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Mineral Retention Values for Blends of Cereal Based Complementary Food in Rats

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Abstract
Thirty five adult rats were used to study mineral utilization of unfermented and fermented blends of cereal based complementary food. Paddy and parboiled rice, soybean and crayfish were obtained from Jos Main Market, Nigeria. The paddy rice malted for 72h and all the foodstuffs were processed into flours. Parboiled rice and soybean mix was formulated in a standard ratio of 70:30g (PR:DSB_0). A modified standard formulation of parboiled rice, soybean, malted rice and crayfish mix in the ratio of 65:25:5:5g (PR:DSB:MR_{72}:CF_0) blend was made. From the formulation fermentation of different blends at varying periods 24, 48, 72, 96 and 120h was carried out. Seven different diets were fed. Five rats were assigned to each diet, and were fed for 12 days. Mineral assays were done by standard techniques. Food intakes were affected by supplements and fermentation period. Mineral retention values were a function of food intakes, supplements, fermentation period, fecal and urinary mineral outputs. The group fed the unfermented modified standard (PR:DSB:MR_{72}:CF_0) blend had the highest foodintake and mineral retention value followed by the group fed the PR:DSB:MR_{72}:CF_{96} blend fermented for 96h. Based on the results fermentation should be for 96h for maximum mineral retention

Key words: Fermentation, complementary, mineral, retention, rats.
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Introduction

Plant foods constitute important sources of vitamins and minerals (Elegbede, 1998). However plant foods contain some anti-nutritional factors that reduce their food values. Cereal staples and household diets can be manipulated to enhance the micronutrients content or alter the levels of absorption modifiers to improve micronutrients bio-availability (Gibson and Hotz, 2001). Strategies include among other processing methods at household levels are soaking, fermentation and germination. Sedden (2004) reported that phytase supplementation improved zinc and other cationic minerals (Ca, Mg, Fe and Cu) bioavailability in young pigs.The non-digestible carbohydrates (dietary fiber) were shown to improve the intestinal absorption of minerals presumably because of their binding or sequestering action (Coudray et al 2003). On the other hand Takahara et al (2000) stated that no increased aborption of phosphorus was observed when feeding rats with prebiotic inulin type fructans. Odumodu, (2007) reported that fermentation for 72h increased most of the minerals in cereal based complementary food but the optimum fermentation period that enhanced mineral retention values is still to be established.

The purpose of this research is to establish the optimum fermentation period that enhanced mineral retention values using rat feeding trials.

Materials and Methods

The 12 - day study consisted of a 5 - day adjustment period followed by a 7 – day mineral balance period.

Animal and Housing: Thirty five adult albino rats supplied by the source cited in Odumodu (2010) were divided into 7 groups of five rats each on the basis of body weight. The rats were weighed on day one of the study individually and housed in stainless steel metabolism cages equipped to separate urine and faeces of the animals. The rats were fed their respective diet blends and deionized water ad libitum for 7 days.

Diets: Paddy and parboiled rice (*Oryza-Sativa*), soybean (*Glycine max L*) and crayfish (*Astacus fluviatilis*) were purchased from Jos Main Market. The grains and crayfish were manually cleaned to remove foreign materials.

Production of Amylase Rich Flour (ARF): Amylase rich flour was produced by the method of Odumodu (2010).

Production of soybean, parboiled rice and crayfish: One kilogram of raw soybean was placed in 20 litres of boiling water containing 50.0 g sodium bicarbonate. The soybean was boiled for 10 min and the water drained off. It was dried in the oven at 80^{o}C for 24 h and dehulled mechanically using laboratory hammer mill.

Five kilograms parboiled rice was washed in tap water and allowed to drain water. It was dried in the oven at 80^{o}C for 24 h. One kilogram of crayfish was measured, dried in the oven at 95^{o}C for 50 min. Each of the foodstuffs was separately milled in a laboratory hammer mill into a fine flour (300 micrometer mesh screen) and packaged separately in a low density name labeled polyethylene bag. The bags were placed in plastic buckets with covers and stored in a deep freezer at –18^{o}C for analysis.

Formulation of rice-soybean mix 70:30 g ratio (FAO/WHO/UNU, 1985): Rice-soybean mix (70:30 g w/w) was formulated and thoroughly mixed using a laboratory hammer mill to ensure evenness. It was packed in a low density name labeled polyethylene bag and stored in a deep freezer (-18^{o}C) for analysis.

Dough preparation using parboiled rice, dehulled soybean, malted rice and crayfish mix (65:25:5:5g w/w ratio) fermented at varying periods: A blend of parboiled rice (65g), dehulled soybean (25g), malted rice (5g) and crayfish (5g) was prepared and divided into six equal parts. Five parts were fermented for 24, 48, 72, 96 and 120 h respectively, after mixing with tap water to form a dough by bringing the moisture content to 50%. The other part served as a control. At the end of each fermentation time the blend was taken out and dried at 80^{o}C in the oven for 24h. The dried blend was remilled in a laboratory mill to fine flour and packaged in low density name labeled polyethylene bag. The bags were placed in plastic buckets with covers and stored in deep freezer (-18^{o}C) for analysis.

Elemental determination: The levels of calcium, magnesium, molybdenum, zinc, iron, selenium, iodine, manganese and copper were determined in the (70:30g) blend, unfermented and fermented blends by the method of Atomic Absorption Spectrophotometric method of Association of Official Analytical Chemists (AOAC, 1990).

The iodine determination was by the method of Muir and Lambert (1973). Sodium thiosulphate (thiosulphate VI) reacted with iodine to produce sodium iodide and sodium tetrathionate. The free iodine produced a deep blue colouration which disappeared as soon as sufficient thiosulphate was added to react with all the iodine.

Laboratory Analysis: Carmine red was fed on the morning of the day 5 and day 12. Coloured feces appeared beginning on days 6 and 12. The coloured feces excreted on day 6 were included in the pool fecal sample and those excreted on day 12 were excluded. Urine was collected from 7.00am of day 6 through the morning of day 12 (7 days) and food consumption was recorded for the same 7 day period. Hydrochloric acid (0.IN)(0.5ml) was used as a preservative to the pooled urine samples for each group. The urine samples were made to a volume of 200ml with distilled water and refrigerated until analysis for minerals. Individual fecal collection was dried at 85^{o}C for 3h, weighed, and ground into a fine powder.

Statistical analysis: All data collected were statistically analyzed using analysis of variance and Duncan's new multiple range test as described by Steel and Torrie (1960). Significance was accepted at $P < 0.05$.

Results

Table 1 presents the mean values for food intakes, calcium and magnesium retention values for the rats fed the unfermented and fermented blends of parboiled rice, dehulled soybean, malted rice and crayfish. The food intakes were influenced by treatments such as supplements and fermentation period. The group of rats fed the unfermented modified standard ($PR:DSB:MR_{72}:CF_O$) blend had the highest food intake (69.0g) while the group fed the $PR:DSB:MR_{72}:CF_{120}$ blend had the least value (24.0g). There was a significant difference ($P< 0.05$) in food intake values between the groups fed the standard ($PR:DSB_O$) and the modified standard ($PR:DSB:MR_{72}:CF_O$) blends. There was also a significant difference ($P< 0.05$) in food intakes between the group fed the $PR:DSP:MR_{72}:CF_O$ and all the groups fed the fermented blends. The group that consumed more food (69.0g) had more calcium intake (10.0lmg) while the group that consumed less (24.0g) had less calcium value (2.42mg). The calcium intakes of the group fed the $PR:DSB:MR_{72}:CF_O$ blend was significantly higher ($P<0.05$) than the groups fed the $PR:DSB_o$ and all the fermented blends. The group fed the $PR:DSB:MR_{72}:CF_0$ blend had the highest calcium retention value (7.19mg) followed by the group fed the $PR:DSB:MR_{72}CF_{24}$ (5.54mg) blend.

The magnesium intake of the group of rats fed the $PR:DSB:MR_{72}:CF_0$ was significantly higher ($P < 0.05$) than the groups fed the $PR:DSB_O$ and all the fermented blends. The group of rats fed the $PR:DSB:MR_{72}:CF_{96}$ blend had higher ($P <0.05$) magnesium intake (9.60mg) than other fermented blends. Despite the high fecal and urinary outputs most of the groups had high magnesium retention values. The group fed the $PR:DSB:MR_{72}:CF_0$ blend had the highest retention value (10.34mg) followed by the group fed the $PR:DSB:MR_{72}:CF_{96}$ blend (7.57mg).

Table 2 presents the values for molybdenum, zinc, iron and selenium retention values for the rats.The groups of rats fed the $PR:DSB:MR_{72}:CF_{24}$, the $PR:DSB:MR_{72}:CF_{48}$ and the $PR:DSB:MR_{72}:CF_{72}$ blends had traces of molybdenum while the groups fed the $PR:DSB_0$, the $PR:DSB:MR_{72}:CF_0$, the $PR:DSB:MR_{72}:CF_{96}$ and the $PR:DSB:MR_{72}:CF_{120}$ blends had values (0.10, 0.11 and 0.02mg, respectively) that were not significantly different ($P > 0.05$). The fecal molybdenum output values were zero for all the groups while there was no significant difference ($P > 0.05$) in urinary Mo values for all the groups.

The value for zinc intakes of the group of rats fed the $PR:DSB:MR_{72}:CF_0$ blend was significantly different ($P <0.05$) from the group fed the $PR:DSB_O$ blend but similar ($P > 0.05$) to the groups fed the $PR:DSB:MR_{72}:CF_{24}$ and the $PR:DSB:MR_{72}:CF_{96}$ blends. The urinary zinc values were similar ($P> 0.05$) except the groups fed the $PR:DSB:MR_{72}:CF_{72}$ and the $PR:DSB:MR_{72}:CF_{120}$ blends that were higher ($P <0.05$) (0.84 and 1.86mg, respectively). The fecal zinc values were higher ($P<0.05$) for the groups fed the $PR:DSB:MR_{72}:CF_o$, the $PR:DSB:MR_{72}:CF_{24}$ and the $PR:DSB:MR_{72}:CF_{48}$ blends (1.17, 2.38 and 1.78mg, respectively). The group of rats fed the $PR:DSB:MR_{72}:CF_o$ blend had the highest zinc retention value (2.47mg) while the groups fed the $PR:DSB:MR_{72}:CF_{48}$ and the $PR:DSB:MR_{72}:CF_{96}$ blends had similar ($P> 0.05$) values (1.08 and 0.90mg, respectively) which were higher ($P < 0.05$) than other fermented blends.

The iron intakes of the group of rats fed the $PR:DSB:MR_{72}:CF_o$ was significantly higher ($P < 0.05$) than the groups fed the $PR:DSB_O$ and all the fermented blends. The groups of rats fed the $PR:DSB:MR_{72}:CF_{24}$ and the $PR:DSB:MR_{72}:CF_{96}$ blends had similar ($P> 0.05$) Fe intakes (6.35 and 6.14mg, respectively) which were higher ($P < 0.05$) than other fermented blends. There seemed to be similarities in the fecal and urinary Fe outputs among the groups except the group fed the $PR:DSB:MR_{72}:CF_{120}$ blend ($P > 0.05$) that had the highest urinary value (0.20mg). The group fed the $PR:DSB:MR_{72}:CF_0$ blend had the highest ($P < 0.05$) Fe retention value (7.42mg) followed by the group fed the $PR:DSB:MR_{72}:CF_{24}$ blend (6.06mg).

The selenium intake of the group of rats fed the $PR:DSB:MR_{72}:CF_{24}$ was significantly higher ($P < 0.05$) than the groups fed the two unfermented ($PR:DSB_O$ and $PR:DSB:MR_{72}:CF_0$) and all the fermented blends. The fecal selenium values for all the groups were zero while the urinary selenium values for all the groups were similar ($P> 0.05$).

Table 3 presents the values for iodine, manganese and copper retention values for the rats..The groups of rats fed the $PR:DSB:MR_{72}:CF_0$, the $PR:DSB:MR_{72}:CF_{24}$ and the $PR:DSB:MR_{72}:CF_{96}$ blends had similar values ($P > 0.05$) (0.20, 0.19, and 0.25mg, respectively) for iodine intakes which were significantly different ($P < 0.05$) from others. There were no significant differences ($P > 0.05$) in the fecal and urinary iodine outputs except the group fed the $PR:DSB:MR_{72}:CF_{120}$ blend that had the highest urinary value (0.14mg). Negative iodine retention values were observed in the groups fed the

PR:DSB:MR_{72}:CF_{48}, the PR:DSB:MR_{72}:CF_{72} and the PR:DSB:MR_{72}:CF_{120} blends (-0.06, -0.02 and –0.07mg respectively). The groups of rats fed the PR:DSB:MR_{72}:CF_0 and the PR:DSB:MR_{72}:CF_{96} blends had similar ($P > 0.05$) iodine retention values (0.14 and 0.16mg respectively) which were higher than other blends. There were similarities in manganese intakes within the groups. The groups fed the PR:DSB_O, the PR:DSB:MR_{72}:CF_{72} and the PR:DSB:MR_{72}:CF_{120} blends had lower, values ($P< 0.05$) (0.41, 0.46 and 0.46mg respectively) which were significantly different ($P < 0.05$) from the rest. . There were high fecal and urinary manganese outputs. The group fed the PR:DSB:$MR_{72}CF_{120}$ blend had a negative value (-0.01mg). The group fed the PR:DSB:MR_{72}:CF_0 blend had the highest manganese retention value (0.84mg) followed by the group fed the PR:DSB:MR_{72}:CF_{96} blend (0.60mg).

There were similarities in copper intakes within the groups. The groups of rats fed the PR:DSB:MR_{72}:CF_0 and the PR:DSB:MR_{72}:CF_{24} blends had similar values (0.33 and 0.25mg, respectively) which were significantly different ($P < 0.05$) from others. The group fed the PR:DSB:MR_{72}:CF_{24} blend had the highest fecal copper output (0.34mg). The urinary copper outputs were generally low. The group fed the PR:DSB:MR_{72}:CF_0 blend had the highest copper retention value (0.27mg). Other groups had similar copper retention values except the groups fed the PR:DSB:MR_{72}:CF_{24} and the PR:DSB:MR_{72}:CF_{120} blends that had negative values (-0.10 and -0.02mg respectively)

Discussion

The difference in food intakes between the two groups of rats fed the PR:DSBo and the PR:DSB:MR_{72}:CFo blends (Table 1) could be attributed to crayfish supplement which improved the flavour, aroma and palatability of the PR:DSB:MR_{72}:CFo blend. While the difference in food intakes between the groups fed the PR:DSB:MR_{72}:CFo and all the fermented blends could be due to a negative influence of fermentation on the flavour of the fermented blends. Odumodu (2008) observed that prolonged fermentation reduced the sweetness of the blends to sourness The higher calcium and magnesium retention values observed in the group of rats fed PR:DSB:MR_{72}:CFo blend than the group fed the PR:DSBo blend could be due to the crayfish and malted rice spplements which enhanced calcium and magnesium values of the blend.The lower calcium and magnesium retention values observed in all the groups fed the fermented blends than the group fed the PR:DSB:MR_{72}:CFo blend might be due to lower calcium and magnesium intakes due to leaching of the minerals into the fermentation media.

The zero and low values (Table 2) for fecal and urinary outputs of molybdenum respectively revealed that the Mo was well retained except the group fed the PR:DSB:MR_{72}:CF_{120} blend that had a negative value (-0.06mg). The negative value could indicate low Mo intake due to leaching of the minerals into fermentation medium.The difference in zinc retention values for the groups fed the PR:DSBo and the PR:DSB:MR_{72}:CFo blends could be associated to differences in the components of foods while the similarity in the groups fed the fermented blends might be due to optimal conditions for release of the zinc. Addition of yogurt to the plant based-diet increased zinc absorption by 68% in Mexican women but no effect on iron was observed by (Rosado et al, 2005). The high fecal values could indicate the presence of anti-nutritional factors which were not hydrolysed during fermentation. Reebe et al (2000) observed that during fermentation organic complexes were hydrolysed in their constituent components. The high retention values for Fe in almost all the groups of rats could be attributed to favourable conditions for release of the mineral and as well as low fecal and urinary outputs of Fe. The favourable conditions for the release of selenium resulted in low values for urinary and fecal outputs .Lopez et al,(2003) observed that sourdough making enhanced magnesium, zinc, iron and copper absorption than in unprocessed reconstituted wheat.

The negative iodine retention values (Table 3) for the groups fed the PR:DSB:MR_{72}:CF_{48}, the PR:DSB:MR_{72}:CF_{72} and the PR:DSB:MR_{72}:CF_{120} blends could be attributed to low intakes of iodine and high urinary outputs for the last group. The negative manganese retention value (-0.01mg) observed in the group of rats fed PR:DSB:$MR_{72:}CF_{120}$ blend could indicate low manganese intakes and high urinary output. The negative copper retention values for the groups of rats fed the PR:DSB:MR_{72}:CF_{24} and the PR:DSB:MR_{72}:CF_{120} blends might be associated to high fecal output and low copper intakes respectively due to leaching of copper into fermentation media.

In conclusion: The food intakes of all the groups of rats were influenced by the supplements (crayfish and malted rice) and the fermentation periods. The supplements enhanced the mineral retention values for the group of rats fed the PR:DSB:MR_{72}:CFo blend while fermentation decreased the minerals retention values for the groups fed fermented blends due to leaching effects.The fecal and urinary outputs of the minerals affected the minerals retention values negatively. Amongs the groups fed the fermented blends the group fed the PR:DSB:MR_{72}:CF_{96} blend had the highest mineral retention values showing that fermentation for 96h enhanced mineral retention values most.

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Table 1: Food intake, calcium and magnesium retention values for rats fed all blends (mg/rat)1

Blend Treatment	PR:DSB$_0$ 70:30	PR:DSB:MR$_{72}$:CFo 65:25:5:5	PR:DSB:MR$_{72}$:CF$_{24}$ 65:25:5:5	PR:DSB:MR$_{72}$:CF$_{48}$ 65:25:5:5	PR:DSB:MR$_{72}$:CF$_{72}$ 65:25:5:5	PR:DSB:MR$_{72}$:CF$_{96}$ 65:25:5:5	PR:DSB:MR$_{72}$:CF$_{120}$ 65:25:5:5	LSD
Food intake (g)	34^{d}±3.5	69^{a}±5.8	56.2^{b}±4.1	50.2^{c}±3.6	29.0^{e}±2.3	55.8^{b}±5.6	24^{f}±2.7	1.2
Calcium intake (mg)	2.42^{f}±0.4	10.01^{a}±3.9	8.72^{b}±0.34	7.70^{d}±1.00	4.58^{e}±0.40	8.20^{c}±0.66	2.98^{f}±0.23	0.9
Fecal Ca (mg)	1.93^{c}±0.1	2.08^{b}±0.2	2.37^{b}±0.2	2.08^{c}±0.5	1.52^{d}±0.30	2.78^{a}±0.20	2.37^{b}±0.20	0.4
Urinary Ca (mg)	0.72^{a}±0.7	0.74^{a}±0.01	0.76^{a}±0.01	0.63^{a}±0.03	0.36^{b}±0.02	0.78^{a}±0.05	0.40^{b}±0.1	0.3
Retained Ca (mg)	-0.23±0.1	7.19^{a}±0.8	5.59^{b}±0.5	4.99^{c}±0.3	2.70^{d}±0.50	4.64^{c}±0.50	0.21^{e}±0.001	1.1
Magnesium intake (mg)	5.41^{d}±0.3	11.25^{a}±0.9	9.17^{b}±1.00	8.27^{c}±0.75	4.90^{e}±0.20	9.60^{b}±1.00	3.84^{f}±0.68	1.3
Fecal Mg (mg)	0.43^{cd}±0.02	0.70^{c}±0.06	1.60^{a}±0.10	1.22^{b}±0.2	0.64^{c}±0.05	1.86^{a}±0.10	0.51^{c}±0.10	0.5
Urinary Mg (mg)	0.31^{c}±0.01	$0.^{2c}$±0.02	0.60^{b}±0.04	0.25^{c}±0.1	0.68^{b}±0.08	0.17^{c}d±0.02	1.36^{a}±0.50	0.3
Retained Mg (mg)	4.67^{d}±0.6	10.34^{a}±0.85	6.67^{c}±0.80	6.80^{c}±0.99	3.58^{e}±0.30	7.57^{b}±0.79	1.97^{c}±0.60	1.0

1 Means ± SEM (5 rats)
Values with different superscript in the same row are significantly different ($p<0.05$)
Values are means ± standard deviations of triplicate determinations
LSD = Least significant difference

TABLE 2: Molybdenum, Zinc, Iron and Selenium Retention Values For Rats Fed All Blends (Mg/Rat)1

Blend Treatment	PR:DSB0 70:30	PR:DSB:MR_{72}:CF0 F0 65:25:5:5	PR:DSB:MR_{72}C F24 65:25:5:5	PR:DSB:MR_{72}:C F48 65:25:5:5	PR:DSB:MR_{72}:F_{72} 65:25:5:5	PR:DSB:MR_{72}:C F_{96} 65:25:5:5	PR:DSB:MR_{72}:C F_{120} 65:25:5:5	LSD
Molybdenum intake (mg)	0.10^{a}±0.03h	0.21^{a}±0.07	Traces	Traces	Traces	0.11^{a}±0.01	0.02^{b}±0.00	0.0
Fecal Mo (mg)	0.00^{a}±0.0	0.00^{a}±0.00	0.00^{a}±0.00	0.00^{a}±0.00	0.00^{a}±0.00	0.00^{a}±0.00	0.00^{a}±0.00	-
Urinary Mo (mg)	0.01^{a}±0.00	0.02^{a}±0.001	0.01^{a}±0.00	0.02^{a}±0.00	0.05^{a}±0.00	0.01^{a}±0.00	0.08^{a}±0.01	-
Retained Mo (mg)	0.09^{a}±0.0	0.19^{a}±0.04	Traces	Traces	Traces	0.10^{a}±0.04	-0.06^{b}±0.00	0.06
Zinc intake (mg)	1.96^{c}±0.2	3.94^{a}±0.50	3.60^{a}±0.80	3.11^{b}±0.90	1.86^{c}±0.60	3.41^{a}±0.80	1.13^{d}±0.20	0.40
Fecal Zn (mg)	0.47^{e}±0.03	1.17^{c}±0.40	2.38^{a}±0.75	1.73^{b}±0.2	0.85^{d}±0.9	0.26^{e}±0.2	0.77^{d}±0.01	0.42
Urinary Zn (mg)	0.36^{c}±0.01	0.30^{c}±0.06	0.37^{c}±0.03	0.30^{c}±0.05	0.84^{b}±0.07	0.27^{c}±0.01	1.86^{a}±0.10	0.51
Retained Zn (mg)	1.13^{b}±0.4	2.47^{a}±0.80	0.85^{c}±0.06	1.08^{b}±0.45	0.17^{c}±0.01	0.90^{b}±2.88	-1.50^{d}±0.07	0.20
Iron intake (mg)	3.06^{d}±0.60	7.52^{a}±1.00	6.35^{b}±0.98	5.57^{c}±0.78	3.28^{d}±0.59	6.14^{b}±0.64	2.31^{e}±0.75	1.01
Fecal Fe (mg)	0.05^{c}±0.01	0.07^{c}±0.01	0.25^{b}±0.04	0.22^{b}±0.03	0.08^{c}±0.00	0.41^{a}±0.02	0.06^{c}±0.00	0.17
Urinary Fe (mg)	0.07^{b}±0.01	0.03^{c}±0.00	0.04^{c}±0.01	0.05^{c}±0.00	0.12^{b}±0.01	0.03^{c}±0.00	0.20^{a}±0.04	0.05
Retained Fe (mg)	2.94^{d}±0.7	7.42^{a}±1.5	6.06^{b}±0.85	5.30^{c}±0.86	3.08^{d}±0.95	5.70^{c}±0.79	2.05^{e}±0.59	0.98
Selenium intake (mg)	0.14^{c}±0.05	0.25^{b}±0.04	0.38^{a}±0.09	0.22^{b}±0.03	0.13^{BC}±0.06	0.23^{b}±0.07	0.06^{d}±0.01	0.14
Fecal Se (mg)	0.00^{a}±0.00	0.00^{a}±0.00	0.00^{a}±0.00	0.00^{a}±0.00	0.00^{a}±0.00	0.00^{a}±0.00	0.00^{a}±0.00	-
Urinary Se (mg)	0.01^{a}±0.00	0.03^{a}±0.00	0.05^{a}±0.00	0.03^{a}±0.00	0.02^{a}±0.00	0.04^{a}±0.00	0.01^{a}±0.00	-
Retained Se (mg)	0.13^{b}±0.06	0.22^{b}±0.08	0.33^{a}±0.06	0.19^{b}±0.07	0.11^{b}±0.04	0.19^{b}±0.03	0.05^{c}±0.00	0.10

1 Means ± SEM (5 rats)
Values with different superscript in the same row are significantly different ($p<0.05$)
Values are means ± standard deviations of triplicate determinations.LSD = Least significant difference

Table 3: Iodine, Manganese And Copper Retention Values For Rats Fed All Blends (Mg/Rat)[1]

Blend Treatment	PR:DSB_0 70:30	PR:DSB:MR_{72}:C F_0 65:25:5:5	PR:DSB:MR_{72}:C F_{24} 65:25:5:5	PR:DSB:MR_{72}:C F_{48} 65:25:5:5	PR:DSB:MR_{72}:C F_{72} 65:25:5:5	PR:DSB:MR_{72}:C F_{96} 65:25:5:5	PR:DSB:MR_{72} :CF_{120} 65:25:5:5	LSD
Iodine intake (mg)	0.09^{b}±0.02	0.20^{a}±0.01	0.19^{a}±0.04	0.01^{b}±0.00	0.09^{b}±0.01	0.25^{a}±0.06	0.09^{b}±0.02	0.13
Fecal I (mg)	0.02^{a}±0.00	0.03^{a}±0.00	0.07^{a}±0.01	0.07^{a}±0.01	0.03^{a}±0.00	0.07^{a}±0.01	0.02^{a}±0.00	-
Urinary I (mg)	0.03^{b}±0.01	0.03^{b}±0.00	0.03^{b}±0.00	0.02^{b}±0.00	0.08^{b}±0.01	0.02^{b}±0.00	0.14^{a}±0.04	0.10
Retained I (mg)	0.04^{b}±0.02	0.14^{a}±0.05	0.09^{b}±0.02	-0.06^{c}±0.01	-0.02^{c}±0.00	0.16^{a}±0.05	-0.07^{c}±0.1	0.09
Manganeseintake (mg)	0.41^{b}±0.10	1.24^{a}±0.24	1.12^{a}±0.4	0.95^{a}±0.1	0.46^{b}±0.06	1.06^{a}±0.07	0.46^{b}±0.08	0.38
Fecal Mn (mg)	0.16^{d}±0.3	0.34^{c}±0.01	0.70^{a}±0.10	0.50^{b}±0.05	0.28^{c}±0.04	0.43^{b}±0.03	0.15^{d}±0.01	0.13
Urinary Mn (mg)	0.13^{b}±0.2	0.06^{c}±0.06	0.06^{c}±0.01	0.05^{c}±0.03	0.14^{b}±0.01	0.04^{c}±0.00	0.32^{a}±0.05	0.07
Retained Mn (mg)	0.12^{d}±0.02	0.84^{a}±0.04	0.36^{c}±0.1	0.40^{c}±0.02	0.04^{e}±0.00	0.60^{b}±0.04	-0.01^{f}±0.00	0.18
Copper intake (mg)	0.11^{c}±0.01	0.33^{a}±0.02	0.25^{a}±0.03	0.20^{b}±0.01	0.13^{c}±0.04	0.23^{b}±0.02	0.08^{c}±0.01	0.10
Fecal Cu (mg)	0.03^{c}±0.00	0.05^{c}±0.00	0.34^{a}±0.04	0.10^{b}±0.03	0.05^{c}±0.01	0.15^{b}±0.03	0.04^{c}±0.00	0.12
Urinary Cu (mg)	0.01^{a}±0.00	$0.^{01a}$±0.00	0.01^{a}±0.00	0.06^{a}±0.00	0.04^{a}±0.01	0.01^{a}±0.00	0.06^{a}±0.01	-
Retained Cu (mg)	0.07^{b}±0.01	0.27^{a}±0.07	-0.10^{c}±0.00	0.04^{b}±0.00	0.04^{b}±0.02	0.07^{b}±0.00	-0.02^{c}±0.00	0.13

1 Means ± SEM (5 rats)Values with different superscript in the same row are significantly different ($p<0.05$)
Values are means ± standard deviations of triplicate determination.LSD = Least significant difference. PR:DSB_0 70:30 = Parboiled rice 70% and 30% dehulled soybean (unfermented). PR:DSB_0:MR_{72}:CF_0= Parboiled rice 65%, dehulled soybean 25%, malted rice (72h) 5% and crayfish 5%, (unfermented). PR:DSB_0:MR_{72}:CF_{24}=Parboiled rice 65%, dehulled soybean 25%, malted rice (72h) 5% and crayfish 5%, (all fermented 24h). PR:DSB_0:MR_{72}:CF_{48}=Parboiled rice 65%, dehulled soybean 25%, malted rice (72h) 5% and crayfish 5%, (all fermented 48h). PR:DSB_0:MR_{72}:CF_{72}=Parboiled rice 65%, dehulled soybean 25%, malted rice (72h) 5% and crayfish 5%, (all fermented 72h). PR:DSB_0:MR_{72}:CF_{96}= Parboiled rice 65%, dehulled soybean 25%, malted rice (72h) 5% and crayfish 5%, (all fermented 96h). PR:DSB_0:MR_{72}:CF_{120}= Parboiled rice 65%, dehulled soybean 25%, malted rice (72h) 5% and crayfish 5%, (all fermented 120h).