Sajid Alavi, Ph.D.

Associate Professor
Dept. of Grain Science and Industry

Impact Report 2010

Program or Project: Extrusion Program

Long Term Intended Outcomes:

ENQFS	Enhanced Nutritional Quality of Food Supply
NEPA	New and Enhanced Products from Agriculture

Faculty Member: Alavi, Sajid

Department or Planning Unit: Grain Science and Industry

Additional Team Leaders: Koushik Adhikari, Scott Bean (USDA-GMPRC), Keith Behnke, Subramanyam Bhadriraju, Yong-Cheng Shi, Praveen Vadlani and Hulya Dogan.

Summarize Program:

Dr. Sajid Alavi is the supervisor of the extrusion lab in the Department of Grain Science and Industry. His actives have a strong emphasis on research, teaching and service. The extrusion lab includes a pilot-scale processing facility in the Bioprocessing and Industrial Value-Added Program building and a lab-scale processing facility in Waters Hall. The lab-scale facility includes single and twin screw extruders that allow time-efficient study of novel ingredients and processes in an economical manner, before scaling up to the pilot level. The pilot-scale facility includes single and twin screw extruders, a gas-fired dryer and a batch mixer. The extrusion lab also has various analytical equipment including differential scanning calorimeter, phase transition analyzer, texture analyzer, controlled humidity chamber and supercritical fat extractor, and adequate bench space for analysis of raw materials and extruded products.

In the eight and a half years since April 2002 when Dr. Alavi was appointed to the Grain Science and Industry faculty, his extensive research, teaching, industry and service-related activities have transformed the extrusion lab into an internationally recognized program. Several extrusion related research projects, with food, feed and industrial applications have been initiated and/ or successfully completed. These projects have focused on the key areas of - 1) dynamics of microstructure formation in extruded biopolymer foams, 2) use of non-invasive X-ray micro tomography (XMT) for characterizing foam micro-structure and structure – texture relationships, 3) concentration and modification of sorghum proteins, 4) interactions of carbohydrate components during processing of high-fiber cellular matrices, 5) new approaches to global food security through processing, 6) starch-clay bio-nanocomposites, and 7) thermo-mechanical of lingo-cellulosic biomass for production of ethanol.

Forty-four peer-reviewed manuscripts co-authored by Dr. Alavi, including 3 book chapters, have been published or accepted for publication. Out of these 36 are based on work originating at Kansas State University. Ten of these manuscripts were accepted for publication in 2010. Fifteen other manuscripts have been submitted to refereed scientific journals and are under review or revision. Dr. Alavi's research is based on strong collaborative partnerships with faculty members from K-State Grain Science, Animal Sciences and Human Nutrition departments, and researchers from other institutions such as USDA-CGAHR, Iowa State University, North Carolina State University and University of Tennessee. Approximately, $1.5 million in extra-mural funding has been secured from his efforts. Three Ph.D. and 2 MS. level students have successfully completed their theses with Dr. Alavi as the major professor. Three more Ph.D. students are scheduled to graduate in 2011. He has also supervised three post-doctoral scientists for periods ranging from 1 to 4 years with support from extra-mural funding.

Dr. Alavi have been responsible for developing 'from scratch' two classes focused on extrusion. GRSC 620 Extrusion Processing in the Food and Feed Industry is a senior level extrusion class with emphasis on introduction to extrusion technology and hands on laboratory exercises, and GRSC 820 Advanced Extrusion Processing is a graduate level extrusion class with group-based research projects as the main focus. Both these classes have seen sustained enrollment over the past 8 years. The importance of this subject area to the training of Grain Science undergraduates was demonstrated by a unanimous decision by the faculty to make GRSC 620 a required course for students enrolled in the Feed Science and Management program. Dr. Alavi also took the lead in developing and teaching a 3-credit faculty-led study abroad class to India (GRSC 790 Agriculture and Food Processing in North India), that was offered in Summer 2010. He has developed yet another new course 'Pet Food Processing' that will be first offered in Fall 2011. Dr. Alavi is also an active member of the planning committee for the K-State South Asia Curriculum Initiative, which is funded by the US Department of Education and focuses on developing a secondary major on South Asia for students in professional and applied disciplines across various colleges.

Dr. Alavi has developed a strong partnership with industry including Frito-Lay/ Pepsico and Wenger Manufacturing. Under his overall supervision, the extrusion lab has become a major service provider to industrial clients. Approximately, 400-500 hours (both industrial and academic including class labs and graduate student research) are devoted to performing extrusion runs for industry, research and teaching purposes every year. Clients include diverse entities such as process equipment manufacturers, ingredient companies, pet food, aqua feed and food processors, and external research organizations. More than $100,000 in annual revenue is brought in by the activities of the extrusion processing facilities, which goes towards operations, maintenance, and staff salaries. Several graduate and hourly undergraduate students help in lab operations and gain valuable hands-on experience. The 'Extrusion Processing: Technology and Commercialization' short course is an annual international event for training participants from industry and academia. In the 6^{th} edition (August 2010), there were 28 participants from 9 countries spanning 4 continents, including the U.S., Canada, Argentina, Brazil, Chile, Peru, Barbados, Japan and Ghana. Dr. Alavi has also focused on international activities and collaboration. He travels annually to India to conduct short courses and work on projects with agricultural universities, government institutions and private industry. He has also developed strong partnerships with non-profit organizations active in Southern Africa with focus on food security, nutrition and agricultural value addition. Another important part of service-related contributions is Dr.Alavi's leadership role in

AACC International and Institute of Food Technologists (IFT). He successfully led the Engineering & Processing and Rheology divisions of AACC over a period of 6 years (2004-2010). He was also a member of the 2008 and 2009 AACC annual meeting planning committee and scientific initiative chair for Engineering, Rheology and Processing. He is a member-at-large for the IFT Food Engineering division. He is actively involved in several university, college and department level bodies and committees, and is an elected representative from the College of Agriculture to the K-State Graduate Council. The research, teaching and service-related activities of the extrusion lab are designed to have a strong 'spill over' into communities across the state of Kansas. A significant impact has been made through outreach activities with middle school and high school students and teachers.

Summarize Impact:

The extrusion program is well-aligned with the mission of the K-State Bioprocessing and Industrial Value-Added Program (BIVAP) and leads to a very unique integration of various disciplines across the University, including Agronomy, Engineering, Food Science, Grain Science, Human Nutrition and Communication.

Agricultural products which utilize extrusion technology constitute approximately a $40 billion annual market in the U.S. alone. This includes breakfast cereal, snacks, pasta, pet food, aquatic feed, and bio-based industrial materials. The extrusion lab in the Department of Grain Science and Industry is an invaluable asset to the ongoing quest for enhancing the value of Kansas agricultural commodities like wheat, corn, sorghum and soybean. An important indication of the impact of Dr. Alavi's research is the AACC International Young Scientist Research Award received in 2010. Other measures of impact include substantial interest shown by industry in nanocomposite packaging technology developed in my lab, the adoption by industry of flow-based characterization of phase transition properties of ingredients and finished products as a rapid testing method, and widespread recognition in scientific and industry circles of the utility of XMT-based non-invasive imaging for understanding process – structure – function relationships in foods products. He has received prestigious USDA-FAS grants under the Cochran, Borlaug and AKI programs. He has also been invited to speak at international forums in countries including U.S.A., Italy, South Africa and India, and several visiting scientists and exchange students from countries such as Brazil, Egypt, Jordan, France and India have spent time in his lab working on joint projects.

Dr. Alavi's national and international outreach activities have assisted in enhancing the visibility and recognition of K-State in the area of food processing. More than 500 industry clients from all over the world have been trained through his short courses. A significant impact has been made in Kansas communities through outreach activities in middle schools for improving healthy snacking habits, and engagement with high school youth for making difference in the lives of deprived people in countries such as Mozambique and Haiti. These projects have been highlighted prominently in high impact forums such as the 'Annual Report to Kansas Legislature' and 'Ag Report', and public media including YouTube. Dr.Alavi offers a wide range of consulting and other services to the industry. He works closely with regional, national and international agri-businesses and provides services to a range of companies like pet food, feed and human food manufacturers (Frito-Lay, Kellogg, Yael Foods, New Life International, Virbac and Agro Food Industries), ingredient companies (example, MGP Ingredients), equipment manufacturers (Wenger Manufacturing) and commodity organizations (American Soybean Association). The extrusion lab

has also gained international recognition in the area of global rice fortification, food security and nutrition, as demonstrated by requests for assistance by foundations and organizations such as the Academy for Educational Development (AED), Wellcome Group (U.K), Applied Strategies (a consulting firm for the Bill and Melinda Gates Foundation), PATH (an international non-profit organization), World Initiative for Soy in Human Health (WISHH) and Tetra Tech ARD (an organization involved in implementing USAID projects). The relationship with Wenger especially is very beneficial to the state of Kansas as a whole, as it serves as both a catalyst and a testing ground for new processing technologies, and shines a spot light on the industrial and technological prowess of the state. This vital partnership involves collaboration on a broad range of areas including research, teaching, short courses, industrial clients and international activities. Another example of the widespread recognition of the services provided by the extrusion lab is the fact that a strong partnership has been developed with Pepsico/ Frito-Lay, which is by far the largest snack food manufacturer in the US and an international leader as well. This partnership is not limited to one or two scientists, but involves working relationships with several R&D personnel, production and operations staff, and the top management. The partnership encompasses short term projects for raw material and finished product analyses, longer term sponsored projects, annual recruitment visits, R&D related interactions, and participation of two scientists as adjunct faculty members in Grain Science.

The teaching activities of the extrusion program have ensured that Grain Science, Animal Sciences and Food Science graduates from the University are well versed with latest processing technologies. K-State is now among a select group of only 3-4 universities which have an extrusion-based teaching program, which strives to meet an ever-increasing industry demand for graduates trained in operations and R&D. Another significant development in the teaching area under my leadership has been the substantial progress towards establishment of a pet food option within the Feed Science and Management program. This effort has major support from industry partners, and once established will be only the second such program in the country. Close to 90 undergraduate and graduate students have been taught in Dr.Alavi's extrusion courses, and six Ph.D. and four MS level students have been mentored by him in the capacity of major professor.

Summarize Next Steps:

In the coming years, the extrusion lab will continue its strong emphasis on the above mentioned thrust areas for research, teaching and extension. We will especially focus efforts towards international projects on food security, nutrition and agricultural value-addition, and collaborate with other researchers from K-State and outside in new areas such as pet food and animal feed.

Important needs of the extrusion lab in the near and long-term future:

1) Continued departmental support for 2-3 graduate students.
2) More laboratory/ analytical equipment for extrusion and rheology-related research. This will tentatively cost about $200,000.
3) Several additional processing equipment including pilot-scale flaking rolls, puffing gun and cooking kettles. These will tentatively cost around $500,000.

Strategies to meet goals and needs:

The extrusion lab will work aggressively towards fulfilling the above mentioned goals and needs by – 1) strategic partnership with major industry partners like Wenger and Frito-Lay and 2) extensive solicitation of funding from external agencies such as USDA and NSF. Collaborative arrangements with other institutions and universities will be actively sought to increase the chances of extra-mural funding. Public-private and international partnerships will also be pursued for obtaining funding from agencies such as the Bill and Melinda Gates Foundation and USAID.

Percent of Faculty Time Invested: 100

Number of Volunteers Involved: None

Total Volunteer Hours: none