APPENDIX D

SAES-422
Format for Multistate Research Activity Accomplishments Report

Project/Activity Number: W-181
Project/Activity Title: Modifying milk fat composition for enhanced manufacturing qualities and consumer acceptability.
Period Covered: January 1 to December 31, 2000
Date of This Report: March 7, 2001
Annual Meeting Date: January 8-9, 2001

Participants:

COOPERATING AGENCIES AND PRINCIPLE LEADERS:

State Agricultural Experiment Stations

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NY	Cornell University	D. Barbano*, D. Bauman
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SC	Clemson University	T. Jenkins*
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Brief summary of the minutes of the annual meeting: www.ag.unr.edu/w181/minutes.html

Accomplishments and Impacts:

IMPACT STATEMENT

Dairy products are an important source of vital nutrients in the human diet. Progress has been made during the year to identify nutritional and genetic factors that influence milk and meat fatty acid composition. Significant knowledge is accumulating on the role of different CLA isomers in reducing incidences of cancer and body fat content. The results of CLA research are exciting because they are among the first to demonstrate that a natural anticarcinogen (CLA) as a component of natural foods (Milk and Beef) effectively reduces tumors in an animal cancer model.

Objective 1: To identify and characterize important regulatory steps in fatty acid synthesis and desaturation and their positional distribution on glycerol in milk fat.

Stearoyl-CoA desaturase (SCD) has an important role in regulating fatty acid synthesis in the mammary gland. Cows were identified for polymorphisms in the gene for SCD. The bovine SCD gene was cloned, sequenced and three closely linked polymorphisms were identified.

In lactating dairy cows it was established that endogenous synthesis of milk fat CLA was possible. There was a 31% increase in milk fat CLA with abomasal infusion of *trans*-11 C18:1 fatty acid. Stearoyl-CoA desaturase enzyme was identified to be responsible for conversion of *trans* C18:1 to CLA in the mammary gland. It was shown that endogenous synthesis of CLA accounted for over 75% of the *cis*-9, *trans*-11 CLA found in milk.

It was found that the *trans*-10 *cis*-12 isomer of CLA reduces milk fat content and fat yield. The carcasses of mice fed *trans*-10 *cis*-12 isomer of CLA had lower percentage of fat and a greater percentage of protein. It was also demonstrated that the decrease in fat from *trans*-10 *cis*-12 isomer of CLA was due to the reduction in the activity of SCD enzyme.

Objective 2: To quantify modification of milk fat composition by manipulating the diet of the cow.

Studies were conducted to determine the influence of feeding various fat sources on fatty acid composition of various breeds of dairy cows. It was found that milk from Jersey cows was more saturated than milk from Holstein and Brown Swiss cows. Feeding supplemental fat reduced the fat globule size in milk.

A study conducted with regional dairy farms in Illinois suggested that the average CLA content of milk was 5.4 mg /g of fat. The CLA content was lowest in winter and highest in summer months. The individual variation in milk fat CLA is also of interest. It is typically observed that there is about a 3-fold difference among individuals fed the same diet. These results suggest that animals may differ substantially in Δ^9 desaturase activity. Feeding fish oil and green algae were shown to increase CLA and *trans*-C18:1 fatty acid contents of milk fat.

An interesting aspect of CLA is its relationship to diet-induced milk fat depression. Recent research results from the Cornell University suggest that it is *trans*-10 C18:1 fatty acid that is responsible for milk fat depression.

A study was conducted to test the hypothesis that biohydrogenation of oleic acid by ruminal microbe results in the formation of *trans* monoenes, rather than being converted directly to stearic acid as commonly reported. Results showed that the pattern of biohydrogenation of oleic acid is similar to the biohydrogenation of polyunsaturated fatty acids. Feeding CLA in amide form to dairy cows resulted in decreased in milk fat content. It was also shown in an in vitro study that supplying oleic acid through the diet enhances the production of *trans*-10 C18:1 fatty acid.

Studies conducted with beef cattle showed that steers raised on forage and pasture with no grain supplementation had 550% more CLA (cis-9 *trans*-11 isomer) in beef compared with steers fed a typical feedlot high grain diet.

Objective 3: To characterize the effects of modified milk fats on physical, chemical, manufacturing, and sensory properties of dairy products.

It was found that feeding supplemental fat decreases the fat globule size in milk, and reduction in fat globule size reduces the time to manufacture butter. An index of atherogenicity (IA) of milk fat from cows was calculated from milk fatty acid composition. The butter with low IA was softer than butter with high IA. The results from this study suggest that natural variation in fatty acid composition provides the possibility of selecting cows that produce a more healthful milk and a milk that can be used to produce a more spreadable butter.

Feeding heat-treated soybeans to dairy cows increases the proportions of polyunsaturated fatty acids in milk fat. Milk with high concentrations of polyunsaturated fatty acids and copper was found to be more susceptible to oxidation and develop oxidized flavor. Feeding fish oil to dairy cows increased the CLA content of milk fat. A trained panel found no flavor difference in milk or butter from cows fed control diet or diet supplemented with fish oil.

Sphingomyelin is a phospholipid referred to as tumor suppressor lipid. Milk is a major source of sphingomyelin in the human diet. Studies conducted at the University of Illinois showed that Sphingomyelin was more concentrated in Holstein milk fat than Jersey milk fat.

A supercritical carbon dioxide processing system was used to prepare CLA-enriched milk fat. The highest concentration of CLA occurred in the raffinate fraction (S1), and this fraction was also low in saturated fatty acids and cholesterol, and higher in unsaturated fatty acids and β-carotene, suggesting that this technology can be used to produce healthy milk fat.

It was established that feeding CLA-enriched butter to rats reduced the incidences of mammary tumors when *cis*-9 *trans*-11 CLA isomer represented 91% of the total CLA in the CLA-enriched butter. These results are exciting because they are among the first to demonstrate that a natural anticarcinogen as a component of a natural food effectively reduces tumors in an animal cancer model. In a similar study, the *cis*-9, *trans*-11 isomer supplied by the CLA-enriched butter was ineffective in the ZDF diabetic rat model.

COLLABORATIVE WORK

Linkages between researchers

1. University of California, Davis, CA and Cornell University, NY.
2. University of Illinois and University of Reading, Dept. of Agriculture, UK.
3. Cornell University is collaborating with University of Helsinki, Finland; University Cagliari, Italy; INRA France; University of Laval, Canada; University of Illinois; Roswell Park Cancer Institute, Buffalo; University of Sao Paulo, Brazil; University of Idaho; Natural lipids, Norway; ARS/USDA; ARO Israel; Purdue University.
4. Utah State University and Western Dairy Center, Logan, Utah

5. Department of Dairy Science and Food Science and Technology, Virginia Polytechnic Institute and State University.
6. Iowa State University, Ames, Iowa and Land O'Lakes, Webster City, Iowa.

Publications:

Journal articles

1. Abughazaleh, A. A., D. J. Schinogoethe, and A. R. Hippen. 2000. Blood amino acids and milk fatty acids in cows fed fishmeal and/or soybean meal. J. Dairy Sci. 83:1182.
2. Avila, C. D., E. J. DePeters, H. Perez-Monti, S. J. Taylor, and R. A. Zinn. 2000. Influences of saturation ratio of supplemental dietary fat on digestion and milk yield in dairy cows. J. Dairy Sci. 83:1505.
3. Bauman, D. E., D. M. Barbano, D. A. Dwyer and J. M. Griinari. 2000. Technical Note: Production of butter with enhanced conjugated linoleic acid for use in biomedical studies with animal models. J. Dairy Sci. 83:2422-2425.
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9. DePeters, E. J., J. B. German, S. J. Taylor, S. T. Essex, and H. Perez-Monti. 2000. Fatty acid and triglyceride composition of milk fat from lactating Holstein dairy cows in response to supplemental canola oil. J. Dairy Sci. (In press).
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11. Dhiman, T. R., L. D. Satter, and M. W. Pariza, M. P. Galli, K. Albright, and M. X. Tolosa. 2000. Conjugated linoleic acid (CLA) content of milk from cows offered diets rich in linoleic and linolenic acid. J. Dairy Sci. 83:1016-1027.
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14. Griinari, J.M., B.A. Corl, S.H. Lacy, P.Y. Chouinard, K.V.V. Nurmela and D.E. Bauman. 2000. Conjugated linoleic acid is synthesized endogenously in lactating cows by Ä^{9}-desaturase. J. Nutr. 130:2285-2291.
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22. Morales, M. S., D. L. Palmquist, and W. P. Weiss. 2000. Milk fat composition of Holstein and Jersey cows with control or depleted copper status and fed whole soybeans or tallow. J. Dairy Sci. 83:2112-2119.
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25. Romero, K. P., S.S.H. Rizvi, M. L. Kelly, and D. E. Bauman. 2000. Short Communication: Concentration of conjugated linoleic acid from milk fat with a continuous supercritical fluid processing system. J. Dairy Sci. 83:20-22.
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Abstracts:

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2. Bauman, D. E. and J. M. Griinari. 2000. Regulation and nutritional manipulation of milk fat: Low-milk fat syndrome. 51st Annual Meeting of the European Association for Animal Production, The Hague, Netherlands. (Abstr.).
3. Baumgard, L. H., B. A. Corl, S. S. Block, D. A. Dwyer, Y. R. Boisclair and D. E. Bauman. 2000. Effect of conjugated linoleic acids (CLA) on parameters of adipose tissue metabolism in the lactating dairy cow. J. Anim. Sci. 78(Suppl. 1)/J. Dairy Sci. 83(Suppl. 1):222. (Abstr.).
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14. Jenkins, T. C. 2000. The influence of linoleamide on linoleic acid concentrations in ruminal in vitro cultures and duodenal contents of sheep. J. Dairy Sci. 83:276(Suppl. 1).
15. Lin, x., J. J. Loor, and J. H. Herbein. 2000. Dietary CLA isomers and *trans*-vaccenic acid reduce mRNA for lipogenic enzymes in mammary tissue of lactating mice. FASEB J. 14 (6) Abstract 253.

16. Loor, J. J., M. Fenaux, X. Lin, and J. H. Herbein. 2000. Influence of dietary CLA isomers and *trans*-vaccenic acid on body composition and fatty acid profile in tissues of lactating mice. FASEB J. 14 (6) Abstract 252.
17. Loor, J. J. and J. H. Herbein. 2000. Exogenous *trans*-10, *cis*-12 C18:2 reduce de novo synthesis and desaturation of milk fatty acids in cows fed diet supplemented with high-oleic or high linoleic oil. J. Dairy Sci. 83 (Suppl. 1):162.
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Proceedings and reports

1. Bauman, D. E. and J. M. Griinari. 2000. Historical perspective and recent developments in identifying the cause of diet-induced milk fat depression. Pages 191-202 *in* Proc., Cornell Nutr. Conf., Cornell University.
2. Baumgard, L. H., B. A. Corl, and D. E. Bauman. 2000. Effect of CLA isomers on fat synthesis during growth and lactation. Pages 180-190 *in* Proc., Cornell Nutr. Conf., Cornell University.
3. Beaulieu, A. D., J. K. Drackley. 2001. Milk produced in Illinois contains variable amounts of conjugated linoleic acid. Pages 54-57 *in* 2001 Illinois Dairy Report.
4. Corl, B. A., L. H. Baumgard and D. E. Bauman. 2000. Role of Δ9-desaturase in the synthesis of the anticarcinogenic isomer of CLA and other milk fatty acids. Pages 203-212. *in* Proc., Cornell Nutr. Conf., Cornell University.
5. Dhiman, T. R. 2000. Conjugated linoleic acid: A food for cancer prevention. Feedstuffs Vol. 72 (18):24-32.
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8. Palmquist, D. L. 2000. Ruminal and endogenous synthesis of CLA in cows. Pages 169-179 *in* Proc. 61st Minnesota Nutrition Conf. Bloomington. Pp. 169-179.
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10. Schinogoethe, D. J., D. C. Donovan, R. J. Baer, and A. R. Hippen. 2000. Production of cancer-preventing milk. Pages 6-8 *in* Proc. 2000 SDSU Dairy Sci. Dept. Res. Updates, Brookings.
11. Schingoethe, D. J., L. A. Whitlock, and A. R. Hippen. 2000. High oil corn for lactating cows. Pages 14-15 *in* Proc. SDSU Dairy Sci. Dept. Res. Updates, Brookings, SD.
12. Schinogoethe, D. J., L. A. Whitlock, A. R. Hippen, R. J. Baer. 2000. Can the feeding of fish oil with another source of fat increase the CLA content of milk? Pages 9-10 *in* Proc. 2000 SDSU Dairy Sci. Dept. Res. Updates, Brookings.

Graduate student Thesis/dissertations

1. Abughazaleh, A. 2000. Fishmeal versus soybean meal in the diet of lactating cows. M.S. Thesis, South Dakota State University.
2. Chen, S. 2000. Comparison of the physical, chemical, and sensory properties of butters made from milks differeing in their antherogenicity index. M. S. Thesis, Iowa State University.
3. Lin, X. 2000. Stearoyl-CoA desaturase gene transcription, mRNA, and activity in response to *trans*-vaccenic acid and conjugated linoleic acid isomers. Ph.D. Dissertation. Virginia Polytechnic Institute and State University.

Book chapter

1. Bauman, D. E. and J. M. Griinari. 2000. Regulation and nutritional manipulation of milk fat: low-fat milk syndrome. In: Biology of the Mammary Gland (J. A. Mol and R. A. Clegg, eds.). Advances in Experimental Medicine and Biology 480:209-216.

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