2004 MAFMA Final Report

Project Title	**Evaluation of nutritional properties and quality of oat products as affected by β-glucan concentration and processing**
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1. Objective Summary

The overarching goal of this project is to provide the knowledge base and the necessary germplasm to increase the economic and nutritional value of the oat crops in the Upper Midwest. The specific objectives of this study are to:

1. Evaluate the impact of β-glucan concentration in oats on the nutritional function by relating selected functional properties in processed oat products to a biochemical response.
2. Determine the potential of these new oat lines to be used in food products by evaluating the sensory characteristics of their processed oat products.

2. Objective Accomplishments

Objective 1:

Four oat lines were grown in two replicate fields, including two experimental oat lines N979 and IA95111 (β-glucan: 8.4-8.7% and 7.2-8.0%, respectively), and two commercial oat lines, 'Jim' and 'Paul' (β-glucan: 4.8-6.4% and 5.8-6.0%, respectively). Oats were processed into flakes, and ground into flours, at the Quaker Oats facility in Cedar Rapids, IA. Extruded oat cereals from the four oat lines were made at the Extrusion Center, Kansas State University. N979 and Jim lines, grown in 2003, were used in a preliminary study to establish the conditions of 180 ^{o}C for extrusion temperature and 18% for feeding moisture to be used in making the final oat cereal products.

Bile acid (BA) binding capacities of cereals made from these oat lines were determined *in vitro* at appropriate dry solids contents by *in vitro* human digestion systems. The cereal was milled in an ultra centrifugal mill (ZM-1, Retch GmbH&Co, Haan, Germany) fitted with a 0.5 mm sieve. Cereal powder was mixed with sodium phosphate buffer (50 mM, pH 6.9) in a 50-mL centrifuge tube (4% dry solids), and stirred slowly at 37 ^{o}C for 15 min. Stirring was continued for 15 min at 37 ^{o}C after adding 100 μL human salivary α-amylase (5 mg/mL in 3.6 mM $CaCl_2$, Cat. No. A1031, EC 3.2.1.1, Sigma-Aldrich Co.). Pepsin and pancreatin were added with the volume adjusted according to the amount of cereals used. The BA mixture (140 μmol) containing sodium cholate, sodium deoxycholate, sodium glycocholate, and sodium taurocholate (Sigma-Aldrich Co.) was added along with pancreatin. The digestion slurry was stirred slowly for 90 min at 37 ^{o}C. The contents were centrifuged at 3, 100 × g for 20 min. Unbound BA in the supernatant after filtering through Whatman No. 1 filter paper was analyzed by using a BA Diagnostic Kit (Trinity Biotech plc, Bray Co., Wicklow, Ireland) and calculated based on a standard curve developed by using a BA mixture with different concentrations. A non-BA binding negative control, cellulose, and a BA binding anionic resin positive control, cholestyramine (Sigma-Aldrich Co.), also were included for each set of analyses. The N979 and IA95111 oat cereals bound significantly greater bile acid (45-50%) than the two commercial oat lines, with Paul cereal at 30-39% and Jim at 12-16%. Results also

indicated that at higher dry solids content, cereals made from oat lines with higher %β-glucan can bind much more bile acid, thus lower cholesterol to a greater extent, than at lower dry solids content, such as 0.8%.

Objective 2:

Cereals made from the four oat lines described in Objective #1 were further evaluated for their sensory characteristics by using trained sensory panels and a large consumer panel. The goal for the trained panel was to detect and describe the sensory aspects of the cereals both qualitatively and quantitatively. The goal in conducting the consumer panel was to assess the personal response (acceptance) as degree of liking by current or potential customers of oat cereals.

Quantitative descriptive analysis (QDA®) tests were conducted by a trained sensory panel. Cereals made from oats grown in two replicate fields showed significantly different appearances and physical properties, thus only cereals from one field replication were chosen for sensory evaluation. An 11-member sensory panel composed of panelists with extensive experience in QDA® was trained during three sessions by using standards representing two extreme ratings for each characteristic, noted at the end of this paragraph. Each characteristic was evaluated on a 15-cm line scale, with a low degree of the characteristic scored at 1 and a high degree scored at 15. During the official evaluations, panelists received a measured portion (2 g) of cereal coded with a three-digit random number. Treatments were evaluated before and after adding milk (1 g of each cereal was provided separately to mix with 14.7 mL milk). Characteristics evaluated before adding milk were color (brownness), gritty, cereal flavor, and tooth packing. Characteristics evaluated after adding milk, which was allowed to mingle for 1 min, were cereal aroma, crunchiness, cereal flavor, and tooth packing.

Cereal made from Jim was lighter in color and cereals made from other oat lines were browner than Cheerios®. Jim cereals also caused greater tooth packing when tasted with or without milk than the other cereals. They also had significantly lower cereal aroma/flavor and were less crunchy than cereals made from the other three oat lines. Except for IA95111 cereals being browner than N979 oat lines, cereals made from these two oat lines had no significant differences in the sensory characteristics measured.

The consumer panel consisted of 115 people from the Ames, Iowa community, who were asked to evaluate their degree of liking for two cereal treatments made from N979 and Paul oat flours. These two treatments were selected for the consumer panel because they represented the oat lines with higher and normal %β-glucan. Jim oat cereal was not chosen to be compared with N979 oat lines because of its pale appearance and low expansion. A 9-point hedonic scale with a verbal description to facilitate understanding was used, with 1 representing Dislike Extremely, and 9 representing Like Extremely. Cereal made from N979 oats tended to have a higher likeness score than cereal made from Paul oats (6.3 vs 6.0), but the data were not statistically different.

3. Unexpected findings, if any

One of the control oat lines, Paul, with 5.8 to 6.0% β-glucan, had greater bile-acid binding (30-39%) than would be predicted by concentration of β-glucan alone. For example, Jim field replication 2 had 6.4% β-glucan but only bound 16% bile acid. The β-glucan in the Paul line had a higher molecular weight than that in the Jim oat line, along with a higher percentage of fat and IDF (insoluble dietary fiber) than Jim oat lines (8.0% vs 6.8% and 6.0% vs 2.8%, respectively). Bile acid also functions as a bi-polar reagent to digest and absorb lipid thus it is possible that the higher % fat in Paul caused higher consumption of bile acid. This oat line is a naked oat line (with no hull), which may have had an impact on cell-wall structure particularly on the outer surfaces. We continue to examine this oat type to help in understanding the reasons for its unpredicted impact on bile-acid binding.

4. Practical impacts of research efforts.

a. Short Term Impacts

We have provided solid evidence that new oat lines with high β-glucan concentrations can be used to make extruded products with consumer acceptance levels similar to or tending to be better than extruded products made from oat lines with typical β-glucan concentrations. The oats with higher β-glucan concentrations were shown to provide greater binding of bile acids in *in vitro* tests, suggesting that they would reduce serum cholesterol at a greater rate in humans than typical oats.

b. Long Term Impacts

Within two to three seasons, the targeted oat lines can be planted in large quantities and the oat lines made commercially available to our industrial partner and other oat-processors.

We continue to fine tune the development of oat lines with high β-glucan concentrations and good agronomic performance so commercial companies can economically take advantage of these and other new oat types with high nutritional benefits.

6. Publications resulting from this research.

Sayar, S., Jannink, J. L., and White, P. J. 2005. In vitro bile acid binding of flours from oat lines varying in percentage and molecular weight distribution of β-glucan. *Journal of Agricultural and Food Chemistry* 53: 8797-8803.

Sayar, S., Jannink, J. L., and White, P. J. 2006. In vitro bile acid binding activity within flour fractions from oat lines with typical and high β-glucan amounts. *Journal of Agricultural and Food Chemistry* (Accepted May 17, 2006) *currently available on-line*.

Yao, N., Jannink, J.L., Alavi, S. and P.J. White. Physical and Sensory Characteristics of Extruded Products Made from Two Oat Lines with Different β-Glucan Concentrations Cereal Chemistry (Accepted Aug. 2, 2006).

Presentations at International meetings:

Sayar, S., Jannink, J. L., and White, P. J. 2005. In vitro bile acid binding capacity of oat flours from new lines with altered beta-glucan amounts and structures, American Association of Cereal Chemists' Annual Meeting, Orlando, FL. (*poster presentation*)

Sayar, S., and White, P. J. 2005. Review of oat starch: physicochemical properties and function, American Association of Cereal Chemists' Annual Meeting, Orlando, FL. (*oral presentation*)

Sayar, S., Jannink, J.L., and White, P.J. 2006. Impact of oat flours with different beta-glucan amounts on *in vitro* fermentation and its products. American Association of Cereal Chemists' Annual Meeting, San Francisco, CA. (*poster presentation)*

Yao N., Jannink J.L, and White P. J. 2006. Molecular weight distribution of (1-3)(1-4)-beta-glucan and pasting property of the flour from oat lines with high and typical amounts of beta-glucan. American Association of Cereal Chemists' Annual Meeting. San Francisco, CA. *(Oral presentation)*.

Yao, N., Alavi, S., and White, P.J. 2006. Properties of extruded products made from high beta-glucan and traditional oat lines. American Association of Cereal Chemists' Annual Meeting, San Francisco, CA. (*poster presentation)*