Public health nutrition for chronic disease control and prevention with rice bran and beans

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Abstract

Whole grains and dry beans demonstrate compelling chronic disease fighting properties, yet consumption of these staple foods remain extremely low. A growing community-academic partnership is conducting clinical trials for increased consumption in children to adults.

Our main objectives are to:

1) establish feasibility of increasing navy bean powder (NBP) and rice bran (RB) intake in children with elevated cholesterol levels (NCT01911390) and adults with a history of colorectal cancer (NCT01929122),

2) examine changes in overall dietary intakes with the addition of RB and/or NBP, and

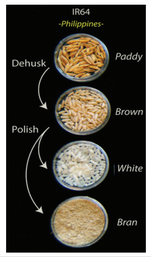
3) favorably modulate the blood and stool metabolome.

Meals and snacks were developed for inclusion of NBP and/or RB in amounts that equate to roughly 5-10% of total dietary intake. Participants completed a pilot placebo-controlled, randomized, single-blinded dietary intervention trial. They consumed study meals daily for 4 weeks and recorded 3-day dietary food logs each week. Blood and stool samples were collected at three time points for blood and stool metabolome, and stool microbiome analyses. Adding NBP or RB into foods provided 4-9% daily caloric intake with 80-100% intervention compliance. Dietary intake data at baseline confirms a western dietary pattern including low fiber, high sodium, and high fat intake. This dietary intervention significantly increased total dietary fiber intakes at 4-weeks ($p<0.05$). Adding NBP or RB into prepared meals represents an economically feasible and safe approach to achieve dietary intakes that may control or prevent chronic diseases. Our data suggest that NBP and RB are promising solutions that merit public health nutrition education and research attention.

Why rice bran and beans?

Figure 1. Staple foods like rice bran (derived from whole grain rice) and dry beans merit public health attention for chronic disease prevention, including cardiovascular disease colorectal cancer. (A) One rice variety at each stage of processing for the bran and (B) Health benefits attributed to eating dry beans

A.



B.

Study food development

Figure 2. A registered dietitian and certified chef developed seven meals and six snacks that included the addition of rice bran and/or navy bean powder.

Meals	Snacks
Baked Pasta Marinara	Banana Nut Muffins
Butternut Squash Soup	Blackberry Cobbler
Mexican Chicken Bake	Caraway Crackers
Pizza Margherita	Cranberry Apple Granola
Homemade Chili	Energy Date Bites
Tomato Basil Soup	Strawberry Pineapple Smoothie
Tuna Cheddar Casserole	

Table 1. Nutrient composition of one study snack across groups. Recipes were analyzed using NutritionistPro™ diet analysis software (Axxya Systems, Redmond, WA).

Snack Example: Banana Nut Muffin	Control	Navy Bean Powder	Rice Bran	Combined (Rice Bran & Navy Bean)
Calories (kcal)	250	260	253	256
Protein (g)	7	10	7	8
Carbohydrates (g)	42	43	39	42
Fat (g)	8	8	10	9
Saturated Fat (g)	2	2	3	3
Fiber (g)	3	7	6	6
Iron (mg)	2	2	4	3
Vitamin C (mg)	4	4	4	5
Folate (µg)	45	53	43	48
Potassium (mg)	269	736	458	598
Sodium (mg)	124	129	222	113

Healthy Hearts

Increasing rice bran and navy bean intake in children with hypercholesterolemia

Figure 3. Participant flow diagram

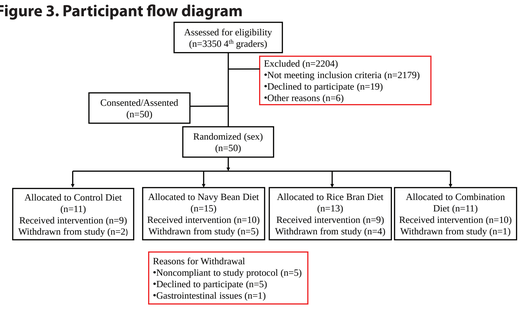


Table 2. Participant characteristics of study population at baseline and week 4

Characteristic	Control (n=9)		Navy Bean Powder (n=10)		Rice Bran (n=9)		Combination (n=10)	
	Baseline	Week 4	Baseline	Week 4	Baseline	Week 4	Baseline	Week 4
Age (years)	9.8 ± 1.0 (10)	n/a	10.2 ± 0.8 (10)	n/a	10.2 ± 0.7 (10)	n/a	10.0 ± 0.7 (10)	n/a
Sex								
Males (%)	5 (56%)	n/a	5 (50%)	n/a	4 (44%)	n/a	5 (50%)	n/a
Females (%)	4 (44%)		5 (50%)		5 (56%)		5 (50%)	
Weight category								
Underweight (%)	0 (0%)		0 (0%)		0 (0%)		0 (0%)	
Healthy Weight (%)	3 (33%)	n/a	5 (50%)	n/a	3 (33%)	n/a	5 (50%)	n/a
Overweight (%)	2 (23%)		3 (30%)		3 (33%)		2 (20%)	
Obese (%)	4 (44%)		2 (20%)		3 (33%)		3 (30%)	
Total Cholesterol (mg/dL)	166 ± 12.8 (169)	165± 19.8 (156)	178 ± 30.2 (171)	172± 32.9 (167)	167 ± 16 (170)	171 ± 18.3 (164)	169 ± 25.7 (167)	168±21.6 (173)
LDL (mg/dL)	103 ± 14.8 (107)	103 ± 22.0 (97)	110 ± 34.5 (96)	106 ± 34.5 (100)	104± 20.4 (106)	105 ± 23.0 (95)	106± 25.1 (100)	102 ± 16 (105)
HDL (mg/dL)	44 ± 6.8 (44)	42 ± 8.2 (41)[2]	47 ± 6.8 (48)	47 ± 4.5 (49)[2]	42 ± 3.6 (42)[2]	42 ± 6.4 (43)[2]	43 ± 9.0 (45)	42 ±7.2 (41)
Triglycerides (mg/dL)	100± 21.9 (104)	98 ± 18 (92)	106± 53 (86)	97 ± 41.5 (89)	104 ± 41.5 (104)	120 ± 45.0 (98)	104 ± 43.5 (114)	117 ± 37.9 (116)
Caloric intake (kcal)	1470 ± 381 (1438)	1799 ± 402 (1730)	1736 ± 287 (1690)	1864 ± 408 (1891)	1645 ± 385 (1606)	1624 ± 333 (1664)	1787± 432 (1851)	1773 ± 382 (1765)

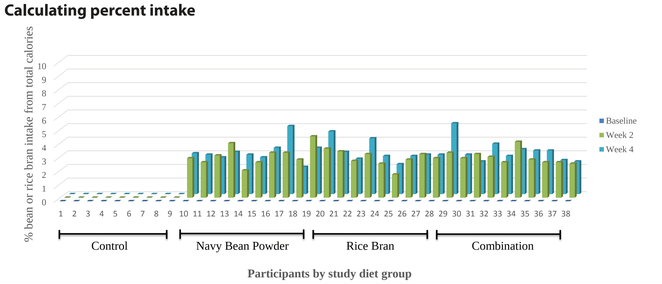
*Average ± standard deviation; ( ) = Median
[1]Significance ($p\leq0.05$) between study groups at Baseline
[2]Significance ($p\leq0.05$) between study groups at Week 4

Table 3. Macronutrient changes for study intervention from baseline to week 4

Nutrient	Control		Navy Bean Powder		Rice Bran		Combination	
	Baseline	Week 4	Baseline	Week 4	Baseline	Week 4	Baseline	Week 4
Calories (kcal)	1470 ± 381 (1438)	1799 ± 402 (1730)	1736 ± 287 (1690)	1864 ± 408 (1891)	1645 ± 385 (1606)	1624 ± 333 (1664)	1787± 432 (1851)	1773 ± 382 (1765)
Protein (g)	60 ± 17 (55)	70 ± 22 (59)	64 ± 15 (63)	70 ± 14 (69)	66 ± 21 (62)	64 ± 14 (62)	74 ± 23 (69)	68 ± 19 (68)
Fat (g)	54 ± 17 (54)	70 ± 15 (67)	64 ± 15 (62)	66 ± 11 (69)	60 ± 19 (56)	61 ± 15 (60)	69 ± 24 (68)	65 ± 21 (71)
Carbohydrate (g)	192 ± 58 (181)	230 ± 40 (218)	230 ± 40 (227)	258 ± 92 (264)	214 ± 44 (207)	217 ± 43 (222)	223 ± 41 (234)[3]	242 ± 46 (249)[3]
Fiber (g)	12 ± 6 (10)[1]	16 ± 6 (15)[2]	16 ± 8 (16)[3]	20 ± 5 (21)[2,3]	17 ± 3 (17)[1]	19 ± 7 (18)	17 ± 5 (17)[1,3]	22 ± 7 (23)[2,3]

Average ± standard deviation; ( ) = Median
[1]Significance ($p\leq0.05$) between study groups at Baseline
[2]Significance ($p\leq0.05$) between Baseline or Week 4 for each study group

Figure 4. Feasibility of increasing consumption of rice bran and navy bean powder: Calculating percent intake



BENEFIT

Beans/Bran Enriching Nutritional Eating For Intestinal health Trial

Figure 5. Participant flow diagram

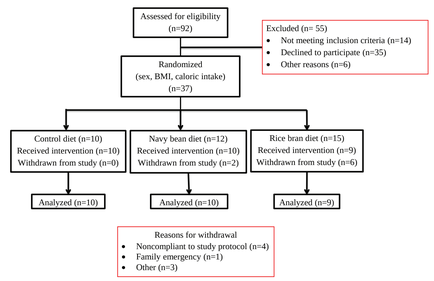


Table 4. Participant characteristics of study population at baseline and week 4

Characteristic	Control (n=10)		Navy Bean Powder (n=10)		Rice Bran (n=9)	
	Baseline	Week 4	Baseline	Week 4	Baseline	Week 4
Age (years)	64.4 ± 13.8 (65.5)	n/a	58.8 ± 11.9 (58)	n/a	61.7 ± 7.5 (63)	n/a
Sex						
Males (%) Females (%)	4 (40%) 6 (60%)	n/a	4 (40%) 6 (60%)	n/a	4 (44%) 5 (56%)	n/a
BMI (kg/m^2)	27.3 ± 3.3 (26.1)	27.1 ± 3.2 (26.1)	28.5 ± 7.9 (26.6)	28.5 ± 8.2 (26.8)	28.7 ± 5.2 (31.5)	28.6 ± 5.4 (30.5)
Total Cholesterol (mg/dL)	167 ± 44 (156)[1]	171 ± 38 (162)[2]	186 ± 40 (195)	187 ± 40 (197)	209 ± 45 (208)[1]	209 ± 43 (207)[2]
LDL (mg/dL)	87 ± 33 (72)[1]	90 ± 29 (85)[2]	109 ± 33 (112)	108 ± 36 (114)	124 ± 41 (127)[1]	125 ± 40 (124)[2]
HDL (mg/dL)	52 ± 19 (51)	52 ± 19 (50)	52 ± 11 (51)	51 ± 11 (51)	53 ± 15 (47)	52 ± 14 (49)
Triglycerides (mg/dL)	146 ± 68 (142)	147 ± 89 (128)	124 ± 81 (106)	143 ± 63 (134)	161 ± 101 (114)	164 ± 104 (135)
Caloric intake (kcal)	2096 ± 818 (1894)	2013 ± 481 (1820)	1919 ± 496 (1765)	1916 ± 389 (1883)	1945 ± 283 (1953)	2141 ± 519 (2006)

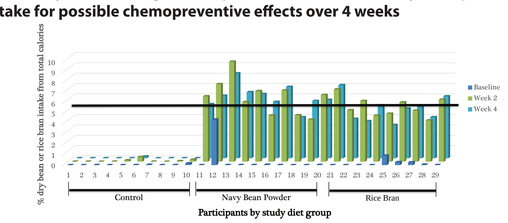
*Average ± standard deviation; ( ) = Median
[1]Significance ($p\leq0.05$) between study groups at Baseline
[2]Significance ($p\leq0.05$) between study groups at Week 4

Table 5. Selected macro- and micronutrient changes for study intervention over

Nutrient	Control			Navy Bean Powder			Rice Bran		
	Baseline[a]	Week 2	Week 4	Baseline[a]	Week 2	Week 4	Baseline[a]	Week 2	Week 4
Calories (kcal)	2,096 ± 818 (1,894)	2,065 ± 415 (2,106)	2,013 ± 481 (1,820)	1,919 ± 496 (1,765)	1,887 ± 515 (1,724)	1,916 ± 389 (1,882)	1,945 ± 283 (1,953)	1,882 ± 332 (1,929)	2,141 ± 519 (2,006)
Protein (g)	81 ± 32 (84)	84 ± 17 (88)	78 ± 19 (76)	73 ± 24 (70)	73 ± 22 (71)	74 ± 16 (82)	75 ± 9 (75)	83 ± 19 (82)	83 ± 21 (76)
Fat (g)	84 ± 42 (71)	84 ± 22 (83)[1]	78 ± 24 (77)	69 ± 25 (63)	65 ± 21 (65)[1]	66 ± 16 (69)	77 ± 14 (75)	77 ± 15 (73)	82 ± 30 (73)
Carbohydrates (g)	268 ± 114 (253)	247 ± 52 (233)	247 ± 60 (226)	251 ± 70 (229)	257 ± 65 (223)	266 ± 47 (254)	238 ± 57 (253)	227 ± 56 (215)[2]	283 ± 79 (245)[2]
Fiber (g)	30 ± 18 (22)	27 ± 5 (26)[1]	24 ± 7 (23)[1]	20 ± 10 (16)[2]	29 ± 7 (28)[2]	33 ± 7 (31)[1,2]	25 ± 8 (24)[2]	32 ± 6 (33)[1,2]	34 ± 7 (37)[1,2]
Iron (mg)	20 ± 14 (18)[1]	15 ± 4 (14)[1]	16 ± 5 (16)[1]	11 ± 5 (10)[1,2]	14 ± 3 (14)[1]	15 ± 4 (15)[1,2]	13 ± 4 (13)[2]	20 ± 3 (19)[1,2]	21 ± 6 (19)[1,2]
Magnesium (mg)	392 ± 226 (327)	342 ± 156 (326)[1]	346 ± 84 (341)[1]	298 ± 225 (236)[2]	365 ± 85 (350)[1,2]	411 ± 83 (394)[1,2]	305 ± 66 (296)[2]	534 ± 63 (537)[1,2]	521 ± 76 (513)[1,2]
Zinc (mg)	10 ± 4 (10)[1]	11 ± 3 (11)	10 ± 3 (10)	6 ± 2 (6)[1,2]	10 ± 4 (9)[2]	9 ± 2 (9)[2]	8 ± 2 (8)[2]	11 ± 4 (10)[2]	10 ± 3 (10)[2]
Vitamin B1 (Thiamin) (mg)	1.8 ± 1.4 (1.4)	1.2 ± 0.4 (1.2)[1,2]	1.5 ± 0.4 (1.7)[1,2]	1.0 ± 0.4 (1.1)	1.0 ± 0.2 (1.0)[1,2]	1.2 ± 0.2 (1.2)[1,2]	1.1 ± 0.2 (1.1)[2]	2.0 ± 0.3 (2.0)[1,2]	2.0 ± 0.3 (2.1)[1,2]
Vitamin B3 (Niacin) (mg)	18 ± 7 (17)	18 ± 6 (18)[1]	19 ± 6 (19)[1]	18 ± 12 (15)	16 ± 6 (16)[1]	18 ± 6 (17)[1]	18 ± 7 (18)[2]	28 ± 3 (28)[1,2]	27 ± 5 (26)[1,2]
Vitamin B6 (mg)	1.6 ± 0.7 (2.1)	1.6 ± 0.3 (1.5)[1]	1.7 ± 0.4 (1.7)[1]	1.3 ± 0.5 (1.3)[2]	1.4 ± 0.3 (1.4)[1]	1.5 ± 0.5 (1.5)[1,2]	1.4 ± 0.2 (1.4)[2]	2.8 ± 0.2 (2.7)[1,2]	2.9 ± 0.4 (2.7)[1,2]
Total Folate (µg)	409 ± 257 (413)	327 ± 112 (320)	388 ± 166 (344)	261 ± 129 (260)[2]	292 ± 69 (315)	335 ± 67 (336)[2]	278 ± 81 (255)[2]	361 ± 94 (352)[2]	355 ± 110 (310)
Alpha-Tocopherol (mg)	13.0 ± 15.9 (5.6)	6.8 ± 3.6 (5.2)[1]	6.8 ± 2.3 (7.6)[1]	6.2 ± 4.8 (3.2)	6.1 ± 2.3 (5.4)[1]	7.2 ± 3.5 (5.5)[1]	5.6 ± 1.8 (6.0)[2]	8.3 ± 1.5 (7.9)[1,2]	8.8 ± 1.8 (8.4)[1,2]

[a]data collected on n=8, 9, 8 for control, navy bean powder, and rice bran groups, respectively
[1]Significance ($p\leq0.05$) between study groups at Week 2 or Week 4
[2]Significance ($p\leq0.05$) between Baseline, Week 2 or Week 4 for each study group

Figure 6. Feasibility of increasing consumption of rice bran and navy bean powder: Calculating percent intake for possible chemopreventive effects over 4 weeks



Conclusions & Future Directions

These results suggest unique phytochemicals and nutrient profiles of rice bran and navy beans may modulate nutrient bioavailability and utilization.

1) **Established feasibility of increased navy bean powder and/or rice bran intake in children with hypercholesterolemia and colorectal cancer survivors.**

2) **Examined dietary intake and baseline and week 4 to understand effects of rice bran and/or navy bean powder on diet composition**

   a) Significantly increased dietary fiber consumption

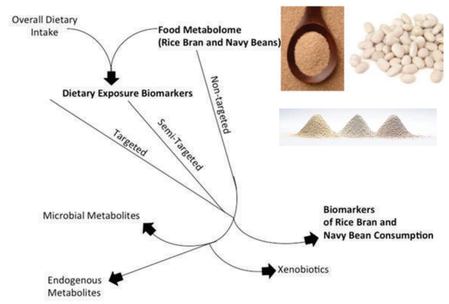
3) **Further evaluation to identify dietary biomarkers of rice bran and navy bean consumption**

4) **Additional research in a larger cohort to understand:**

   a) blood metabolome profiles on cardiometabolic effects in children with hypercholesterolemia

   b) tissue and stool metabolome profiles on inhibition of recurrence of adenomatous polyps for the prevention of colorectal cancer.

Figure 7. Identification of dietary biomarkers for rice bran and beans associated with precise levels of intake from Healthy Hearts and BENEFIT will be important next steps prior to implementation of larger scale public health interventions with these foods



Acknowledgments

The authors wish to thank Dr. Anna McClung from USDA Rice Research Unit, Gordon Gregory from ADM Edible Bean Specialties, Inc., as well as Kerry Gundlach, Brianna Nervig, Laura Dvorak, Adam Jaskowiak, Katie Hansen, and Meghan Willis for technical support. Funding was provided by the NIH 1R21CA161472, Dry Bean Health Research Group, Poudre Valley Health System Foundation, and University of Colorado Cancer Center Control and Prevention Division.

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