Background

Wheat bran is a rich source of phenolic compounds that, if absorbed, are thought to have highly beneficial health effects. Unfortunately, these phenolic compounds are normally bound in such a way that they remain almost entirely unavailable for absorption. As part of a recently completed USDA grant, we have conducted a study in obese, diabetic rats in which we fed wheat bran that was chemically treated and subjected to high pressure homogenization to release the phenolic compounds, thereby making the phenolic compounds present in the wheat bran available for intestinal absorption. The wheat bran processed in this way is food grade and completely safe to eat.

The diabetic, obese rats fed the processed wheat bran were found to have lower plasma insulin levels and improved insulin sensitivity, indicating that they were less diabetic as a result of consuming the processed wheat bran, compared to normal (unprocessed) wheat bran. Rats consuming the processed wheat bran tended to weigh less and tended to consume less diet that rats consuming normal wheat bran. Most importantly, the rats consuming the processed wheat bran diet clearly had less body fat, indicating that the processed wheat bran was in some way reducing the accumulation of body fat.

Control of eating is clearly a very complex phenomenon. However, a number of hormones have been identified that play important roles in both the desire to begin eating and the signal to stop eating. These are referred to as satiety-related hormones. We hypothesized that consumption of the processed wheat bran may have changed the concentration of these satiety-related hormones in such a way as to decrease food intake in our animals compared to rats eating normal, unprocessed wheat bran.

Results

Satiety-related hormones are peptide hormones released from the gastrointestinal tract or the pancreas that influence food intake. They often act on nervous fibers, either centrally (e.g. the hypothalamus in the brain) or peripherally (e.g. the vagus nerve).

Ghrelin is produced in the stomach and the small intestine. As ghrelin concentrations in the plasma increase, hunger increases. Ghrelin is the only satiety-related hormone that increases food intake. Normally, after a meal, plasma ghrelin decreases. As seen in Figure 1, this was found in the normal rats. However, in the Diabetic Zucker Fatty (ZDF) rats, ghrelin tended to increase after a meal, indicating they are responding to a meal in a very different way. However, in the fasted state, the rats fed the soluble fraction of the processed wheat bran had the lowest plasma ghrelin concentration, suggesting that rats consuming the soluble fraction of wheat brain were less hungry.

Amylin is produced in the pancreas in the same cells that produce insulin, and are co-secreted with insulin. High plasma concentrations of amylin are thought to increase satiety and decrease food intake. However, recent evidence suggests that amylin concentrations may also reflect the total amount of body fat. This appears to be true, as all the ZDF rats, which are much fatter than the lean rats, had a much higher concentration of plasma amylin (Figure 2). The ZDF animals that had less body fat — the Optimized, Soluble, Insoluble, and LV-HPMC groups — also had less plasma amylin in the fasted state. This appears to confirm that the processed wheat bran is lowering body fat.

PYY is produced in the lower part of the small intestine.

Procedures

In our experiment, obese, diabetic rats (Zucker Diabetic Fatty, ZDF) were fed one of the following diets for three weeks:

- Control (no wheat bran) – lean – normal rats
- Control (no wheat bran) – obese – ZDF rats
- Wheat Bran – obese – ZDF rats
- Optimized Wheat Bran (processed) – obese – ZDF rats
- Soluble Fraction of Optimized Wheat Bran – obese – ZDF rats
- Insoluble Fraction of Optimized Wheat Bran – obese – ZDF rats
- Low viscosity hydroxypropyl methylcellulose (a viscous dietary fiber) – obese – ZDF rats

The diets were fed for three weeks. Blood was drawn from the rats in both the fasted state and at two hours after a meal. Body weight, food intake, and body fat have already been measured in these animals.

The specific hormones to be measured are amylin, ghrelin, PYY, and insulin. All the assays for hormones will be radioimmunoassays, and will be purchased as commercial kits.
tine and the colon, and high concentrations in the plasma have been found to lower food intake. That is, high PYY concentrations are thought to increase satiety. As shown in Figure 3, all ZDF rats had higher concentrations of PYY than did the lean animals. Plasma PYY concentrations were more variable within a diet group than the other hormones; consequently, no statistically significant differences were found among the ZDF groups. However, there was a tendency for the processed wheat bran-fed groups to be increased after a meal compared to the wheat bran group. This would suggest a tendency for the processed wheat bran to be more satiating after a meal.

To integrate the information obtained in this study and develop a clearer story of what is affecting food intake, we conducted a multiple regression analysis of all the plasma parameters measure against food intake (Table 1). The combined measures of insulin concentration in the fed state, fasting plasma glucose, and PYY concentrations in the fed state explained about half the variation in food intake among the animals. That is, differences in these three measures are half the explanation as to why different animals eat different amount of food. These same three measures were either lower or strongly tended to be lower in the processed wheat bran groups.

<table>
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<th>Variable</th>
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<td>PYY in fed state</td>
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Table 1. Multiple regression analysis of food intake & plasma parameters among ZDF rats.

Summary

The Zucker Diabetic Fatty (ZDF) rat is a model for the human condition referred to as metabolic disease. Metabolic disease is a risk factor for diabetes and cardiovascular disease. Rats fed processed wheat bran had reductions in the factors that define metabolic disease, such as high cholesterol, high fasting glucose, insulin resistance, and excess body fat. These rats also ate less diet. Although the hormone results were complex and the interpretation challenging, overall, the changes in the satiety-related hormones were in the direction that would suggest that the processed wheat bran increased satiety and therefore may explain, in part, the decrease in food intake.

Figure 1. Plasma concentrations of ghrelin in the fasted and meal-fed states.

Bars represent the means ± SEM, n=12. Bars within a feeding state (fasted vs. fed) with different letters are significantly different (p<0.05).
Figure 2. Plasma concentrations of amylin in the fasted and meal-fed states.

Bars represent the means ± SEM, n=12. Bars within a feeding state (fasted vs. fed) with different letters are significantly different (p<0.05).

- Concentrations increased in obese groups
- Concentrations correlate with degree of adiposity

Figure 3. Plasma concentrations of PYY in the fasted and meal-fed states

Bars represent the means ± SEM, n=12. Bars within a feeding state (fasted vs. fed) with different letters are significantly different (p<0.05).

- Concentrations tended to increase after a meal
- Tendency for processed wheat bran to increase concentrations after meal