorbed antimicrobial agents for inhibiting the growth of pathogenic *Listeria* on food contact surfaces. The incumbent was also first to demonstrate that surface conditions, such as hydrophobicity, could be used to control the lethality of antimicrobial compounds during adsorption. This research was expanded to produce the first-of-its-kind *in vivo* study of surface-adsorbed antimicrobial agents to increase the safety of biomedical devices. The incumbent's current research focuses on stabilization of highly perishable fish by-products, which are considered to be waste matter by the fish-processing industry. Converting these materials into more valuable "co-products" is a critical issue in Alaska for both economic and environmental reasons. In approaching this broad research topic, Dr. Bower initiated a series of innovative proof-of-concept studies including acidification of fish silage using safe and easy to produce electrolyzed oxidized water, rather than the traditional, more dangerous, concentrated acids. Additionally, fish-skin gelatin films were studied for their ability to incorporate antimicrobial agents and retain activity within the film, which is critical for the safety of perishable foods. The incumbent also conceived the idea of converting discarded fish biomass into energy through gasification, which resulted in a Specific Cooperative Agreement with Oklahoma State University.

Factor 4 – **Contributions, Impact, and Stature**

A. **Demonstrated Accomplishments**

Dr. Bower has been conducting research in science, agriculture, and bioengineering for over 17 years. She has published 21 manuscripts, 18 of which were first-author publications. Her research has been cited in Scopus 152 times, both nationally and internationally, including 41 citations for her groundbreaking paper on surface-adsorbed nisin.

1. **Accomplishment:**
Bacteria that attach to food-contact surfaces demonstrate increased resistance to antimicrobial agents, and lead to biofilms, which create processing problems such as increased fluid frictional resistance and decreased heat transfer efficiency. However, contamination of food products by bacterial pathogens is the most serious concern. Dr. Bower investigated the efficacy of adsorbing biologically active proteins to surfaces to inhibit the initial attachment of bacterial growth, rather than trying to remove microorganisms after adhesion had occurred. Using real-time image analysis, the incumbent visually demonstrated that the activity of adsorbed antimicrobial compounds was dependent upon the degree of surface hydrophobicity. Knowledge of surface hydrophobicity is invaluable for food processors when selecting food-contact materials that will minimize bacterial attachment. **Role:** Research was initially planned with assistance from two professors. The incumbent conducted all experiments and drafted two manuscripts for publication. **Impact:** Dr. Bower's successful experiments were in support of U.S. Patent 5,451,369 (issued 19 September, 1995), which continues to generate funds for Oregon State University. This cutting-edge research is still being cited in publications today. (Exhibit 1a, #1; Exhibit 1b, #2)

2. **Accomplishment:** Biologically active proteins, such as enzymes, are optimized to recognize a ligand or transition state and may not be stable enough to retain their active conformation when adsorbed to a surface. Dr. Bower determined that structural differences affected the function of proteins by using a set of bacteriophage T-4 lysozyme variants that differed in structure by a single amino acid residue. By testing de-stabilized T-4 lysozyme "mutants" containing residues in the enzyme's critical activity zone, the incumbent conclusively documented changes in activity of the adsorbed lysozyme variants. **Role:** Dr. Bower planned and conducted adsorbed enzyme structure and function research using T4-lysozyme variants. This required cultivation of the *Escherichia coli* vectors harboring each desired bacteriophage variety, and subsequent purification of each T4-lysozyme mutant. The incumbent also supervised student projects that involved enzyme activity losses caused by adsorption. **Impact:** These studies were groundbreaking in establishing a correlation between low structural stability of an enzyme, and subsequent high activity loss during adsorption. This research contributed to the key engineering concept that proteins unfold within an interface, and it is the degree of unfolding that influences the loss of functionality for each molecule. This line of interfacial investigation added a new dimension to the field of designer proteins, genetically engineered to have specific adsorptive properties in a defined environment. (Exhibit 2a, #5; Exhibit 2b, #6)

3. **Accomplishment:** A novel approach to controlling unwanted microbial adhesion in a clinical environment is to inhibit the initial attachment of bacteria, rather than trying to remove them once they have adhered. Dr. Bower demonstrated that the antimicrobial peptide, nisin, can successfully inhibit bacterial colonization at surfaces *in vitro*, and then determined the most effective and practical conditions for adsorbing nisin onto biomedical materials. Using these data, tests were conducted *in vivo* on actual medical

implants (in blood vessels and in the upper airway) through a unique collaboration with Oregon State University's College of Veterinary Medicine. **Role:** Dr. Bower conducted the initial *in vitro* experimentation as well as all microbiological challenge studies involving pathogenic bacteria. During the *in vivo* portion of the study, the incumbent prepared all antimicrobial and control solutions for the Veterinary school, then performed testing on the implantable devices after their removal. The incumbent prepared the first draft of the manuscript. **Impact:** This study was the first preclinical trial of nisin-treated implantable materials, and therefore represented an important first step for developing protein antimicrobial films on implantable medical devices. A major finding was that nisin-coated catheters had a protective effect on vascular endothelium. (Exhibit 3a, #9; Exhibit 3b, #10)

*4. **Accomplishment:** Fish skins are a collagen-rich by-product of the fishing industry that can be used to produce food-grade gelatin. However, gelatin can also serve as a source of nutrition for bacteria. In this study, the incumbent was first to demonstrate that fish-skin gelatin gels and films could be protected against potential spoilage bacteria by inclusion of the food-safe antibacterial enzyme, lysozyme. Dr. Bower discovered that the presence of lysozyme did not seriously affect essential gelatin characteristics such as gelation temperature, although gel strength was slightly impacted. **Role:** The incumbent designed and carried out the microbiology component of the lysozyme-enhanced gelatin study, while collaborating with ARS scientists at WRRC in Albany, California for technical expertise involving gelatin film production and gel-strength testing. **Impact:** Fish-skin gelatin gels and films, when formulated with lysozyme, provided a unique, functional barrier with value for protecting perishable products such as food. This proof of concept study opened the field for safer fish-skin gelatin films and coatings, which is especially relevant today for people with kosher and halal dietary restrictions. (Exhibit 4a, #12; Exhibit 4b, abstract)

*5. **Accomplishment:** Alaska's fishing industry generates over one million metric tons of processing waste each year, much of which is discarded. Dr. Bower stabilized fish by-products to determine the efficacy of different preservation techniques, including direct acidification using organic and inorganic acids, and through fermentation using lactic acid bacteria. Characterization of the resulting silages and fermentates established that salmon by-products can be preserved at least 4 months for later use. However, protein quality of the fish decreased over time, thereby lowering its value for agricultural feeds, and relegating it to fertilizers, or feedstock for energy production. **Role:** The incumbent designed the experiments and carried out all the sampling and data analysis. **Impact:** Preservation of low-value by-products through stabilization represents the most efficient method for decreasing the current amount of discarded fish biomass. Dr. Bower's study of acidified electrolyzed water as a novel stabilization technique received numerous inquiries when presented at the Institute of Food Technologists annual meeting. The incumbent was also first to discover that salmon viscera and heads preserved separately can be stabilized at a higher quality and for a longer time than when the heads and viscera are mixed together, a common fish-processing practice. This finding has major implications for how fish processing waste should be collected and stored if maximum nutritional value is to be preserved. (Exhibit 5a, abstract; Exhibit 5b, abstract)

B. Stature and Recognition

1. Honors and Awards

1991-1992	American Society for Enology and Viticulture Scholarship (for scholastic excellence)
1991-1992	Clorox Co. Graduate Student Scholarship (for scholastic excellence)
1992	Honor Society of Phi Kappa Phi member

1992 Gamma Sigma Delta Honor Society of Agriculture member
1992-1993 Institute of Food Technologists Certificate of Merit (for scholastic excellence)
1995 Registry of Distinguished Students, College of Agricultural Sciences, Oregon State University

2. Special Invitations
a. Bower, C.K. and McGuire, J. 1995, Adsorption of Antimicrobial Agents, American Inst. Chem Engrs Conference on Food Engineering, Chicago, IL. *invited speaker*
b. Bower, C.K. 2002, Microbial Biofilms, Food Microbiology & Food Safety Short Course, Food Innovation Center, Portland, OR. *invited speaker*
c. Bower, C.K. 2005, Cold-water Fish Skin Gelatin, Fishery Industrial Technology Center, University of Alaska, Kodiak, AK *invited speaker*
d. Bower, C.K. 2006, Foodborne Illnesses, Food Safety/Food Preservation course, University of Alaska Fairbanks, AK *invited speaker*
e. Bower, C.K. 2006, Gasification of Food Byproducts, Fishery Industrial Technology Center, University of Alaska, Kodiak, AK *invited speaker*
f. Bower, C.K. 2006, – Post Harvest Handling, Storage, and Treatment for Fresh Market of Berry Fruit. *invited book chapter*
g. Bower, C.K. 2007, Solving the Fish Byproducts Puzzle, the Institute of Marine Science, University of Alaska, Fairbanks *invited speaker*
h. Bower, C.K. 2008, Waste Protein Generated by Seafood Processing, American Oil Chemist's Society annual meeting, Seattle, WA *invited speaker*
i. 2008-2010, Aquatic Food Products Division, Executive Committee member at large, *invited nominee*

3. Offices & Committee Assignments Held in Professional & Honorary Societies
None

4. Participation in Professional Meetings, Technical Conferences, Workshops, etc.
a. American Society for Enology and Viticulture, 1991
Attended 1 meeting and made 1 presentation
b. Institute of Food Technologists, 1993-2007
Attended 6 meetings and made 6 presentations
c. American Institute of Chemical Engineers Conference on Food Engineering, 1995
Attended 1 meeting and made 1 presentation
d. Pacific Food Technologists, 2006
Attended 1 meeting and made 1 presentation
e. American Aquaculture Society / World Aquaculture Society
Attended 1 meeting and made 1 presentation
f. American Association for the Advancement of Science, 2005-2007
Attended 3 meetings and made 3 presentations
g. Trans-Atlantic Fisheries Technology, 2006
Attended 1 meeting and made 1 presentation

C. Advisory and Consultant Activities
1. Professional Advisory and Consulting Activities
a. Reviewer for 7 journals (Journal of Aquatic Food Product Technology, Food Hydrocolloids, Journal of Food Science, Langmuir Journal, Annals of Biomedical Engineering, Journal of Colloid and Interface Science, Journal of Women and Minorities in Science and Engr) 1995-2007
b. Reviewer for US Small Business Administration (SBIR) grants, and USDA National Research Initiative Competitive Grants Program 1996-1998
c. Panel member, CSREES NRI Competitive Grants Program, Value-Added Products,

Washington D.C., May, 2001, **and** Food Safety, Washington D.C., March, 2003

d. Paid consultant for Food Science Department, Oregon State University, (provided information concerning safety consequences in the dairy industry associated with queso fresco cheese), 2004
e. Paid consultant for Hayes and Associates, Corvallis, OR, (provided technical information concerning the clinical consequences of ultrahigh molecular weight polyethylene wear debris for total knee and hip replacements), 2000

2. Special Assignments
None

D. **Other**

1. Educational Background

1974-78 Oregon State University, Zoology B.S. 1979
1982-83 Oregon Health Sciences University, Medical Technology B.S. 1983
1990-94 Oregon State University, Food Science and Technology Ph.D. 1995

2. Research Experience

1990-94 Graduate Research Assistant, Oregon State University, Corvallis, OR
1995-97 Post Doctoral Research Associate, Bioresource Engr. OSU, Corvallis, OR
1999-01 Asst Professor (Senior Research), Bioengineering, OSU, Corvallis, OR
2002-03 Asst Professor (Senior Research), Food Science, OSU, Corvallis, OR
2003-04 Research Asst, Environ. Molecular Toxicology, OSU, Corvallis, OR
2004-present, GS-12, Research Food Technologist, USDA ARS, Fairbanks, AK

3. Other Significant Information

a. The incumbent is ADODR for Specific Cooperative Agreement (No. 58-5341-6-0139) with Oklahoma State University, exploring gasification as a new technology for utilizing fish by-products to create energy, 2006-2007

b. The incumbent is an Affiliate Professor with the Fishery Industrial Technology Center (Kodiak AK) in the School of Fisheries and Ocean Sciences at University of Alaska, Fairbanks AK.

c. The incumbent received over $500,000 in competitive grants
   - Protein antimicrobial barriers to bacterial adhesion. McGuire, J., Daeschel, M.A., and Bower, C.K. $13,667, Mallinckrodt Medical, Inc., 1997
   - Efficacy of nisin as a surface-active agent in pharmaceutical applications. Ayres, J.W., Daeschel, M.A., McGuire, J., Ofoli, R.Y., and Bower, C.K. $169,400, USDA, 1998-2001
   - Protein antimicrobial barriers to bacterial adhesion *in vivo*. Bower, C.K., and Parker, J. $8,000, Oregon State University Research Council, 2000-2001
   - Production of Entomopathogenic nematodes using novel *in vitro* methods. Fisher, G., Gothro, P., and Bower, C.K. $30,000, USDA, 2001-2002
   - Improving Microbial Safety of Northwest Fresh and Processed Berries. Yanyun Zhao, M.A. Daeschel, Bower, C.K., and John Henry Wells. $325,000, USDA, 2002-2005

d. The incumbent routinely disseminates information about the ARS fish by-products project by staffing booths at fish processing trade shows and rural small business conferences.

- 2005- 2007, ComFish annual commercial fisheries trade show, Kodiak, AK
- 2006, Changing Tides: Wild Alaskan Salmon event, Anchorage, AK
- 2007, Rural Small Business Conference, Anchorage, AK
- 2007, Global Food Alaska Conference and Tradeshow, Soldotna, AK

e. Committee Service
- 1999-2000, Member of the Graduate Admissions Committee, Department of Bioengineering, Oregon State University
- 1999-2001, Member of the Bicycle Advisory Committee, Oregon State University
- 2004-2006, Member of the SARU Safety Committee, Fairbanks, AK. Designed and maintained an informative safety-quiz webpage for the Unit.
- 2005-present, Member of the Lab Chemical Safety Committee, University of Alaska Fairbanks

E. **Publications**

Peer-Reviewed Journal Publications

1. **Bower, C.K**., McGuire, J. and Daeschel, M.A. 1995. Suppression of *Listeria monocytogenes* colonization following adsorption of nisin onto silica surfaces. Appl. Environ. Microbiol. 61: 992-997.

2. **Bower, C.K**., McGuire, J. and Daeschel, M.A. 1995. Influences on the antimicrobial activity of surface-adsorbed nisin. J. Ind. Microbiol. 15: 227-233.

3. **Bower, C**., McGuire, J. and Daeschel, M.A. 1996. The adhesion and detachment of bacteria and spores on food-contact surfaces. Trends Food Sci. Technol. 7:152-157.

4. **Bower, C.K**., Daeschel, M.A. and McGuire, J. 1998. Protein antimicrobial barriers to microbial adhesion. J. Dairy Sci. 81(10): 2771-2778.

5. **Bower, C.K.,** *Xu, Q*. and McGuire, J. 1998. Activity losses among T4 lysozyme variants after adsorption to silica nanoparticles. Biotechnol. Bioeng. 58: 658-662.

6. **Bower, C.K**., *Sananikone*, *S*., Bothwell, M.K. and McGuire, J. 1999. Activity losses among T4 lysozyme charge variants after adsorption to colloidal silica. Biotechnol. Bioeng. 64: 373-376.

7. **Bower, C.K**. and Daeschel, M.A. 1999. Resistance Responses of Microorganisms in Food Environments. Int. J. Food Microbiol. 50: 33-44.

8. McGuire, J., **Bower, C.K.** and Bothwell, M.K. 2000. On the molecular origins of protein structure and function at interfaces. Australian J. Dairy Technol., 55: 65-70.

9. **Bower, C.K**., Bothwell, M.K, and McGuire, J. 2001. Lantibiotics as surface active agents for biomedical applications. Colloids Surf. B: Biointerfaces 22: 259-265.

10. **Bower, C.K**., Parker, J.E., *Higgins, A.Z., Oest, M.E., Wilson, J.T.,* Valentine, B., Bothwell, M.K, and McGuire, J. 2002. Protein antimicrobial barriers to bacterial adhesion: *in vitro* and *in vivo* evaluation of nisin-treated implantable materials. Colloids Surf. B: Biointerfaces 25: 81-90.

11. **Bower, C.K**., *Schilke, K.F*. and Daeschel, M.A. 2003. Antimicrobial properties of raisins in beef jerky preservation. J. Food Sci. 68(4):1484-1489.

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12. **Bower, C.K**, Avena-Bustillos, R.J., Olsen, C.W., McHugh, T.H., and Bechtel, P.J. 2006. Characterization of Fish-Skin Gelatin Gels and Films Containing the Antimicrobial Enzyme Lysozyme. J. Food Sci. 71(5): M141-145.

13. **Bower, C.K.,** Malemute, C.L., and Oliveira. A.C.M. 2007. Preservation Methods for Retaining n-3 Polyunsaturated fatty acids in Alaska Coho Salmon

(*Oncorhynchus kisutch*) Products. Journal of Aquatic Food Product Technology. *In press*

Other Publications

14. **Bower, C.K.**, Watson, B.T., and Daeschel, M.A. 1992. Applications of Bacteriocins in controlling bacterial spoilage and malolactic fermentation of wine: interactions between the bacteriocin nisin and components of red wines. In: Proceedings of the 3rd International Symposium: Innovations in Wine Technology. May 25-27. (Peer Reviewed Conference Proceedings)

15. **Bower, C.K.** 1994. Physical and Antimicrobial Characteristics of Nisin Adsorbed onto Model Food Contact Surfaces, Oregon State Univ. 123 pp (Thesis)

16. **Bower, C.,** *Lakamraju, M*., McGuire, J. and Daeschel, M. 1997. Nisin adsorption, exchange, and antimicrobial activity at interfaces. In: Advances in Food Engineering, G. Narsimhan, M.R. Okos, and S. Lombardo (eds), Purdue University, West Lafayette, pp 10-13. (Peer-Reviewed Book Chapter)

17. **Bower, C.K**., McGuire, J. and Daeschel, M. 1999. Resistance responses of microorganisms in food environments. In: Proceedings of the 17th Intl Conf of the International Committee on Food Microbiology and Hygiene, Veldhoven, The Netherlands. (Peer Reviewed Conference Proceedings)

18. McGuire, J., **Bower, C.K.** and Bothwell, M.K. 2000. Protein films. In Encyclopedia of Surface and Colloid Science, A. Hubbard (ed.), Marcel Dekker, New York. (Peer-Reviewed Book Chapter)

19. **Bower, CK**., McGuire, J., Bothwell, M.K.. 2003. Substrate Kinetics. In: Encyclopedia of Agricultural, Food, and Biological Engineering. Marcel Dekker, New York. (Peer-Reviewed Book Chapter)

20. **Bower, C.K**., Stan, S., Daeschel, M. and Zhao, Y. 2003. Promoting the Safety of Northwest Fresh and Processed Berries, 34 pp. Oregon State University Extension Publication, Corvallis, OR.

21. **Bower, C.K.** 2007. Post Harvest Handling, Storage, and Treatment for Fresh Market of Berry Fruit. In: Berry Fruit: Value-Added Products for Health Promotion, Y. Zhao, (ed). Taylor and Francis Group, Boca Raton, FL. (Peer-Reviewed Book Chapter)