

Canadian Feed Technology Research Facility (CFTRF)

The new CFTRF provides important strategic research capability in support of animal nutrition and feed development research at the University of Saskatchewan and elsewhere. In 2009 the University of Saskatchewan acquired a state of the art industrial feed production facility located in the City of North Battleford, Saskatchewan to convert this into a leading international feed processing research centre (please refer to news release below).

The total project cost is \$12.6 million and is funded by the Canada Foundation for Innovation, the Government of Saskatchewan and the private sector.



May 04, 2009

U of S to Transform Feed Mill into National Feeds Research Centre

FOR IMMEDIATE RELEASE – May 4, 2009

2009-05-03-AG

The University of Saskatchewan has purchased a North Battleford feed mill to develop a unique-in-Canada national research facility that will enhance animal nutrition and feeds research and benefit Canadian crop, livestock and feed processing industries.

The \$12.6-million Canadian Feed Technology Research Facility will research, develop and commercialize new and better high-value animal feeds from low-value crops and from byproducts of biofuels production such as ethanol and biodiesel.

The crop, livestock and feed processing industries have indicated a strong need for this research. Funding has been committed by the Canada Foundation for Innovation, the provincial government, and industry sources.

“This new research centre will benefit both animal and human health and help make the U of S an international leader in feeds processing research and commercialization,” said Karen Chad, U of S Acting Vice-President Research.

“It will advance undergraduate and graduate student training programs and also provide training opportunities for producers and feed processors. More than 25 researchers and 30 graduate students from many disciplines will use the facility.”

Renovations to transform the feed mill into a research facility are expected to begin in July. The research operation will begin in late summer or early fall of 2010.

To generate revenue for facility maintenance and research, a part of the industrial capability has been licensed to Cargill, a global leader in animal nutrition and feeds, for commercial feed processing and toll feed processing services.

“We are pleased to collaborate with Cargill, a company whose recognized expertise, market presence, and understanding of global markets will help attract global clients to the facility and to Saskatchewan,” said Chad, noting the facility will serve a broad range of industries and involve regional, national, and international partnerships.

Project leader Bernard Laarveld said the feed mill provides an excellent research base for the U of S because there’s significant space to accommodate the full range of activity—from laboratory to pilot plant to industrial-scale research—a major advantage in generating value for industry. The U of S will offer contract research opportunities to the private sector.

“Researchers are extremely keen to use this centre as it will advance research in many areas that include crop breeding for feed quality traits, reduced antibiotic use, better livestock nutrition, improved animal health and product safety, feed delivery of vaccines for disease control, environmental protection, and higher-value commodity crops,” Laarveld said, noting that new feeds produced at the mill will be used for animal feeding research at the U of S and elsewhere.

He noted the new centre will enhance and support the U of S feeds research cluster that includes the Crop Development Centre, the Feeds Innovation Institute, the Prairie Swine Centre, the Poultry Centre, the Beef Research Station, the new Dairy Innovation Centre, the

Prairie Aquaculture Research Centre, and the Canadian Light Source synchrotron which can be used to relate structural characteristics of feeds to nutritional quality.

Located in the heart of Saskatoon, the University of Saskatchewan is one of the leading medical doctoral universities in Canada. With 58 degrees, diplomas and certificates in over 100 areas of study, the University is uniquely positioned in the areas of human, animal and plant studies. World-class research facilities, renowned faculty and award winning students make the U of S a leader in post-secondary education.

Research Capabilities of the CFTRF

The CFTRF provides unique feed processing research capabilities covering the full scale spectrum from the research laboratory to pilot scale to industrial scale and will be in full operation in July, 2010.

- The pilot scale feed processing line has a maximum capacity of 2 tonnes feed per hour and includes the following components: roller mill, hammer mill, 500 kg mixer, flaker with a steam chamber, pellet mill including a feeder and a triple pass conditioner, twin-screw extruder including a feeder and a conditioner, counterflow cooler, crumbler, triple deck screener, dryer, and lab and industrial scale vacuum coaters. The pilot line also includes bulk ingredient receiving and storage and load-out, and will be completely automated with capability for extensive data and sample collection.
- A pilot plant area with workstations for the development and testing of processing equipment.
- The industrial line has a fully automated 20 tonne per hour multi-species feed capacity and includes two 250 HP hammer mills, a 3-tonne Ribbon mixer and a 3 tonne surge



hopper, a 300 HP pellet mill with conditioner and screener, liquid coating application system, bulk receiving, storage and load-out systems and complete process control.

The presence of the pilot and industrial scale feed processing lines allows the CFTRF to support research through:

1. Preparation of feed and diets to high specification for use in animal feeding and nutrition research studies. Typical batch quantities produced may range from 50 kg to 20 tonnes and can be provided in bulk or in bags.
2. Experimentation to study the effects of different equipment, processing techniques and conditions, and different feed ingredients on nutritional value and cost of animal feeds.
3. Research toll processing and facility rental to industry clients for proprietary research.
4. Scaling up of research findings from the pilot scale line to the industrial scale line for effective and efficient transfer of technology to industry.
5. Training and workshops

How to Access the Research Capabilities of the Canadian Feed Technology Research Facility?

The CFTRF is managed by the Department of Animal and Poultry Science in the College of Agriculture and Bioresources. A Research Management Committee provides the general oversight and schedules the use of the facility for research.

Institutional researchers who wish to access the CFTRF research services should contact:

Dr. B. Laarveld, Professor, College of Agriculture and Bioresources

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Industry clients can access the CFTRF research and technology transfer services through the Feeds Innovation Institute (<http://feeds.innovation.usask.ca/index.html>) and should contact:

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Science Areas Supported through the Canadian Feed Technology Research Facility

Synchrotron Science

The Canadian Light Source (CLS) has enabled the University of Saskatchewan to establish a unique, world-leading program in synchrotron applications in nutrition and feed sciences. Typical wet analysis methods used destroy inherent structure in plant tissue and provide chemical composition only. Synchrotron Fourier Transform Infra-Red (FTIR) microspectroscopy is a rapid, non-destructive analytical tool that not only reveals chemical and molecular composition, but also in a micro-structural context, even within cellular dimensions. FTIR therefore provides a new capability to characterize plant and feed inherent chemical structure at cellular and subcellular levels in relation to feed quality, digestive behavior and nutrient utilization in animals. For example, FTIR allows the ultraspatial imaging of feed protein β -sheet : α helix ratios to predict protein secondary structure and nutritional quality. It can also reveal the physicochemical effects of processing on amino acid availability and interactions between amino acids, carbohydrates and fiber during processing or in the gastrointestinal tract and effect on nutrient bioavailability. FTIR can also be used to identify chemical differences in the ultrastructural matrix of endosperm of different grain varieties, relate this to effects in animals in vivo, apply this information in crop breeding and recommend variety-specific processing parameters. For example FTIR showed that differences in the distribution and size of starch granules in the protein matrix between different barley varieties accounted for different starch degradation rates in the rumen and susceptibility to rumen acidosis, a serious metabolic disease in cattle. In another example, FTIR can be used to reveal ultrastructural differences in chemical composition in oilseeds within cellular dimensions, including protein, carbohydrate, cellulose, lignin and lipids, and aid in genetic selection programs for nutritional value. Synchrotron X-ray Absorption Near Edge Structure (XANES) spectroscopy is used for mineral nutrition and toxicology research. For example, we are interested in using XANES to study the sequestration of dietary copper by thiomolybdates (TM) formed from dietary molybdenum and sulfur in the reducing environment of the rumen, and monitor the biochemical effects of TM and sulfur at the cellular level in tissues such as brain. A long term goal of the synchrotron research is to increase the basic knowledge of the nutritional relevance of feed chemistry and structure and to apply this to the production of high quality feeding programs through plant breeding and feeds and feed processing techniques. In the immediate term the goal is to study the effect of physicochemical conditions during processing on changes to the protein matrix associated with other nutrients (such as starch, lipid and fiber) at the cellular level and on nutrient utilization, and to develop a diagnostic method for quality prediction of feed protein. The application of synchrotron techniques holds tremendous potential for breakthrough advances in nutrition and feed processing and will improve selection of superior crop varieties, improve prediction of feed nutritive value and assess/predict changes in physical-chemical properties due to feed processing methods and conditions.

Feed Nutraceutical Properties

Functional/nutraceutical properties are an important differentiating quality in the feed market place. Consumers and health authorities are concerned about animal feeding-related transmission of infectious diseases, microbial antibiotic resistance and food safety. The EU has a pro-active regulatory approach and banned the non-therapeutic use of most antibiotics. Similar pressure is building in North America, but our long-term reliance on feed antibiotics has detracted us from research into alternative approaches to microbial and disease management. Animal vaccine development is important, but changing functional characteristics of feeds through processing combined with functional feed and biological ingredients such as pre- and probiotics, organic acids and immune supplements, also is promising. We are studying approaches to promote growth of beneficial commensal bacteria in the gut that competitively exclude pathogens, improve gastrointestinal health and digestive function, improve nutrient availability and productivity in animals, and provide safe, healthy food for consumers. With the Plant Biotechnology Institute-NRC and the WCVM we use PCR-based molecular microbial screening technology to characterize complex microbial community composition in response to physical and chemical properties of feeds. This is coupled with host response differential gene expression analysis in gut tissues for indicators of gut health and function. This is an important growth area in global feed markets and we have attracted considerable industry interest and funding for this research.

Feed Biologicals

The use of feed “biologicals”, including enzymes, pre- and probiotics, immune supplements and in the future edible vaccines, is expanding rapidly. These biologicals are both expensive and sensitive to degradation. They are typically sprayed on the feed after pelleting, but the adsorption capacity of pellets is too limited for the increasing number of biologicals used. Alternate processing techniques including the use of vacuum coaters are promising but require more research. Enzymes that digest and neutralize anti-nutritional factors are included in the feed but conditions within the digestive tract of animals are not optimal. Alternate processing such as batch enzymatic processing of feeds may be more effective, allowing greater flexibility and a more enhanced response in animals. This particularly applies to potential removal or enzymatic neutralization of anti-nutritional factors such as phytate, saponins and lectins, but may also include pre-treatment of feeds with fibrolytic and digestive enzymes to improve nutrient availability. Industrial scale enzymatic treatment for high value specialty feeds, such as aquaculture feed, milk replacers, pig weanling diets and pet foods is likely.

Plant Breeding

Another area of great potential is the breeding of feed grains/stuffs with dramatically improved feed “processability” and nutritional characteristics. Genomic techniques such as marker assisted selection are improving breeding, but depend on accurate phenotyping of processing characteristics of genetic materials available and this requires feed processing research infrastructure. Recently the university released new varieties such as superior feed peas; hullless feed barley (lower fibre); a low phytate, hullless feed barley (low P excretion), and; a low lignin hulled, high fat oat (superior feed oat). We are targeting industrial use traits such as high starch content to improve efficiency of ethanol production.

Co-breeding for improved feed quality, such as amino acid composition and reduced fiber content, will open up new animal feed markets for DDGS such as the swine sector, and lower environmental impact. The biofuels sector is stimulating new plant breeding approaches such as including digestive enzymes for starch within the plant material to optimize ethanol fermentation efficiency to reduce costs.

Bio-Processing

Bioprocessing research will cover process optimization, particle flow, sensing technologies, energy efficiency, biosecurity (prevention of cross contamination; pasteurization and sterilization). This research will cross over with feed ingredient and plant breeding research to define specific optimal processing conditions for nutritional value. The facility will also support research on biomass particle size reduction (chopping and grinding; energy requirement and effect of moisture content, composition and physical properties) and on physical properties such as particle size, bulk and particle densities of biomass grind. Densification (pellets and cubes) research will determine compression and compaction characteristics of different biomass and process parameters that affect the physical quality of densified biomass. Current research capability is mainly in small scale type processing and testing and adjustment of product development parameters in the CFTRF will assist with commercialization.

Environment

Nutritional and feed processing strategies, particularly for low value feeds and feed by-products, can reduce the environmental impact of livestock production. Improved computer models on the characteristics of feed utilization and metabolism in animals will reduce nutrient waste. Increased use of enzymes to digest and reduce environmental contaminants in feed such as phytic acid, responsible for high P levels in manure, are a high priority but their optimal inclusion in diets and effect of processing on enzyme activities remain unknown. Alternatively crops may be bred for reduced content of these factors. Feed research also can be used to reduce green house gas emissions as ingredients such as flax or canola oils can reduce methane production in ruminants and at the same time provide animal products with nutraceutical properties. Feeds for poultry and swine may be formulated for reduced soluble fiber and protein content which reduces hind gut fermentation activity and odour. Enzymes such as endo-glucanase or endo-xylanase may be used to partially digest soluble fiber and reduce microbial fermentation or feeds may be fractionated to remove problematic components.

Value Adding to Commodity Crops and By-Products

A major focus of the feed development research with short-term commercialization potential will be to add value to feed grade crops and by-products, such as distillers dried grains and solubles (DDGS), from primary product processing. These feeds will be used mostly in ruminant production systems, such as beef and dairy. However, opportunity feeds (distressed crops, screenings) and DDGS, if improved in feed quality and economic value through processing, can be attractive in swine and poultry production. Other feed development includes enhanced oilseed, pea, legume and cereal combinations with optimized processing formulations for monogastric and ruminant application. Extruding under specific conditions of whole canola-pea-legume mixtures can provide special high value feeding characteristics.

To achieve the true potential of these products novel research is required on extrusion processing of high fat blends, which increases the amount of rumen bypass fat to approximately 35% and with the potential to achieve 60 or 70% bypass fat. Preparation of extrusion blends for studies on oil-protein-carbohydrate chemistry and studies on molecular structure influencing rumen fermentation are required to determine optimal processing conditions. The processing of forage and fibrous products by chemical means such as ammoniation or by enzymatic means such as cellulytic enzyme treatment is of interest. It is not well understood how such primary processing increases feed utilization and how it can be optimized through novel means of secondary processing. Another area is the effect of feed ingredient and processing on rate and site of nutrient absorption and utilization in monogastric species, and effect on microbial ecology in the gut. For example, a more gradual digestion of glucose from starch, measured by the rate of glucose appearance in the blood circulation (glycemic index), affects protein metabolism and N excretion.

The dramatic growth in demand for high quality processed feeds for the fast growing (9% annually) international aquaculture industry is another major opportunity. Fish meal and fish oil from the wild marine harvest are the major feed ingredients, but supply is limited, if not declining, and cannot support the industry's rapid growth. Consumers are concerned about fish oil toxins in the food supply. Plant-based fish feed can become an important alternative non-marine fish feed, but requires development of innovative processing techniques such as separation/fractionation of feeds into protein, fiber and starch; removal of anti-nutritional components through processing or enzymatic treatment; treatment with industrial enzymes for improved nutrient availability; supplementation with plant oils with appropriate fatty acid profiles, and; blending, processing (extrusion) of fractions, feeds, and nutritional supplements to achieve optimal nutritional value for fish. Other approaches may involve genetic selection in crops for feed and processing characteristics such as increased omega-3 fatty acids. Byproducts generated through such extensive processing may then provide important feedstock for other uses, such as for ethanol production or as by-product feed for ruminants. The CFTRF is absolutely critical to the success of aquaculture feed development research.