Ultra Rice Technology Research Summary Table
October 1, 2013

Study Code Number	Type of Research	Research Organization	Country/ Year	Study Objectives	Study Methods	Study Results	Population Studied/ Sample Size	Study Details	Publication Status	Reference
1	Safety	PATH Canada, Ottawa, Canada	Brazil, Canada 1999	To assess the optimal fortification level in Ultra Rice (UR) grains for alleviating vitamin A deficiency in young children, and to determine the upper limit of vitamin A based on the potential for toxicity to developing fetuses.	Theoretical assessment.	The maximum level of vitamin A required to meet normative requirements in children is 17 IU/g of cooked rice. This is well under the upper limit (30 IU/g) considered safe for consumption by pregnant women.	No clinical research conducted.	Formulation studied: Vitamin A (retinyl palmitate); Fortification level used:1600 IU vitamin A per gram Ultra Rice, blended with normal rice at a ratio of 1:200	Unpublished report prepared for PATH.	Berti PR, Fitzgerald S. "Advancement of Vitamin A Fortified Ultra Rice"
2	Safety	PATH Canada, Ontario, Canada	Brazil, Canada 2001	To assess circulating retinol levels after ingestion of rice fortified with Ultra Rice grains (comparing vitamin A level at 6 and 12 times the RDA per single meal).	Participants received either 10,000 IU or 20,000 IU vitamin A per 100 g uncooked rice. Serum retinol was measured at baseline and 3, 5, 7, and 24 hours after ingestion. Participants did not fast and had no dietary restrictions.	Serum retinol increased on average 25%–50% above baseline levels, and no individual increased more than 2.5 times baseline levels. Consumption of high levels of rice fortified with Ultra Rice grains (i.e., 600 g of uncooked rice = 30,000 IU in this study) is expected to provide vitamin A well below the levels suspected to be unsafe.	26 nonpregnant women in Toronto, Canada, and 25 nonpregnant women in Recife, Brazil.	Source of UR supply: Bon Dente International, Inc.; Duration of consumption: 1 meal; Formulation studied: Vitamin A (retinyl palmitate); Baseline biomarkers: Serum retinol	Unpublished report prepared for PATH.	Berti PR, Krasevec J, Flores H, Schauer C. "Total Serum Retinol Levels After Consumption of Vitamin A Fortified Ultra Rice"
3	Safety	Department of Nutrition, Center of Health Sciences, Federal University of Pernambuco, Recife, Brazil	Brazil 1994	To assess the potential for vitamin A toxicity after consumption of rice fortified with Ultra Rice grains.	Participant consumed 66,000 IU of vitamin A daily (i.e., more than 25 times the daily dose intended for the children).	No adverse effects were detected either by clinical examination or standard laboratory evaluation of serum retinol, glycemia, hemogram, blood urea, serum total protein, and serum lipids.	1 adult volunteer.	Source of UR supply: Bon Dente International, Inc.; Duration of consumption: 20 days; Formulation studied: Vitamin A (retinyl palmitate); Baseline biomarkers: Serum retinol, glycemia, hemogram, blood urea, serum total protein, serum lipids	Journal of Food Science, 1994;59(2):371-372,377	Flores H, Guerra NB, Cavalcanti ACA, Campos FACS, Azevedo MCNA, Silva MBM. "Bioavailability of Vitamin A in a synthetic rice premix"
4	Stability	Department of Food Technology, Iowa State University, Ames, Iowa, USA	United States 1989	To assess the effect of two different vitamin A fortificants and different antioxidants on the stability of Ultra Rice grains.	Analyze rinse resistance, cooking stability, and shelf life using an accelerated storage stability study.	Ultra Rice formulations prepared with retinyl palmitate 250 SD and higher antioxidant levels showed a more rinse-stable product with longer shelf life. Minimizing heat and oxygen exposure during production and storage would lengthen shelf life.	No clinical research conducted.	Source of UR supply: Bon Dente International, Inc.; Duration of storage study: 12 weeks; Formulation studied: Vitamin A	Unpublished study supported by U.S. Department of Agriculture, Office of International Cooperation and Development, and the U.S. Agency for International Development, Bureau for Science and Technology, Office of Nutrition	Murphy PA, Fratzke A, Hauck C, O' Connor K. "Fortification of Ultra Rice with Vitamin A"
5	Stability	Department of Food Science & Human Nutrition, Iowa State University, Ames, Iowa, USA; Minnesota Valley Testing Laboratories, New Ulm, Minnesota, USA	United States 1992	To assess the effect of different formulation ingredients on the stability of Ultra Rice grains.	Analyze rinse resistance, cooking stability, and shelf life using an accelerated storage stability study.	Ascorbate was critical to maintain or improve stability at high humidity. Combinations of more saturated oils and multiple antioxidants increased vitamin A stability.	No clinical research conducted.	Source of UR supply: Bon Dente International, Inc.; Duration of storage study: Not provided; Formulation studied: Vitamin A (retinyl palmitate)	Journal of Food Science, 1992;57(2):437-439	Murphy PA, Smith B, Hauck C, O' Connor K. "Stabilization of Vitamin A in a synthetic rice premix"
3	Stability	Department of Nutrition, Center of Health Sciences, Federal University of Pernambuco, Recife, Brazil	Brazil 1994	To assess the nutrient retention of Ultra Rice prepared with all-trans-retinyl-palmitate during storage and to study the influence of cooking on the vitamin A content of Ultra Rice.	Samples tested for stability were stored out of direct sunlight at about 26°C and analyzed for vitamin A at 4 intervals over a six-month period. Cooked samples were boiled ~5 min followed by 20-25 min under low heat.	A six-month stability study showed initial vitamin A losses of about 25% after which the values stabilized. The loss of vitamin A from 70 samples during normal cooking was 25.9+ 9.1%.	No clinical research conducted.	Source of UR supply: Bon Dente International, Inc.; Duration of storage study: 180 days; Formulation studied: Vitamin A (retinyl palmitate)	Journal of Food Science, 1994;59(2):371-372,377	Flores H, Guerra NB, Cavalcanti ACA, Campos FACS, Azevedo MCNA, Silva MBM. "Bioavailability of Vitamin A in a synthetic rice premix"

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6	Stability	Department of Food Science & Human Nutrition, Iowa State University, Ames, Iowa, USA	United States 1996	To simulate the effect of tropical temperature and humidity to assess the stability of Ultra Rice grains, including formulations combining both vitamin A and iron.	Analyze rinse resistance, cooking stability, and shelf life using an accelerated storage stability study.	The type of antioxidants and lipids used in the formulation were significant factors in the stability of vitamin A. Co-fortification of vitamin A and iron was not successful due to discoloration and oxidation of vitamin A.	No clinical research conducted.	Source of UR supply: Bon Dente International, Inc.; Duration of storage study: Not provided; Formulation studied: Vitamin A (retinyl palmitate) only; vitamin A and iron	Food Technology, 1996:69-74	Murphy PA. "Technology of vitamin A fortification of foods in developing countries"
7	Stability	Department of Food Science and Technology, University of Georgia, Athens, Georgia, USA; PATH, Seattle, Washington, USA	United States 2000	To test the stability of vitamin A in Ultra Rice grains during cooking and after 6 months storage.	Analyze rinse resistance, cooking stability, and shelf life using an accelerated storage stability study.	No significant difference in vitamin A retention between 3 cooking methods. The shelf life stability of vitamin A was affected much more by temperature than variation of relative humidity. Stability at 23° C was 85%, this was significantly reduced when stored at 35° C. No significant difference in stability was detected between 23° C and 0° C under nitrogen. No significant difference in stability when stored at 55% compared to 80% relative humidity.	No clinical research conducted.	Source of UR supply: Bon Dente International, Inc.; Duration of storage study: 6 months; Formulation studied: Vitamin A (retinyl palmitate)	Journal of Food Science, 2000;65:915-919	Lee J, Hamer ML, Eitenmiller RR. "Stability of retinyl palmitate during cooking and storing rice fortified with Ultra Rice fortification technology"
8	Stability	Philippines National Food Authority (NFA), Manila, Philippines	Philippines 2002	To determine the retention of iron after washing and cooking iron fortified rice, and to determine the effect of Ultra Rice grains on the color and flavor of cooked fortified rice.	Analyze rinse resistance and cooking stability.	Iron retention of cooked fortified rice varied depending on the blend ratio. Fortified rice made from Ultra Rice grains had similar color and flavor and better iron retention than the iron rice-premix made by NFA.	No clinical research conducted.	Source of UR supply: Bon Dente International, Inc.; Duration of storage study: No storage study conducted; Formulation studied: Iron (ferrous sulfate)	Unpublished report.	Philippines National Food Authority (NFA), Food Development Center. "Iron Retention of Ultra Rice Premix in the Iron Fortified Cooked Rice." Manila, Philippines: NFA; 2002
9	Stability	Southern Regional Research Center, Agricultural Research Service, United States Department of Agriculture; New Orleans, Louisiana, USA	United States 2000	To determine how differing sources and amounts of iron fortificant affect the oxidation properties of rice.	Product stability was determined by gas chromatographic analysis of lipid oxidation products. The storage variables included temperature and packaging.	Rice fortified with elemental iron alone or with multiple fortificants had better storage characteristics than that fortified with ferrous sulfate alone.	No clinical research conducted.	Source of UR supply: Bon Dente International, Inc.; Duration of storage study: 6 months; Formulations studied: Iron (ferrous sulfate or elemental iron), thiamin (thiamin mononitrate), folic acid and zinc (zinc oxide)	Cereal Chemistry. 2004;81:384-388. Based on research done in 2000.	Bett-Garber KL, Champagne ET, Ingram DA, Grimm CC. "Impact of iron source and concentration on rice flavor using a simulated rice kernel micronutrient delivery system"
10	Stability	Food BioTek Corp., Toronto, Canada	Canada 2003	To review, test, and reformulate the antioxidant components of the Ultra Rice formula to improve stability and meet international food standards.	Twenty formulations were tested, including 4 different vitamin A powders and 10 different antioxidants. Stability was analyzed under varying temperature and relative humidity conditions.	The best formulations retained nearly 80% of added vitamin A even after 24 weeks at 45°C and 60% humidity. This was better and cheaper than the original Ultra Rice formulation and included only Codex Alimentarius-compliant ingredients.	No clinical research conducted.	Source of UR supply: University of Toronto; Duration of storage study: 6 months; Formulation studied: Vitamin A (retinyl palmitate)	Unpublished report prepared for PATH.	"Antioxidant Systems for the Preservation of Vitamin A in Ultra Rice"
11	Stability	Medallion Laboratories, Minneapolis, Minnesota, USA	Colombia, United States 2004	A storage study was conducted to determine the stability of the original vitamin A premix over time and to assess whether the micronutrient overages used for production were adequate.	Samples from a single production lot were separated into two different batches—one stored frozen and the second stored at ambient conditions. Over a period of 9 months, nutrient levels from both the frozen and ambient samples were analyzed and compared.	Micronutrient levels varied depending on whether the samples were stored under frozen or ambient conditions. Zinc is stable regardless of storage conditions. Vitamin E is stable for 9 months if the premix is frozen, but begins to oxidize after about 4 months under ambient conditions. Losses of folic acid were comparable under both storage conditions. Vitamin A was very unstable, with only 30% remaining after one month storage under ambient conditions. Thiamin results were inconclusive.	No clinical research conducted.	Source of UR supply: Union de Arroceros, S.A.; Duration of storage study: 9 months; Formulation studied: Vitamin A (retinyl palmitate), vitamin E (d-l alpha tocopherol), thiamin (thiamin mononitrate), folic acid, and zinc (zinc oxide)	Unpublished report prepared for PATH.	Rief D. "Comparative Stability Study Using Colombian Fortified Premix"
12	Stability	Food BioTek Corp., Toronto, Canada	Canada 2005	To expand on earlier research to develop an Ultra Rice formulation incorporating iron, zinc, and multiple B vitamins that maintains its color and iron bioavailability, as well as most of its vitamin B activity, over the normal shelf life of Ultra Rice.	Sixteen different formulations were made using 4 different iron compounds and 4 different antioxidant combinations. Stability studies were conducted at varying temperature and relative humidity conditions. Samples were examined each 6 to 8 weeks and analyzed for micronutrient content, color, and rancidity.	It is feasible to produce an Ultra Rice premix with a good shelf life combining several B vitamins, iron, and zinc with good micronutrient stability. The current Ultra Rice formulation possesses good micronutrient stability and undergoes minimal changes in color and flavor, even under harsh environmental conditions, for periods up to 6 months.	No clinical research conducted.	Source of UR supply: University of Toronto; Duration of storage study: 6 months; Formulation studied: Iron (ferric pyrophosphate, ferrous fumarate), thiamin (thiamin mononitrate), folic acid, niacin (niacinamide) and zinc (zinc oxide)	Li Y, Diosady LL, Jankowski S. 2006. Effect of iron compounds on the storage stability of multiple-fortified Ultra Rice. International Journal of Food Science and Technology, Online Early Articles. Published article online: June 21, 2007.	Diosady L, Li OY. "Final report on Phase II report on the development and stability testing of an iron-containing formulation of Ultra Rice"

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13	Stability	Food BioTek Corp., Toronto, Canada	Canada 2008	To investigate the stability of thiamin (vitamin B1) and its effects on organoleptic properties in Ultra Rice in the presence of encapsulated ferrous fumarate.	Three formulas were produced containing ferrous fumarate, thiamin, and three different antioxidant combinations. Stability studies were conducted at varying temperature and relative humidity conditions with measurements at 6,12, and 20 weeks.	This study demonstrated the feasibility of incorporating encapsulated ferrous fumarate in a stable Ultra Rice formulation containing vitamin B1. When incorporated into simulated rice grains, its bioavailability and stability were not affected.	No clinical research conducted.	Source of UR supply: University of Toronto; Duration of storage: 20 weeks; Formulation studied: Iron (ferrous fumarate), thiamin (thiamin mononitrate)	International Journal of Food Sciences and Nutrition. 2008;59(1):24-33	Li Y, Diosady L, Jankowski S. "Stability of vitamin B1 in Ultra Rice in the presence of encapsulated ferrous fumarate"
3	Bioavailability	Department of Nutrition, Center of Health Sciences, Federal University of Pernambuco, Recife, Brazil	Brazil 1994	To assess the bioavailability of vitamin A in Ultra Rice grains using the relative dose response test.	A relative dose response test was conducted measuring pre- and post-challenge dose serum retinol values to indirectly show the status of vitamin A reserves in the liver.	The fact that deficient subjects showed a serum retinol reaction in a 5-hour period indicates that the retinol in Ultra Rice was absorbed and transported.	83 children aged 11-77 months.	Source of UR supply: Bon Dente International, Inc.; Duration of consumption: 1 meal; Formulation studied: Vitamin A (retinyl palmitate); Baseline biomarkers: Serum retinol	Journal of Food Science 1994;59(2):371-372,377	Flores H, Guerra NB, Cavalcanti ACA, Campos FACS, Azevedo MCNA, Silva MBM. "Bioavailability of Vitamin A in a synthetic rice premix"
14	Bioavailability	Human Nutrition Research Center, Agricultural Research Center, United States Department of Agriculture, Grand Forks, North Dakota, USA	United States 2003	To determine the relative bioavailability (RBV) of iron from four ferric pyrophosphate compounds using the AOAC Rat Hemoglobin Repletion Method.	Nineteen different dietary treatment groups were evaluated. The rats were weighed and their Hb levels were measured, both following a low-iron depletion diet of 24 days, and after consuming an iron-fortified diet for 14 days. Hb repletion data were analyzed by the slope ratio assay method, expressing bioavailability relative to ferrous sulfate.	SunActive® iron was more bioavailable than the other ferric pyrophosphate compounds for correcting the iron deficiency of anemic rats (92%–94% RBV). The bioavailability of the other ferric pyrophosphate compounds was approximately 70%–75% RBV.	171 weanling male Sprague-Dawley rats (approx: 83 g) were randomized into three cohorts (57 rats per cohort) and given 24 days of an iron depletion diet followed by a 14-day repletion period.	Duration of consumption:14 days after 24 day depletion period; Formulation studied: Iron (ferric pyrophosphate and ferrous sulfate); Baseline biomarkers: Blood hemoglobin (Hb)	Unpublished report prepared for PATH.	Hunt JR. "Assessment of the Bioavailability of Ferric Pyrophosphate in Ultra Rice Using the AOAC Rat Hemoglobin Repletion Method"
15	Effectiveness	Department of Nutrition, Center of Health Sciences, Federal University of Pernambuco, Recife, Brazil	Brazil 1994	To assess the effectiveness of including vitamin A- fortified rice in the normal food given to preschool children.	Fasting blood samples were taken at baseline, and then at 4-month intervals, to determine serum retinol. At the baseline and 12-month evaluations, the children underwent a Relative Dose Response test. Anthropometry, clinical vitamin A status, morbidity, and dietary evaluation were assessed.	Serum retinol values continually increased at each of the four monthly measurements up to 1 year of age. After a full year, no children were deficient compared to 44% at baseline.	415 children aged 7.7-83.6 months, from 6 randomly selected municipal day care centers.	Source of UR supply: Bon Dente International, Inc.; Duration of consumption: 12 months; Formulation studied: Vitamin A (retinyl palmitate); Baseline biomarkers: Serum retinol	Unpublished report.	Flores H, Campos FACs, Silva MBM, Lins MH, Barretto E, Albuquerque S. "Efficacy of Vitamin A Enriched Rice in the Treatment and Prevention of Vitamin A Deficiency"
16	Effectiveness	Program in International Nutrition, Department of Nutrition, University of California-Davis, USA; Nepali Technical Assistance Group, Kathmandu, Nepal	Nepal, United States 2000-2003	To assess the effect of daily consumption of small doses of vitamin A from various natural food sources, vitamin A-fortified rice, and retinyl palmitate supplement for treating vitamin A deficiency and improving plasma retinol concentrations in night-blind pregnant Nepali women.	Night-blind women were randomly assigned to 1 of 6 treatment groups to receive 6 d/wk for 6 wks either 850 mcg RE/d as retinyl palmitate, vitamin A fortified rice, goat liver, GLV, carrots or 2000 mcg RE/d as a capsule. Plasma concentrations of retinol, carotenoids, tocopherols, ferritin, zinc, Hb, and C-reactive protein were measured as well as anthropometry taken before and after the intervention period. At weekly visits, frequency of consuming vitamin A rich foods, and dark adaptation was assessed by pupillary response threshold.	In night-blind women, the mean pupillary response threshold (PT) improved significantly in response to all interventions (liver, greens, carrots, fortified rice, high-dose vitamin A, low-dose vitamin A). Only 2 cases of night-blindness remained at endline, both in the carrot group. Improvement in dark adaptation was greatest in the liver group; PT improvement in the liver group was significantly better than the fortified rice group. Final mean plasma retinol concentration was highest in the liver group and significantly greater than all other groups except the high-dose vitamin A group; the high-dose vitamin A group had significantly greater levels than the carrots, greens, and low-dose vitamin A groups but not the fortified rice group.	348 pregnant nightblind Nepali women.	Source of UR supply: Bon Dente International, Inc.; Duration of consumption: 6 weeks; Formulation studied: Vitamin A; Baseline biomarkers: Pupillary response, plasma retinol	American Journal of Clinical Nutrition, 2005;81:461-1. Study initiated in 2000; completed in 2003.	Haskell MJ, Pandey P, Graham JM, Shrestha RK, Brown KH. "Recovery from impaired dark adaptation in night-blind pregnant Nepali women who receive small daily doses of vitamin A as amaranth leaves, carrots, goat liver, vitamin A-fortified rice or retinyl palmitate"
17	Effectiveness	Centro de Investigacion en Nutricion y Salud; PATH	Mexico 2005	To test the efficacy of rice fortified with microencapsulated, micronized pyrophosphate (Sun Active Fe) to improve the iron status of women in Mexico consuming 20 mg iron per day.	A randomized, blinded, placebo-controlled feeding trial, women were recruited from 6 factories and received a daily portion of cooked rice 5 days per week for a period of 6 months. At baseline and endline, venous blood was collected for biochemical analysis. At midline, capillary blood obtained by the finger prick method was analyzed for Hb and urine for pregnancy.	The absolute change in prevalence between the iron-fortified group and the control group was 10.3% for anemia and 15.1% for iron deficiency. An absolute reduction of 6.2% in iron deficiency anemia may be attributed to the intervention.	180 nonpregnant non-lactating women aged 18-49 years.	Source of UR supply: University of Toronto; Duration of consumption: 6 months Formula studied: Iron (ferric pyrophosphate) Baseline biomarkers: Plasma ferritin, transferrin receptor, C-reactive protein	Food and Nutrition Bulletin. 2008; 29(2):140-149.	Hotz C, Porcayo M, Onofre G, Garcia-Guerra A, Elliott T, Jankowski S, Greiner T. "Efficacy of iron-fortified Ultra Rice in improving the iron status of women in Mexico"

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18	Effectiveness	National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, India	India 2007-2008	To assess the impact of consuming rice fortified with iron, Ultra Rice, on the iron status of children in a mid-day meal program in India.	A double-blind, 8-mo, placebo-controlled trial was conducted in 5-11-yr-old schoolchildren (n = 140) who were randomly assigned to receive either an FR-MDM (fortified rice-Midday Meal) or an UFR-MDM (unfortified rice-Midday Meal). Iron-Ultra Rice containing 9.6 mg Fe/g was blended with natural rice using a 1.6:98.4 blend ratio. Average consumption amounts of the MDM, height, weight, hemoglobin, ferritin, and C-reactive protein were measured at baseline and 8 mo.	The in vitro iron availability from FR-MDM (1.3%) was significantly ($P < 0.05$) lower than that from UFR-MDM (3.3%). Providing FR-MDM to the schoolchildren for 8 mo improved ferritin significantly ($P < 0.001$), by 8.2 ± 2.10 µg/L. However, the increase in hemoglobin was similar between groups (FR: 0.99 ± 0.10 g/dL; UFR: 1.15 ± 0.10 g/dL), suggesting that other factors beyond additional iron intake had a large influence on hemoglobin concentration. The prevalence of iron deficiency decreased significantly ($P < 0.05$) in the FR group (33–14%) and increased marginally in the UFR group (31–37%). The prevalence of anemia and iron deficiency anemia was similar between groups at baseline and at 8 mo. Conclusion: Regular intake of 19 mg iron/d in MFPP supplied through extruded rice kernels improves iron stores and reduces iron deficiency among schoolchildren in India.	140 children aged 5-11 years with hemoglobin levels >7 g/dl and regularly participating in a mid-day meal program.	Source of UR supply: Camil Alimentos, S.A.; Duration of consumption: 166 days; Formulation studied: Iron (ferric pyrophosphate, 3 um); Baseline biomarkers: Hemoglobin, serum ferritin, C-reactive protein	American Journal of Clinical Nutrition, doi: 10.3945/ajcn.110.007179.	Radhika MS, Nair KM, Kumar RH, et al. "Micronized ferric pyrophosphate supplied through extruded rice kernels improves body iron stores in children: a double-blind, randomized, placebo-controlled midday meal feeding trial in Indian schoolchildren"
19	Effectiveness	Department of Pediatrics, School of Medicine, Federal University of Minas Gerais, Minas Gerais, Belo Horizonte, Brazil	Brazil 2007	To compare the effectiveness of iron-fortified rice with iron drops in improving young child iron status among families in a Southeast region of Brazil.	A randomized, double-blinded effectiveness trial comparing biochemical indicators after consuming iron-fortified Ultra Rice 6 days per week or receiving iron drops 3 times per week. Subjects were evaluated at baseline and after a 5-month period.	There was a significant improvement in iron status in both groups; however, the shift from severe deficiency to moderate/low deficiency of hemoglobin levels was significantly greater in the group receiving iron fortified rice. The findings suggest that providing rice fortified with iron Ultra Rice is an effective strategy for improving iron status in children.	175 children aged 6-24 months with a hemoglobin concentration between 8.0 and 11.0 g/dl.	Source of UR supply: Camil Alimentos, S.A.; Duration of consumption: 5 months; Formulation studied: Iron (ferric pyrophosphate, 3 um); Baseline biomarkers: Hemoglobin	Journal of Nutriion, 2009; 140;49–53.	Beinner MA, et al. "Iron-Fortified Rice Is As Efficacious As Supplemental Iron Drops in Infants and Young Children"
20	Effectiveness	Federal University of Ceará, Sobral Unit, Sobral, Brazil	Brazil 2010	To evaluate the impact of consuming rice fortified with iron, Ultra Rice, on hemoglobin and anemia in infants from public day centers in Brazil.	A cluster-randomized, placebo-controlled double-blind effectiveness trial to compare iron-fortified rice with standard rice in infants from two randomly chosen public child day care centers in the City of Morrinhos, Brazil. The trial and control schools were provided Ultra Rice weekly for 18 weeks. The intervention group received individual portions of fortified rice (50 g) provided 56.4 mg elemental/Fe. Subjects received two biochemical evaluations in the form of finger prick blood samples that were used to determine hemoglobin concentrations before and after the 18 week study period.	Iron-fortified rice was effective in increasing hemoglobin levels and reducing anemia in infants. Anemia prevalence reduced significantly in the intervention group, with no significant reduction in the control group. For every 7 infants that were enrolled in the intervention 1 recovered hemoglobin levels to achieve non-anemic status, which represents a positive outcome in an intervention that submitted infants to no discomfort whatsoever. The findings demonstrated that rice is a suitable vehicle to deliver iron to anemic populations which have rice as a staple in their diet.	188 children aged 10-23 months.	Source of UR supply: Adorella Alimentos, Brazil; Duration of consumption:18 weeks; Formulation studied:Iron (ferric pyrophosphate, 3 um); zinc, thiamine, folic acid; Baseline biomarkers: Hemoglobin	Journal of Tropical Pediatrics, 2012. Based on research done in 2010	F.P.N. Arcanjo, et al. "Use of Iron-Fortified Rice Reduces Anemia in Infants"
3	Acceptability, Sensory	Department of Nutrition, Center of Health Sciences, Federal University of Pernambuco, Recife, Brazil	Brazil 1994	To test the acceptability of rice fortified with Ultra Rice grains.	Panelists responded to "difference" and "preference" questionnaires comparing normal rice and rice fortified with Ultra Rice grains using the Lamond method (1970).	"Difference" testing showed no significant difference between the taste of normal and enriched rice. The sensory properties of enriched rice were rated higher for enriched rice based on "preference" testing.	14 panelists participated in the sensory evaluation.	Source of UR supply: Bon Dente International, Inc.; Formulation studied: Vitamin A (retinyl palmitate)	Journal of Food Science, 1994;59(2):371-372,377.	Flores H, Guerra NB, Cavalcanti ACA, Campos FACS, Azevedo MCNA, Silva MBM. "Bioavailability of vitamin A in a synthetic rice premix"
9	Acceptability, Sensory	Southern Regional Research Center, Agricultural Research Service, United States Department of Agriculture, New Orleans, Louisiana, USA	United States 2000	To determine how differing sources of iron impact the effect of Ultra Rice on the flavor of milled rice, as determined by descriptive analysis.	Flavor was determined by smelling and evaluation in the mouth by trained panelists to assess 12 unique flavor attributes.	The effects of iron fortification on flavor were dependent on iron source and concentration.	12 panelists participated in the sensory evaluation.	Source of UR supply: Bon Dente International, Inc.; Formulation studied: Iron (ferrous sulfate, elemental iron) only and iron, thiamin (thiamin mononitrate), folic acid, and zinc (zinc oxide)	Cereal Chemistry. 2004;81:384-388. Based on research done in 2000.	Bett Garber KL, Champagne ET, Ingram DA, Grimm CC. "Impact on iron source and concentration on rice flavor using a simulated rice kernel micronutrient delivery system"

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18	Acceptability, Sensory	National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, India	India 2006	To test the organoleptic properties of rice fortified with iron Ultra Rice.	Participants assessed color, appearance, texture, smell, taste, and overall acceptability of cooked iron-fortified or unfortified rice using a 5-point hedonic scale. The children were randomly assigned to 2 groups and received either fortified or non-fortified rice as part of the mid-day meal program.	The overall acceptability of cooked fortified rice was 86% vs. 97% for unfortified rice. The difference in scores was not statistically significant, suggesting that both types of rice were well accepted by the children. (Note: The NIN study was initiated in 2006 and this acceptability component was completed in the initial trial. The efficacy componenet was done again in 2007-08, the results of which are outlined above.)	134 children aged 8-11 years old participating in an Indian mid-day meal program	Source of UR supply: Camil Alimentos, S.A.; Formulation studied: Iron (ferric pyrophosphate, 3 um)	American Journal of Clinical Nutrition, doi: 10.3945/ajcn.110.007179.	Radhika MS, Nair KM, Kumar RH, et al. "Micronized ferric pyrophosphate supplied through extruded rice kernels improves body iron stores in children: a double-blind, randomized, placebo-controlled midday meal feeding trial in Indian schoolchildren"
19	Acceptability, Sensory	Department of Pediatrics, School of Medicine, Federal University of Minas Gerais, Minas Gerais, Belo Horizonte, Brazil	Brazil 2007	To examine sensory differences between conventional rice and rice fortified with iron Ultra Rice and determine consumer acceptance.	Differences between both types of rice were analyzed using the Duo-Trio Test. The acceptance test evaluated general rice appearance, color, aroma, and taste using a 7-point hedonic scale with extremes ranging from really disliked to really liked.	There were no significant differences between the analyzed samples of conventional rice and iron Ultra Rice-fortified rice. The iron did not alter the rice sensory characteristics and the fortified rice was well accepted.	37 non-trained subjects assessed the difference between samples; 43 subjects analyzed the fortified rice for acceptance.	Source of UR supply: Camil Alimentos, S.A.; Formulation studied: Iron (ferric pyrophosphate, 3 um)	Journal of Nutriion, 2009; 140;49–53.	Beinner MA, et al. "Iron-Fortified Rice Is As Efficacious As Supplemental Iron Drops in Infants and Young Children"
21	Acceptability, Sensory	Indian Market Research Bureau International (IMRB), New Delhi, India	India 2003	To gauge the organoleptic acceptance of Ultra Rice fortified with ferrous sulfate and the sensitivity of potential target segments.	6 different samples of fortified rice were presented to consumers in a "blind," rotating order. Consumers ranked each sample on a five-point scale on smell, taste, aftertaste, similarity to normal rice, and overall liking.	Consumers were generally unable to sense any difference between fortified rice and regular rice and liked them equally well, although small percentages did not like the grayish color or reported an aftertaste.	600 consumers were assessed for the evaluation.	Source of UR supply: Bon Dente International, Inc.; Formulation studied: Iron (ferrous sulfate), zinc (zinc oxide), thiamin (thiamin mononitrate), and folic acid	Unpublished report prepared for PATH.	IMRB. "Potential Introduction of Ultra Rice in India: Complete Market Assessment"
22	Acceptability, Sensory	Consultor Apoyo, Quito, Ecuador	Ecuador 2003	To evaluate consumer acceptance and preference of regular rice and rice fortified with either sodium iron EDTA or ferric pyrophosphate using Ultra Rice grains.	Consumers assessed both raw and cooked rice to evaluate appearance, taste, and aroma, and to evaluate the general concept of fortified rice and intent to purchase.	In general, regular rice was preferred over fortified rice, and samples containing ferric pyrophosphate were favored over those fortified with sodium iron EDTA. The concept of fortified rice was considered to be important among those surveyed, and respondents said they would buy it if available (4.3 on a 5-point "intent to purchase" scale).	419 participants were assessed for the evaluation.	Source of UR supply: Bon Dente International, Inc.; Formulation studied: Iron (ferric pyrophosphate or sodium iron EDTA)	Unpublished report prepared for PATH.	Consultor Apoyo. "Ultra Rice Organoleptic Tests in Ecuador"
23	Acceptability, Sensory	Institut de Recherche pour le Developpement (IRD), Marseille, France	Cambodia 2010	To assess acceptability of fortified rice among mothers, teachers, directors, and students.	Kitchen cooks received training from PATH on the proper blending procedure prior to the start of the pilot. Samples were collected at 3 of the 7 pilot schools. Each 400g sample was analyzed for iron and zinc content by Embrapa laboratories in Dourados - samples were ashed, the resulting ash was further homogonized before taking sub-samples for measurement of the micronutrient content.	62% of teachers and 85% of mothers correctly identified the cooked fortified rice (both P<0.001). Normal and fortified rice were scored similarly for color, smell, appearance, stickiness, or hardness by teachers and partners (P>0.05). School children scored fortified rice slightly better than normal rice for taste and smell.	2,000 school children.	Source of UR supply: Camil Alimentos, S.A.; Duration of consumption: XX days Formulation studied: Iron (ferric pyrophosphate, 3 um); zinc, thiamine, folic acid	Unpublished report.	Wieringa F. "UM-204 Prevention of Malnutrition." Presentation at the National Insitute of Nutrition in Hanoi. IRD; 2010.

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24	Acceptability, Sensory	National Institute of Nutrition (NIN), Hanoi, Vietnam	Vietnam 2010	To examine the factors affecting the intention/decision to buy fortified rice.	Cross-sectional study in 2 communes in 2 districts. ***Sensory test description:*** Each test taker received 3 different bowls of rice, of which 2 bowls were similar (also called repeated sample products). These 2 bowls contained either normal rice or fortified rice. The 3rd bowl contained either fortified rice or normal rice respectively. A bowl starting with an odd digit was fortified rice and a bowl starting with an even digit was normal rice. ***Predilection test*** : 135 subjects tried fortified rice and were then asked to rank it on a scale from "extremely disliked" to "extremely liked."	There is a significantly different sensory between fortified rice and normal rice after cooking. There is no difference between Ultra Rice and NutriRice. A predilection test showed the attitude of women toward fortified rice is quite good (negative 7.8%, neutral 34.3%, positive 60.84%). Women's knowledge of iron, vitamin A, folic acid, and micronutrients is very poor although information about these micronutrients was provided in many intervention programs. Women are willing to buy the fortified rice if they are convinced of its health benefits.	***Sensory test:*** 60 subjects (triangle test, single blind test). ***Predilection test:*** 135 subjects. ***Focus group discussion:*** 4 groups of women (10 each) and 2 groups of millers (10 each).	Source of UR supply: Camil Alimentos, S.A.; Duration of consumption: XX days Formulation studied: Iron (ferric pyrophosphate, 3 um); zinc, thiamine, folic acid	Unpublished report.	Tran KV. "Acceptability of Fortified Rice in Vietnamese." Presentation. NIN.
25	Acceptability, Sensory	Nicaraguan Ministry of Health, Managua, Nicaragua; United Nations Children's Fund, New York, USA	Nicarauga 2010	To establish the acceptability of fortified rice.	Each subject was given fortified rice (2 samples) and non-fortified rice (1 sample). Subjects used a ballot with a 7-point hedonic scale. The results were analyzed using a randomized block arrangement through an analysis of variance for each of the attributes evaluated (color, odor, texture, flavor, and overall liking) to establish a test performed at a level of significance of 0.05.	Ultra Rice obtained general satisfaction scores above 4 points. It was concluded that consumers perceive positive sensory attributes and acceptability of rice fortified with Ultra Rice.	50 people from different social strata. The assessment took place in the dining facilities of the Autonomous University of Nicaragua (UNAN) in cubicle-like spaces to minimize interference emission of comments from participants.	Source of UR supply: Adorella Alimentos, Brazil; Formulation studied: Iron (ferric pyrophosphate, 3 um); zinc, thiamine, folic acid	Published UNICEF report.	Reyes CM, Alvarado M. "Technology assessment of rice fortification in Nicaragua"
26	Acceptability, Sensory	World Vision	Burundi 2011	To test whether subjects were able to differentiate between fortified and traditional rice in terms of color, taste, smell, etc. Study was done to ensure that students and parents would accept and appreciate fortified rice before instroduction into school lunch programs.	A triangle test: 2 types of rice simultaneously prepared and served to 64 people on three differently numbered plates (2 contianing traditional rice and one containing fortified rice). Qualitative surveys were completed by participants after eating.	82.56% of study participants found no difference between the two types of rice. Appearance: 21% noticed difference, 79% did not; Taste: 25% noticed difference, 75% did not; Smell: 93.38% of participants did not notice a difference.	64 people	Source of UR not specificed.	Unpublished report.	World Vision. "Acceptability study of fortified rice towards beneficiaries of FANEP Fortified Rice Project in Gasorwe Communi, Muyinga Province, Burundi." June 2011
27	Acceptability, Sensory	Food Security and Nutrition Research Unit, Research and Evaluation Division (RED), BRAC and University of Washington	Bangladesh 2012	To assess consumer acceptance of fortified rice in both rural and urban households in Bangladesh.	Cross-sectional study in 6 rural and 4 urban areas in and around the Dhaka city, Bangladesh. In each study location on a given day ten households were pre-selected by the BRAC village level health volunteers who were given pre-service training. Each family was given enough fortified rice for a mid-day meal and the fortified rice was cooking according to household norm. Female heads of household were interviewed later that day about taste, distinction, and acceptability of the rice. Cooking: All households washed it before boiling, 70% discarded excess water after boiling, 30% absorbed it during boiling. Rice was eaten with whatever other sides normally consumed in the household.	Over 3/4 of the respondents felt that the color of the fortified rice was the same or better than traditional rice when cooked. Nearly 90% believed that the smell was the same as traditional rice or better. 69.4% would buy if the price of fortified rice was the same as the price of the rice they normally eat. 19.8% of households would buy fortified rice if it was more than the price of the rice they normally eat (22.6% urban/17.2%rural). 94.6% would buy fortified rice if it was less than the price of rice they normally eat.	111 households; 48% urban, 52% rural. Average size of household was 4.4 members. Overall, 416 participants ate the fortified rice; 14% children, 9% pregnant and lactating mothers.	Source of UR supply: Adorella Alimentos, Brazil; Formulation studied: Iron (ferric pyrophosphate, 3 um); zinc, thiamine, folic acid	Unpublished report from BRAC and University of Washington.	Chakraborty B, Mukta US, Majumder SI. "A pilot study on the consumer acceptance of micronutrient fortified Ultra Rice in Bangladesh"

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28	Nutrient retention	PATH; Dourados Municipality, Brazil; Embrapa, Brasilia, Brazil	Brazil 2010	To monitor both nutrient retention and compliance of kitchen staff implementing the school meal pilot in Dourados.	Kitchen cooks received training from PATH on the proper blending procedure prior to the start of the pilot. Samples were collected at 3 of the 7 pilot schools. Each 400g sample was analyzed for iron and zinc content by Embrapa laboratories in Dourados--samples were ashed, and the resulting ash was further homogenized before taking sub-samples for measurement of the micronutrient content.	Coefficient of variation between expected and observed levels of Fe and Zn were calculated. The baseline content of Fe and Zn in the Ultra Rice was analyzed by the laboratory at Embrapa--this enabled the team to calculate the expected value for each mineral in the cooked fortified rice samples. The difference between mean observed value and expected values in each school were as follows: School #1 - Fe 14%, Zn 25%; School #2 - Fe 21%, Zn 10%; School #3 - Fe 11%, Zn 26%. Sample-to-sample variation expressed by CVs were all within an acceptable range, suggesting: 1) The chefs complied with the blending protocol and added the proper amount of Ultra Rice per batch; and 2) micronutrients were retained from baseline to post cooking.	400g samples (total, n=12) of cooked fortified rice were taken from the top (n=3), middle (n=3), and bottom (n=3) of a single cooking vessel in each of the 3 schools.	Source of UR supply: Adorella Alimentos, Brazil; Formulation studied: Iron (ferric pyrophosphate, 3 um); zinc, thiamine, folic acid	Unpublished data: Lab analysis commissioned by PATH. Conducted at third-party laboratory, Silliker Labs Canada, Markham Ontario.	
29	Nutrient retention	PATH; Naandi Foundation, Hyderabad, India; Global Alliance for Improved Nutrition (GAIN), Geneva, Switzerland	India 2009	To monitor nutrient retention of fortified rice cooked by 2 different methods and by 2 different preparation methods; also to monitor the compliance of kitchen staff in adding the proper amount of Ultra Rice.	***Cooking methods*** : Rice is cooked by 2 methods: absorption in which all water is absorbed, and excess water in which water not absorbed during cooked is discarded. Six 100g samples of cooked rice from both methods were collected. ***Preparation methods*** : In addition, nutrient retention after the 2 preparation techniques was evaluated: 1) Ultra Rice was added directly to the cooking vessel and 2) Ultra Rice was added to soaking tubs before rice was transferred to the larger rice cookers. The latter method was preferred because kitchen workers had difficulty properly mixing the Ultra Rice grains in the extremely large 125kg cauldrons of rice. This analysis helped determine whether exposing the Ultra Rice grains to a pre-soaking procedure would reduce the iron content in the cooked rice (due to a potential breach of integrity from greater exposure to water).	***Cooking methods*** : Mean Fe content of samples cooked by excess water (values in mg/100 grams): 14.1 + 8.33; by absorption method: 19.96 + 8.4. The difference between the observed and expected Fe content (20mg) was minimal when cooking by absorption. For the excess water method, however, there was approximately 30% loss of Fe. ***Preparation methods*** : The difference in iron (values in mg/100 grams) content of cooked rice when Ultra Rice was added directly to the cooking vessel or to the tubs with soaked rice was not statistically significant (4.24 + 2.5 when adding directly to the cooking vessel; 6.7 + 4.9 when adding to soaking tubs). These samples were cooked in excess water and hence their iron content was lower than what would be found through the absorption method of cooking. Note: the difference in reported Fe content between the 2 samples that were cooked in excess water was related to the fact that 1 sample was not reported on a dry basis (i.e., no moisture content was given by the lab). Therefore, they could not be directly compared.	Six 100g samples were taken for each cooking method and preparation method.	Source of UR supply: Swagat Foods, India; Formulation studied: Iron (ferric pyrophosphate, 3 um)	Unpublished data: prepared in final report for GAIN.	"GAIN-Naandi-PATH Pilot Study: A comprehensive report." PATH; October 2010
30	Nutrient retention	Silliker Laboratories, Ontario, Canada	Canada 2010	To determine the nutrient retention of Ultra Rice grains after rigorous cooking and preparation practices.	Soaking, rinsing, and cooking tests were carried out on individual 100g samples of blended, fortified rice. Each 100g sample contained 99.5g traditional rice and 0.5g Ultra Rice. Iron and thiamine content were analyzed at baseline, and then after the following procedures: 1) rinsing; 2) rinsing and soaking; 3) rinsing, soaking, and cooking in excess water; 4) rinsing, soaking, and cooking by absorption; 5) rinsing, soaking, frying in oil, and then cooking by absoprtion.	Fe baseline: 13.3 +/- 1.72 (values in mg/100g). Virtually no iron was lost after rinsing, soaking, and cooking by both methods. Fe losses: frying in oil did result in 46% loss of iron from baseline (7.15+/-3.74); vitamin B1 baseline :1.14+/- 0.07 (values in mg/100g); vitamin B1 losses (values in mg/100g): 23% after rinsing (0.88); 30% after rinsing and soaking (0.80 +/- 0.28); 17.5% after rinsing, soaking, and cooking by absorption (0.94+/- 0.02); and 39% after rinsing, soaking, pan frying, and cooking by excess water (0.69). There were not enough samples to determine whether the greater losses seen in Fe compared to vitamin B1 after pan frying (46% vs. 39%) were statistically significant.	Number of 100g samples "n" taken at each step: baseline (n=3); rinsing (n=1); rinsing and soaking (n=2); cooking by absorption (n=2); cooking in excess water (n=2); frying in oil (n=3).	Source of UR supply: Adorella Alimentos, Brazil; Formulation studied: Iron (ferric pyrophosphate, 3 um); zinc, thiamine, folic acid	Unpublished data: Lab analysis commissioned by PATH, conducted by third-party laboratory, Silliker Labs Canada, Markham Ontario.	

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29	Blend homogeneity	PATH; Naandi Foundation, Hyderabad, India; Global Alliance for Improved Nutrition (GAIN), Geneva, Switzerland	India 2009	To evaluate blend homogeneity of fortified rice using 2 blending methods: point-of-use blending (Phase A) and blending further up in the supply chain at a rice mill (Phase B).	***Phase A*** : 1) Inter-batch variation (same chef) - samples were taken from 3 batches of fortified rice to measure mean iron content; 2) Inter-chef variation - samples were taken from 3 batches prepared by different chefs to analyze mean iron content in each batch. ***Phase B*** : Iron content was analyzed from samples of both dry-blended fortified rice, and after this dry-blended fortified rice was cooked, as described above.	***Phase A*** : The mean coefficient of variation in iron content was found to be 47%. Interbatch variation between 2 of the 3 batches was insignificant but samples from Batch #2 were much lower than expected, possibly due to lack of chef compliance. Inter-chef variation: Little difference was seen in the mean iron content between 2 chefs. ***Phase B:*** The CV of the dry, uncooked fortified rice was found to be 17% - well within the standard acceptable range for other fortified foods; after cooking, the CV increased to 39%. It is unclear as to why the homogeneity decreased after cooking. To further investigate this issue, larger samples sizes will be used in the next operational trial to rule out an artificial sampling error as a reason for the increase. ***Comparing Phase A and Phase B:*** The mean co-efficient of variation of iron content in cooked rice was used as a test for homogeneity, and found to be 47% in Phase A and 39% in Phase B. With a p-value <0.00001, the difference in variance or homogeneity between wet blend and dry blend is significant, with dry blend proving to be better. However, both CV values are high. This could be due to a sampling problems at the lab--the cooked fortified rice samples may not have been adequately homogenized before sub-sampling, confounding the results.	Samples of cooked rice weighing 250g each were drawn from top, middle, and bottom layers of cooked rice from the cauldron.	Source of UR supply: Swagat Foods, India; Formulation studied: Iron (ferric pyrophosphate, 3 um)	Unpublished data: prepared in final report for GAIN.	"GAIN-Naandi-PATH Pilot Study: A comprehensive report." PATH; October 2010.
28	Blend homogeneity	PATH; Dourados Municipality, Brazil; Embrapa, Brasilia, Brazil	Brazil 2010	To evaluate blend homogeneity of fortified rice using the point-of-use method in school lunch programs.	Kitchen cooks received training from PATH on the proper blending procedure prior to the start of the pilot. Samples were collected at 3 of the 7 pilot schools. Each 400g sample was analyzed for iron and zinc content by Embrapa laboratories in Dourados--samples were ashed, and the resulting ash was further homogenized before taking the sub-samples.	The results confirmed that the cooks were properly mixing the Ultra Rice into traditional rice and the resulting mixture was at or close to the industry standard for acceptable CV for fortified foods (20%). CV of Fe content between 12 samples: School #1 - 20%; School #2 - 31%; School #3 - 21%; CV of Zn content between 12 samples: School #1 - 21%; School #2 - 11%; School #3 - 17%.	Twelve 400g samples of cooked fortified rice were taken from the top (n=3), middle (n=3), and bottom (n=3) of a single cooking vessel in each of the 3 schools.	Source of UR supply: Adorella Alimentos, Brazil; Formulation studied: Iron (ferric pyrophosphate, 3 um); zinc, thiamine, folic acid	Unpublished report.	"GAIN-Naandi-PATH Pilot Study: A comprehensive report." PATH; October 2010