Dietary Rice Bran Decreases Plasma and Whole-Blood Taurine in Cats1,2

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EXPANDED ABSTRACT

KEY WORDS: • taurine • feline • rice bran • cats

Taurine is an amino-sulfonic acid that is required in the diet of cats. Although cats can synthesize a limited amount of taurine from cystine, they require dietary taurine to maintain a variety of important metabolic functions. Without adequate dietary supplementation, the amount of taurine lost in the feces as bile acids exceeds the amount of taurine that is synthesized. Deficiencies of taurine result in clinical diseases including feline central retinal degeneration and dilated cardiomyopathy (1,2). Despite the routine supplementation of commercial feline diets with taurine, cats continue to be diagnosed with taurine deficiency.

Cats fed canned foods require a higher quantity of taurine than those fed dry foods to prevent taurine deficiency resulting from alterations in the bioavailability of taurine attributed to the effects of processing (3,4). In addition to processing, both the fiber and fat content of canned feline diets may affect taurine metabolism through an alteration of intestinal bacteria and subsequent changes in the excretion of bile acids. Cats fed a standard canned diet showed significantly lower concentrations of plasma and whole-blood taurine, and excreted significantly higher concentrations of total and secondary bile acids compared to that of cats fed a dry diet that contained less soluble fiber, fat and one-third less taurine (5). This effect was attributed to differences in the intestinal microflora, secondary to the fat levels in the diet. Although supplementation of the standard canned diet with a soluble fiber source ( guar gum) at 2.5% dry matter (DM) did not result in significant changes in plasma or whole-blood taurine, or in the excretion of fecal bile acids, the researchers speculated that the level of soluble fiber was too low to cause an effect. Taurine depletion in both plasma and whole blood, and elevated fecal bile acid excretion in cats fed either canned heat-processed diets or heat-treated purified diets is reversed with the addition of antibiotics to the diets (6,7). A significant decrease in fecal cholytyraurine hydrolase activity (an enzyme produced by intestinal bacteria), and a significant decrease in total fecal bile acid excretion, which occurred with the addition of dietary antibiotics, resulted in the repletion of taurine in study cats within 3 wk of antibiotic treatment (6,7). Because cats conjugate bile acids exclusively with taurine, any dietary factors that increase the excretion of fecal bile acids will increase the dietary requirement for taurine.

Rice bran and whole rice products are sources of moderately soluble fiber, and contain relatively high amounts of fat. The fiber, fat and/or protein content of the rice bran may alter the excretion of bile acids, predisposing cats to the development of taurine deficiency (8,9). Taurine deficiency was documented in a group of 15 adult Newfoundland dogs that consumed commercial lambmeal and rice diets (10). Researchers at the University of Minnesota have also identified three dogs, all consuming commercial lamb and rice diets, that developed dilated cardiomyopathy and silica urolithiasis (11). In rats, the excretion of fecal bile acids is significantly increased when rice bran is fed at a concentration of 10% (DM) of the diet compared to supplementation with 10% (DM) wheat bran (12). A similar loss of taurine through fecal bile acids may occur in cats fed rice bran, and may increase their dietary requirement for taurine. Although rice products are common ingredients in commercial pet foods, no studies have reported the effect of full-fat rice bran on the metabolism of taurine in cats. The objectives of this study were to determine the effect of a purified diet containing 26% full-fat rice bran (DM) on whole blood and plasma taurine concentrations in young adult cats.

MATERIALS AND METHODS

The experimental protocol was approved by the Animal Use and Care Administrative Advisory Committee of the University of California, Davis.

Animals and their management

Sixteen, intact, male, domestic short-hair, specific-pathogen-free cats 20 to 22 wk of age, from the Feline Nutrition and Pet Care Center of the University of California, Davis were used. Cats were...
processed after the erythrocytes were lysed with two freeze-thaw cycles. Blood samples were then diluted 1:1 (v:v) with deionized water followed by deproteination with an equal volume of 0.24 mol/L sulfosalicylic acid. Taurine analysis on blood and plasma samples was performed using an amino acid analyzer (Model 121-MB amino acid analyzer; Beckman Instruments, Palo Alto, CA).

### Statistical analysis

Statistical analyses on plasma and whole-blood taurine were performed with a mixed model ANOVA with a Bonferroni adjustment using the SAS system (version 8.1; SAS Institute, Cary, NC) (15). Plasma taurine concentrations were log transformed to achieve a normal distribution. Analyses on mean food consumption was performed using SYSTAT (version 9.0; SPSS, Chicago, IL). Differences were considered significant at $P < 0.05$.

## RESULTS

Mean food consumption was not different between the RB and C group cats until wk 40 when a difference in food consumption was found. One cat in the RB group was removed from the study after developing acute renal failure 11 wk after the start of the project. The renal failure did not appear to be related to the diet treatment. No retinal or cardiac lesions were identified in any of the study animals. There was no significant difference in mean plasma or whole-blood taurine concentrations between the groups at the start of the study (Figs. 1 and 2). After 12 wk of the diet treatment, the mean plasma taurine concentration in the RB group was significantly lower than that in the control group ($P < 0.003$) (Fig. 1); after 6 wk of the diet treatment, the mean whole-blood taurine concentration in the RB group was significantly lower than that in the control group ($P < 0.003$) (Fig. 2). Mean plasma and whole-blood taurine concentrations continued to decline in the RB group and remained lower than that in the C group throughout the remainder of the study ($P < 0.0001$). Critically low levels of plasma and whole-blood taurine were measured in the RB group cats by wk 6 and wk 22, respectively.

## DISCUSSION

Young-adult male cats that consumed a purified diet containing 26% full-fat stabilized rice bran (DM) had lower plasma and...
whole-blood taurine than cats consuming a purified diet with 26% corn starch (DM). The decrease in plasma taurine in the C cats after wk 8 (32 ± 3 nmol/mL), followed by a subsequent increase by wk 12 (69 ± 7 nmol/mL) and plateau by wk 22 (51 ± 7 nmol/mL) was previously observed with purified diets containing 500 mg taurine/kg diet (16). Cats show an adaptive renal response to decreased dietary taurine by increasing the sodium-dependent transport of taurine across the proximal tubular epithelium. The control cats likely upregulated the renal transport of taurine after being changed from a diet containing 1.5 g/kg taurine (DM) to the diet containing 0.5 g/kg taurine (DM).

Although food consumption was not different between the RB and C group cats throughout most of the study, a difference in food intake was measured by wk 40 (RB: 44.1 g ± 1.1 vs. C: 55.1 g ± 3.5, respectively). We speculate that the difference was attributed to inaccurate measurements of food remnant weights. One C group cat spilled food throughout the cage, which was difficult to fully remove and likely resulted in a false increase in measured food consumption, whereas one of the RB cats urinated in his food bowl, which likely resulted in a false decrease in measured food intake. Cat weights did not change at wk 40, suggesting an adequate intake of energy. The difference in food consumption at wk 40 was not great enough to result in a significant decrease in taurine intake.

Cats have a dietary requirement for taurine as a result of a limited activity of cysteine dioxygenase and cysteinyl-tRNA-synthetase de-carboxylase, the enzymes required to convert cystine to taurine (17). In addition, cats conjugate bile acids only with taurine, even during periods of dietary taurine deficiency (18,19). Previous research has shown that taurine is not degraded by mammalian tissues, and that degradation occurs solely by intestinal bacteria (20). If taurine deficiency develops in cats fed diets with seemingly adequate taurine supplementation, then there may be an increased degradation of taurine by the intestinal bacteria, an increase in the loss of taurine in the urine or an increased loss of taurine-conjugated bile acids in the feces. We hypothesize that the addition of full-fat rice bran to the diet of cats either alters the excretion of fecal bile acids or changes the intestinal bacterial population, resulting in a greater fecal loss of taurine and a subsequent depletion of taurine in plasma and whole blood.

When either rice bran or whole rice is added to commercial food, it affects the fat, protein and fiber contents, which means that any of these components potentially could alter taurine metabolism. The component of the rice bran that causes a biologic effect related to bile acid metabolism has been postulated to be included in the fat content, rather than in the fiber (8). Compared to other fiber sources, rice bran has a relatively high percentage of fat (12–23% DM) (8). When full-fat rice bran is included in the diet, a total cholesterol-lowering effect is identified in mice, and a decrease in both total and LDL cholesterol is measured in humans (8,9). However, when rice bran has been defatted, and is used solely as an insoluble fiber source, no effect on cholesterol reduction has been documented (21). A significant increase in fecal bile acid excretion and an increased bacterial mass were measured in rats fed a diet with 10% rice bran (DM) compared to that of rats fed diets that contained 10% wheat bran (DM) (12). The indigestible protein content of the rice bran may also alter the intestinal bacterial population, resulting in an increased degradation of fecal bile acids and a greater loss of taurine in the feces, either as free taurine or as taurine-conjugated bile acids. In addition to the effect of the fat and protein content of rice bran, taurine deficiency in cats fed rice bran occurs if increased amounts of conjugated bile acids bind to the fiber component of the rice bran and are subsequently lost in the feces (12). Diet formulations with normally adequate taurine supplementation may actually be deficient in taurine if rice bran or whole rice is included as an ingredient.

Taurine was added to the control and rice bran purified diets at a level of 0.5 g/kg. This concentration has been previously shown to support maintenance in cats (22). The concentration of rice bran in this study was selected at 26% to determine whether there was an association between rice bran and taurine metabolism in cats. Although rice bran or whole rice products are included in commercial cat foods at levels between 5 and 20% diet (DM), this study shows that feline diets containing these materials may need a higher content of taurine than that in similar products without them. Future dose response studies are required to determine the quantitative relationship between rice bran content and taurine adequacy in feline diets.

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LITERATURE CITED