Sajid Alavi, Ph.D.

Associate Professor
Dept. of Grain Science and Industry

Impact Report 2009

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 a 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 seven 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) gluten-free foods based on grain sorghum, 4) high-fiber and fruit-based healthy snacks, 5) specialty product for nutritional intervention programs in developing countries, 6) starch-clay nano-composite packaging, and 7) cellulosic ethanol. Twenty nine peer-reviewed manuscripts including 3 book chapters have been published or accepted for publication since 2002, out of which 25 are based on work originating at Kansas State University. Five of these

manuscripts were accepted for publication in 2009. Thirteen other manuscripts have been submitted and are under consideration by peer-reviewed journals. Dr. Alavi's research is based on strong collaborative partnerships with faculty members from K-State Grain Science, Animal Science, Human Nutrition and Electrical Engineering departments, and researchers from other institutions such as USDA-GMPRC, Iowa State University, North Carolina State University and University of Tennessee. More than a million dollars in extra-mural funding has been secured from his efforts as the primary investigator. Three Ph.D. and one MS. level students have successfully completed their theses with Dr. Alavi as the major professor. Currently three Ph.D. students and one M.S. student are being supervised by him. 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 720 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 increased enrollment over the past 6 years. He also took the lead in developing a 3-credit study abroad class to India (GRSC 790 Agriculture and Food Processing in North India), is being offered in Summer 2010.

Dr. Alavi has developed a strong partnership with industry including Frito-Lay and Wenger Manufacturing. Under his overall supervision, the extrusion lab has become a major service provider to industrial clients. Approximately, 500-600 hours (70% industrial and 30% academic including lab classes and graduate student research) are devoted to performing extrusion runs for industry, research and teaching purposes every year. Industrial clients included diverse entities including coops and companies involved in pet food, aqua feed and food production and also other research organizations. At an average, more than $100,000 in annual revenue is brought in by the service-related activities of the extrusion lab, which go towards operations, maintenance, and salary of one full-time operations manager and hourly wages of several students who help in the lab and also 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 5th edition (August 2009), there were 36 participants from the U.S., India, Brazil, Paraguay, Argentina, Bolivia, South Africa and Norway. Dr. Alavi has also focused on international activities and collaboration. He travels annually to India to conduct short courses and strengthen linkages with agricultural universities, government institutions and private industry. Another important part of service-related contributions is Dr.Alavi's leadership role in AACC International and Institute of Food Technologists (IFT). He was the AACC Engineering and Processing division Chair/ Elect for 2008-09 and Chair for 2009-10. He was also a member of the 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 divison.

The research, teaching and service-related activities of the extrusion lab are not conducted in isolation but overlap with each other. 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. Both of these projects have been highlighted prominently in the January 2010 Annual Report to Kansas Legislature in reports titled 'Grains for Hope Program Changes Many Lives' and 'Grants Aids Families'.

Summarize Impact:

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. Some measures of the impact of Dr. Alavi's research include substantial interest shown by industry in nanocomposite packaging technology developed in his 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 and India, and several visiting scientists from countries such as Brazil, Egypt, Jordan and India have spent time in his lab engaging in collaborative research.

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 400 industry clients from all over the world have been trained through his short courses. The extrusion program has also made significant impact 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. Both of these projects have been highlighted prominently in a 2-page section of the January 2010 Annual Report to Kansas Legislature in reports titled 'Grains for Hope Program Changes Many Lives' and 'Grants Aids Families'. Dr.Alavi offers a wide range of consulting and other services to the industry. He work closely with regional and national agri-businesses and provide services to a range of companies like pet food, feed and human food manufacturers (example, Frito-Lay and Kellogg's), ingredient companies (example, MGP Ingredients), equipment manufacturers (example, Wenger Manufacturing) and commodity organizations (American Soybean Association). The extrusion lab has also gained international recognition in the area of rice fortification, as demonstrated by requests for assistance by foundations such as the Wellcome Group (U.K) and Applied Strategies (a consulting firm for the Bill and Melinda Gates Foundation), and an invitation from PATH (an international non-profit organization) for speaking at a major rice fortification conference in Sydney (Australia). 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 include 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 top management as well. The partnership encompasses short term projects for raw material and finished product analyses, longer term sponsored projects, annual recruitment

visits and other R&D related visit to K-State, and participation as adjunct faculty 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. Close to 80 undergraduate and graduate students have been taught in Dr.Alavi's extrusion courses, and six Ph.D. and one MS level students have been mentored by him in the capacity of major professor.

The extrusion program is well-aligned with the mission of the 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.

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. In addition, we will continue efforts towards community engagement projects and collaboration with other K-State researchers in the areas of nutritious foods, biofuels, value-added industrial products, petfood and animal feed research.

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 more 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 U.S.D.A., N.S.F., and regional commodity organizations. 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