

DEVELOP NEW STRATEGIES TO EFFICIENTLY UTILIZE OAT GRAINS IN HIGH PRODUCTION DAIRY COWS TO MAXIMUM ECONOMIC RETURN AND BENEFIT TO PRAIRIE OAT GROWERS

Progress Report

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1. Executive Summary:

This 3rd progress report provides information on the current status of this collaborative oat feed research program. The objectives of this Prairie feed oat grain research program are: Long-term: To increase economic returns to oat producers and related industries; To advance our current knowledge by increasing and enhancing basic knowledge of the optimal nutrient supply to dairy cattle through variety selection, feed processing, and optimal feed ingredient blending; To advance our molecular structure and nutrition interaction knowledge by increasing and enhancing basic knowledge of the nutritional relevance of biopolymers intrinsic structure and chemistry on a molecular basis. Short-term: In general: To use a systematic approach to develop new strategies to more efficiently utilize feed type and milling type of oat grain grown in Prairie by integration with or maximum replacing barley or other cereal grains in sustainable dairy production for improving animal production and health; To assist Canadian dairy industry to develop low-cost/alternative feeding strategies by utilizing alternative feed resources (Prairie oat grain).

This Prairie oat research program (with POGA and SaskMilk) consists of the following sub-projects which are close related to each other. This multi-years feed (oat) research program includes following projects and will be completed in different phases: Project 1: Systematically compare prairie oat grain varieties/types with common barley in Feed Milk Value (FMV) for dairy cattle in western Canada in order to find the good variety or type of oat grain with highest FMV value for dairy cows; Project 2: Improve/increase FMV of oat grain through feed processing applications (steam-flaking vs. rolling vs. pelleting) in comparison with barley for lactating dairy cows. The suitable processing will be determined for Prairie oat grain grown under western Canadian cool climate condition. Feed processing methods/technology will be tested and applied at Canadian Feed Research Centre (CFRC: Feed Processing Centre); Project 3: Effect of various feed processing applications on FMV of the Feed-Type and Milling-Type of oat grain in comparison with barley for lactating dairy cows; Project 4: Develop new feeding strategies of the milling type or feed-type oat grain to find maximum or optimal replacement level of barley grain with of oat grain in high production lactation dairy cow to maximize benefit and economic return to prairie oat growers and dairy milk producers; Project 5: Develop new feeding strategy for heated feed type or milling type of oat grain based on the performance of the best ratio found in above Projects in high production lactation dairy cows to benefit of prairie oat growers and dairy milk producers.

The project has been initiated and is on track. The PDF research fellows and graduate students have been hired for the project.

In the 3rd progress report, we provide information on the current status of the ongoing projects, which is undertaken by the PDF fellows and graduate students and SRP Feed Chair Research Team (SRP Research Technician/Assistant as well as other PDF fellow and graduate students) since we initiated this program. Up to date, Project 1, Project 2 and Project 3 have been completed. The project 4 is ongoing and will be reported in future Progress Report 4. In this report, we also reported full details of available results that includes several studies.

In terms of Tech Transfer Activities, this SRP Feed (Oat) Chair program with POGA-NSERC and SaskMilk has caused lots of attention. For example, this Oat-for-Milk program was selected to be presented at Annual Dairy Information Day (10th, 8th, 6th) which were organized by dairy producers organization- SaskMilk and Uni of Sask) in Brian King Centre, Warman, SK in 2021; This Oat-for-Milk program was also selected to be presented at the 37th Western Canadian Dairy Research Seminar (37th WCDS) in Red Deer (mainly focus on dairy producers, nutritionists, and livestock specialist in western Canada). Our Oat-for-Milk projects have also been presented in various other industry meetings and scientific meetings: ADSA meeting, Joint ASAS-CSAS meeting, Annual Dairy Information Day (by SaskMilk). We are also writing and have published extension articles on our oat for animals in industry newsletter and magazines. The oat research findings have also been published high impact peer-reviewed scientific journals in our discipline (see the following section for the details in Tech Transfer Activities)

2. Research Progress:

2.1. Background and Motivation:

Why proposes this research? Background: Development of domestic and international market for oat producers and oat related industries is a key to maintain and increase business, maximize profit, and provide economic return and benefit to prairie oat producers. To develop competitive market in dairy industry, we need to investigate which oat grain variety or what types of oat grain (milling-type or feed-type) has highest Feed Milk Value (FMV) and highest absorbed nutrient supply and determine how much FMV in oat grain can be further/highly improved/increased by optimal feed processing applications, what is suitable and optimal processing conditions for oat grain, and how much corn, barley or other cereal grains can be replaced by oat grain in high production dairy diets.

The present feeding barley grain to dairy cattle is faced with increasing challenges in terms of price volatility, animal health, nutrient availability, utilization efficiency, and/or environmental pollution. The cost of feed grains has more than doubled in the last several years, seriously threatening the economic competitiveness dairy production in western Canada.

In Canada, the largest single cost of production facing dairy operations is feed (ca. 60-70%). Research to enhance feed efficiency and develop low-cost and alternative feeding strategies to conventional feed sources is most important for feed and dairy industries (Note: feed prices remains potential for great volatility). Compared to corn, barley has lower energy value and lower nutrient availability mainly due to two facts: (1) its extremely higher undigested hull content (11-23% of total weight), and (2) its higher extent and rate of rumen degradation of starch and protein (>80%). This often results in three big problems: a) Digestive disorders e.g bloat and acidosis, which have a serious economic impact on feeding program (and cause dairy producers millions of lost dollars each year); b) An imbalance between nutrient breakdown and microbial protein synthesis, resulting in unnecessary nutrient loss from the rumen and inefficient utilization of nutrient components; c) An inefficient utilization of nutrient components can result in environment pollution in some intensive dairy production areas.

There is an urgent need (1) To use a systematic approach to find best variety or best type of oat grain with highest FMV and high nutrient supply for high production lactation dairy cows, (2) To further

improve digestive behaviors and FMV in dairy cows through optimal feed processing technology, and (3) To develop new and alternative feeding strategies to efficiently utilize oat grains in high production lactation dairy cows to find a maximum replacement level to common barley or corn with feed-type or milling-type of oat grain in order to maximum economic return and benefit to prairie oat growers and support market development of oat grain nationally and internationally.

It is anticipated that the proposed research program with the systematic approach has tremendous potential that can highly influence and benefit not only prairie oat producers but also dairy and feed industries. Even a small improvement in the nutritive value of the oat grains could be of significant economic consequence. For example, if western Canada produces 15-20 million tons of oats per year. An improvement of only 1% in improved nutrient utilization has the potential to increase extra feed oats by 15,000-20,000 tones for dairy production and highly benefit to oat producers and dairy industry.

Objectives of Overall Project:

Short-term: In general: To use a systematic approach to develop new strategies to more efficiently utilize feed type and milling type of oat grain grown in Prairie by integration with or maximum replacing barley or other cereal grains in sustainable dairy production for improving animal production and health; To assist Canadian dairy industry to develop low-cost/alternative feeding strategies by utilizing alternative feed resources (oat grain).

This prairie oat research program (which was asked by oat grower industry-POGA) consists of the following projects which are close related to each other.

Overall objective of Project 1 is to systematically compare several different prairie oat grain varieties/types with common barley in FMV for dairy cattle in western Canada in order to find best variety or best type of oat grain with highest FMV value for dairy cows;

Overall objective of Project 2 is to highly improve/increase FMV of the feed type or milling type of oat grain through feed processing applications in comparison with barley for lactating dairy cows. The suitable and optimal processing conditions will be determined for Prairie oat grain grown under western Canadian cool climate condition. Several different feed processing methods/technology will be tested and applied at Canadian Feed Research Center (CFRC);

Overall objective of Project 3 (extra) is to study effect of various feed processing applications on FMV of the Feed-Type and Milling-Type of oat grain in comparison with barley for lactating dairy cows;

Overall objective of Project 4 is to develop new feeding strategies of the milling type or feed-type oat grain to find maximum or optimal replacement level of barley grain with oat grain in high production lactation dairy cow to maxim benefit and economic return to prairie oat growers and dairy milk producers;

Overall objective of Project 5 is to develop new feeding strategy for heated feed type or milling type of oat grain based on the performance of the best ration in high production lactation dairy cows to benefit of prairie oat growers and dairy milk producers.

Long-term: To increase economic returns to oat producers and related industries; To advance our current knowledge by increasing and enhancing basic knowledge of the optimal nutrient supply to dairy cattle through variety selection, feed processing, and optimal feed ingredient blending; To advance our molecular structure and nutrition interaction knowledge by increasing and enhancing basic knowledge of the nutritional relevance of biopolymers intrinsic structure and chemistry on a molecular basis.

2.2. The Graduate Student Research Proposals (MSc (1st graduate student) and PhD (2nd and 3rd graduate students) Full Proposals/Protocols)

Based on our objectives, we have developed the 1st MSc proposal and the protocol for each study of her program. We are carrying out studies one by one.

We have also developed the 2nd and 3rd PhD proposals in oat grain's internal molecular structure profile in relation to nutrient utilization and availability study in dairy cows. The proposals have been approved by student advisory committee. Now the students are doing proposed studies one by one.

3. Progress to Date

3.1. Project 1: Systematically compare prairie oat grain varieties/types with common barley in FMV for dairy cattle in western Canada in order to find best variety or type of oat grain with highest FMV value for dairy cows (Completed)

This project has been completed with different studies in each sub-project. Details of this project have been presented at various industry meetings and the project findings have also been written as extension article and full scientific papers. The oat feed results have been presentation at the 6th Dairy Information Day organized by SaskMilk and the 37th Western Canadian Dairy Seminar in Red Deer, Organized by Dairy Industry and Universities.

Please see the detailed results, finding, tech transfer (extension and scientific publication) in our first progress report (submitted in 2019).

3.2. Project 2: Improve/increase FMV of oat grain through feed processing applications (eg. steam-flaking vs. rolling vs. pelleting) in comparison with barley for lactating dairy cows. The suitable processing will be determined for Prairie oat grain grown under western Canadian cool climate condition. Feed processing methods/technology will be tested and applied at Canadian Feed Research Centre (CFRC: Feed Processing Centre) (Completed)

This project has been completed with different studies. Details of this project have been presented at industry and scientific meetings. The project findings have also been written as extension article and full scientific paper.

Please see the detailed results, finding, tech transfer (extension and scientific publication) in our 2nd progress report (submitted in 2020).

3.3. Project 3: Effect of various feed processing applications on FMV of the Feed-Type and Milling-Type of oat grain in comparison with barley for lactating dairy cows; (Ongoing)

This project is ongoing. This project consists of two sub-projects. The 1st sub-project has been completed. The results are presented here in this Progress Report #3. The 2nd sub-project will be reported in the Progress Report #3. The interesting findings of Prairied Oat research are being presented at industry meeting and scientific meeting and two full manuscripts will be written.

- Sub-Project 1: Completed. The detailed research results are presented in this report.
- Sub-Project 2: Ongoing. The detailed findings will be reported in next progress report.

Sub-Project 1: Effect of Heat Processing in Protein Molecular Structure of Newly Developed Oat Varieties/Types (Feed-Type and Milling-Type) and Protein Nutritive Value in Dairy Cows

Abstract: The objectives of this study were to evaluate grain varieties and heat processing effects on chemical profiles, protein subfraction profiles, rumen degradable protein (RDP), rumen undegradable protein (RUP) and feed protein intestinal digestibility; to reveal the heat processing effects on protein intrinsic molecular structures by using Fourier transform infrared attenuated total reflectance (FTIR-ATR) spectroscopy in newly developed oat varieties (CDC Nasser and CDC Seabiscuit). Samples were dry-heated, autoclaved and irradiated on similar conditions. CDC Seabiscuit showed greater crude protein than CDC Nasser. Heat processing mainly affected components related to protein profile. Dry heating increased the RDP, while Moist heating increased the RUP content, however it did not affect the protein intestinal digestibility in oat grains. The effect of interacting grain varieties and heat processing on protein molecular structure suggested that grain varieties could be submitted to specify heat treatment according to their intrinsic features. The multivariate analysis did not detect differences in between the raw and heat-processed grains. It can be concluded that heat processing can change the chemical profile, the protein subfractions proportions, as well as RDP and RUP, without negatively affect the intestinal digestibility. FTIR-ATR revealed that heat processing changes the molecular protein structures in CDC Nasser and CDC Seabiscuit.

Keywords: Heat processing treatment, rumen degradation, protein subfractions, spectroscopy

4. Highly Qualified Personal Training from This Feed Research Program

Graduate Student Training:

One MSc student and two PhD students are being trained through this POGA, SaskMilk, and NSERC-CRD as well as SRP Chair program.

PDF research fellow Training:

Two PDF fellows are being trained through this POGA, SaskMilk, and NSERC-CRD as well as SRP Chair program.

5. Technology Transfer, Extension Activities, Research Publications, and Industry Presentations /Seminars

Summary: Presentations in the industry and scientific meetings, such as:

- The Annual Dairy Info Day (Organized by SaskMilk-Dairy Producers Organization).
- The Western Canadian Dairy Seminar
- The Western Nutrition Conference
- Animal Nutrition Congress of Canada (ANCC)
- ASAS-ADSA-CSAS-WSASAS Joint Annual Meeting
- ASAS-CSAS Joint Annual Meeting
- ADSA Annual Meeting

Industry Presentations: Examples

Presentation for Industry “[The 10th Annual Dairy Info Day organized by SaskMilk-Milk Producers Organization](#)” (To Farmers, Nutritionist and Livestock Producers): María E. Rodríguez Espinosa, Marcela Tosta, David A. Christensen, John McKinnon, Peiqiang Yu*. 2021. Impact of processing methods of prairie oats in comparison with barley grain on milk production in dairy cows. [The 10th Annual Dairy Info Day](#), Virtual conference, January 21, 2021, University of Saskatchewan, SK, Canada, Available on <http://www.saskmilk.ca/index.php/publications/dairy-info-day>

Presentation for Researcher and Industry “[Annual American Society of Animal Science; CSAS= Canadian Society of Animal Science](#)” (To Researchers, Nutritionist and Livestock Producers): Chaoli Lang, Peiqiang Yu* 2021. Using synchrotron/globar techniques to reveal synergistic and interactive association between molecular structures and nutrient supply in enzymatic and thermal treated oat tissue and whole grain. [2021 ASAS-CSAS-SSASAS Virtual Annual Meeting & Trade Show](#), USA, July 14-18, 2021 (ASAS= American Society of Animal Science; CSAS= Canadian Society of Animal Science) (*My role: as supervisor, PI, corresponding author).

Presentation for Researcher and Industry “[Annual American Society of Animal Science; CSAS= Canadian Society of Animal Science](#)” (To Researchers, Nutritionist and Livestock Producers): Marcela R. Tosta, Luciana L. Prates, David A. Christensen, Peiqiang Yu* 2020. True Nutrient Supply to Dairy Cows from Rolled, Steam Flaked and Pelleted Oat vs. Barley Grain with An Advanced Modeling Approach. [2020 ASAS-CSAS- Virtual WSASAS Meeting & Trade Show](#), USA, July 19-23, 2020 (ASAS= American Society of Animal Science; CSAS= Canadian Society of Animal Science) (*My role: as supervisor, PI, corresponding author).

Presentation for Industry “[37th Western Canadian Dairy Seminar](#)” (To Farmers, Nutritionist and Livestock Producers): Marcela Tosta, Luciana Prates, David Christensen, John McKinnon, and Peiqiang Yu*. 2019. Physiochemical, molecular structural and nutritional characterization of Oat grain varieties in comparison to barley grain. [The 37th Western Canadian Dairy Seminar](#), Red Deer, Canada, March 5-8, 2019 (*My role: as supervisor, PI, corresponding author).

Presentation for Industry “[7th Annual Dairy Information Day](#)” (To Farmers, Nutritionist and Livestock Producers): Luciana L. Prates, Peiqiang Yu*. 2018. Effect of Oat Type (Feed-Type vs. Milling Type) and Processing Method on True Nutrient Supply to Dairy Cattle. [The 7th Annual Dairy Information Day](#), SaskMilk, January 25, 2018, Brian King Centre, Warman SK, <http://www.saskmilk.ca/index.php/publications/dairy-info-day> (*My role: as supervisor, PI, corresponding author).

Extension Articles and Abstracts for Various Meetings:

Published Feed Extension Article: In: “The Milk Producer (Magazine)”, Title “P. Yu* 2022. HDL: Reduce Feeding Costs by Adding oats. SUB: Research examines using processed prairie oat grain to replace barely grain in dairy cow diets Milk Producer - Canada’s Best Read Dairy Magazine, In press, Editors: Sharon Laidlaw (submit on 6Jan22 to Sharon Laidlaw [editor](#); [Original title](#): “*Focus on Feed: Feed Rumen Degradation Kinetic of Rolled Oat, Flaked Oat, and Pelleted Oat in Comparison with Conventional Rolled Barley Grain in western Canada for Dairy Cows*”. Accepted on 18Jan2022 for Feb Issue; Proof received on 18Jan22)

Published Feed Extension Article: In: “Advances in Dairy Technology”: Title Chaoli Lang, and Peiqiang Yu*. 2021. Using synchrotron and global molecular spectroscopic techniques to reveal synergistic impact and interactive association between molecular structure and nutrient properties and supply to dairy cows in enzymatic and thermal treated oat endosperm tissue and whole oat grain. Advances in Dairy Technology (2021). Volume 33, 2021, pp 170 (*My role: [as supervisor, PI, corresponding author](#)).

Industry Support: Assisted to write industry extension article regarding our project information for Oat organizations: Prairie Oat Growers Association, The Alberta Oat Growers Commission, The Manitoba Oat Growers Association, The Saskatchewan Oat Development Commission (Required in May 2020)

Published in Journal of Dairy Science (Annual ADSA Dairy Meeting Proceedings): M. R. Tosta, L. L. Prates, D. A. Christensen, J. J. McKinnon, and P. Yu*. 2019. Milk Production Performance and Ruminal Fermentation in Lactating Dairy Cows Fed Processed Oats Grain in Comparison with Barley Grain. J. Dairy Sci. Vol. 102, Suppl. 2: pp 370 (2019 ADSA Annual Meeting Integrating Dairy Science Globally, June 23–26, Cincinnati, Ohio, pp 370 in the Book of Abstract, June 23-26, 2019 (*My role: [as supervisor, PI, corresponding author](#)).

Published Feed Extension Article: In: “The Milk Producer (Magazine)”, Title “Peiqiang Yu*. 2018. FOCUS ON FEED: What are Feed Milk Value (FMV) and Available Nutrients of New Feed-Type and Milling-Type of Oats for Dairy Cows in Comparison with Common Barley Grain? The Milk Producer (Magazine), Vol 94 Issue 5 (Accepted in 27Feb2018; Proof on 23Apr2018; Published in May2018).

Published Feed Extension Article: In: “Forage and Livestock eNews”: Title “Peiqiang Yu*. 2018. Prairie Oats for Beef and Dairy Cattle: Effect of Oat Type (Feed-Type vs. Milling Type) and Feed Processing Method on Feed Milk Value and True Nutrient Supply. Forage and Livestock eNews, Vol 10 Issue 4 (Accepted on 21Feb2018; published in 17Apr2018) www.saskforage.ca

Published Feed Extension Article: In: “Advances in Dairy Technology”: Title “Marcela Tosta, Luciana Prates, David Christensen, John McKinnon, and Peiqiang Yu*. 2019. Effects of Feeding Processed Oats Grain on Ruminal Fermentation and Animal Production Performance in Lactating Dairy Cows” Advances in Dairy Technology, Volume 31, pp 359, Editor: Mike Steele, Editor, Published by the University of Alberta, Edmonton, Alberta, Canada; Article Available Online: <http://www.wcds.ca/proceedings.cgi> (*Role: [as supervisor, PI, corresponding author](#)).

Published Feed Extension Article: In: “Advances in Dairy Technology”: Title “Marcela Tosta, Luciana Prates, David Christensen, John McKinnon, and Peiqiang Yu*. 2019. Physiochemical, Molecular Structural and Nutritional Characterization of Oat Grain Varieties in Comparison to Barley Grain” Advances in Dairy Technology, Volume 31, pp 358, Editor: Mike Steele, Editor, Published by the University of Alberta, Edmonton, Alberta, Canada; Article Available Online: <http://www.wcds.ca/proceedings.cgi> (*Role: [as supervisor, PI, corresponding author](#)).

Industry Support: Review a short web article regarding our project information for Oat organizations: Prairie Oat Growers Association, The Alberta Oat Growers Commission, The Manitoba Oat Growers Association, The Saskatchewan Oat Development Commission (Required on 15Jun 2017)

Industry Support: Review a short article for Oat organizations: Prairie Oat Growers Association (Required on 25Sept2017)

Research Findings for Scientific Journals: Manuscripts and Publications:

Peiqiang Yu*. 2022. Book Chapter 40: Cereal Grain (Oat and Barley) as Feed for Livestock, In: ICC Handbook of 21st Century Cereal Science and Technology, Editor: Professor Dr. John Tyler, Elsevier, pp (Received Book Chapter Invitation on 14Jun21; Accepted invitation on 125Jun21; Submitted book chapter outline on 13Sept21; Accepted outline on 16Sep22; submitted book chapter to Editor online on 18May22)

Marcela Ribeiro Tosta, Luciana Louzada Prates, Xin Feng, Maria E. Rodríguez-Espinosa Huihua Zhang, Weixian Zhang*, Peiqiang Yu*. 2021. Research Progress in Structural and Nutritional Characterization and Technologically Processing Impact on Cool-Season Adapted Oat and Barley Cereal Kernels with Wet Chemistry and Advanced Vibrational Molecular Spectroscopy. Critical Reviews in Food Science and Nutrition. In Press (DOI: 10.1080/10408398.2021.1882380) (*My role: [as Supervisor, PI, and Corresponding Author](#)).

Marcela Ribeiro Tosta, Luciana Louzada Prates, David A. Christensen, Peiqiang Yu* 2019. Biodegradation Kinetics by Microorganisms, Enzymatic Biodigestion, and Fractionation of Protein in Kernels of Cool-Season Adapted Oats: Comparison among Varieties and between Milling-Type and Feed-Type. Journal of Cereal Science. 89: In press (DOI: 10.1016/j.jcs.2019.102814) ([Fully Accepted on 15Dec2019; Published online on 18Dec 2019](#)) (*My role: as supervisor, PI and corresponding author).

Marcela Ribeiro Tosta, Luciana Louzada Prates, David A. Christensen, Peiqiang Yu* 2019. Effect of Processing Methods (Rolling, Steam-Flaking, Pelleting) on Protein Molecular Structure Profile, Rumen Degradation, and Intestinal Digestion of Cool-Climate Adapted Oats Grain in Comparison with Barley Grain in Western Canada. Livestock Science. 232: In press (DOI: 10.1016/j.livsci.2019.103901) ([Fully Accepted on 25Jul2019; Published online on 8Aug 2019](#)) (*My role: as supervisor, PI and corresponding author).

Luciana L. Prates, Peiqiang Yu. 2017. Detect Unique Molecular Structure Associated with Physiochemical and Nutrient Properties in CDC Developed Oat Varieties in Comparison with Barley Grain Using Advanced Molecular Spectroscopy as a Non-Destructive Biological Tool. Journal of Cereal Science (England, IF=2.223) 74: 37-45 (DOI: 10.1016/j.jcs.2017.01.006) ([Fully Accepted on 16Jan2017; Published online on 29Jan 2017](#)) (*My role: as supervisor, PI and corresponding author).

Luciana Louzada-Prates, Basim Refat, Yaogeng Lei, Mariana Louzada-Prates, Peiqiang Yu*. 2018. Relationship of Carbohydrates and Lignin Molecular Structure Spectral Profiles to Nutrient Profile in Newly Developed Oats Cultivars and Barley Grain. Spectrochimica Acta Part A - Molecular and Biomolecular Spectroscopy (IF=2.880 in 2017). 188: 495-506. (DOI: 10.1016/j.saa.2017.07.042). (Fully Accepted on 20Jul2017; Published online on 24Jul2017) (*My role: as Supervisor, PI and Corresponding Author)

Luciana L. Prates, Peiqiang Yu*. 2017. Recent Research on Molecular Structure, Physiochemical Properties, Metabolic Characteristics of Food & Feed-Type Avena Sativa Oats and Processing-Induced Changes with Molecular MicroSpectroscopic Techniques. Applied Spectroscopy Reviews (USA IF=3.226). 52 (10): 850-867 (DOI: 10.1080/05704928.2017.1331447) ([Fully Accepted on 14May2017; Published online on 16May2017](#)) (*My role: as Supervisor, PI and Corresponding Author)