Sensory evaluation of fortified rice flour based foods at different levels of fortification

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Abstract

In order to determine the effects on the physical and sensory characteristics of rice flour preparations after fortification with different levels of iron and zinc a study was carried out to ascertain which level of fortification would be most appropriate in Sri Lanka. The mineral forms tested were ferrous sulfate, zinc oxide, folic acid and Di-sodium EDTA. Iron and zinc were added to rice flour to provide 60, 80 and 100mg per kilogram of flour. Folic acid was added to provide 2mg per kilogram of flour. Na_2EDTA was mixed at a molar ratio of 1:1 of Fe: Na_2EDTA and 1:0.7 of zinc: Na_2EDTA in a tumble laboratory blender. The flour was stored at ambient conditions (30^0-40^0C, relative humidity nearly 80.0%) at the Nutrition Research Laboratory (NRL) of the Faculty of Medicine, Galle. At monthly intervals, three dishes, viz., string hoppers, pittu and aluwa, that were prepared out of enriched flour were evaluated for their sensory characteristics, using 13 trained and experienced panelists. Meals were prepared at the NRL. The sensory changes of all foods over the unfortified food remained positive and, most of the changes were related to flour storage time and to the level of the fortificant. A significant difference in acceptability of pittu over aluwa (p=0.028) was observed in all stages of the trial. Odour of meals made out of flour at 80 mg/kg level were significantly different from that of meals of 60 mg/kg (p=0.046). Odour of meals at second month were significant from meals at the end of first month (p=0.004). Taste of meals made out of 80 mg/kg was shown to be more acceptable to the panelists from 60 mg/kg (p=0.019) and 100 mg/kg (p=0.001). There was no significant difference in taste between type of meals (p=0.991) and duration of storage (p =0.735). Fortificant level of 80mg /kg for iron and zinc appeared viable.

Key words: rice flour fortification, sensory evaluation, micronutrients

Introduction

Rice flour fortification is a novel approach we sought to evaluate as a possible vehicle for a national food fortification programme in Sri Lanka. Experience to date suggests that fortification of staples (eg. wheat flour) is a cost-effective and feasible strategy, but regulatory monitoring is required to demonstrate effectiveness and ensure quality (Yip and Ramachrishnan, 2002). Common food vehicles used around the world for iron fortification include processed cereals (such as wheat and corn), salt, sugar, condiments and other processed foods (Lofti *et.al.,* 1996). In Sri Lanka, rice flour represents perhaps the most appropriate vehicle for fortification because it meets the classical considerations for food vehicle choice. It is widely consumed in different forms of local dishes affordable by the groups with less income and vulnerable to iron deficiency anemia. Rice flour is generally processed in few large mills in most instances; can be distributed through widespread networks that reach all regions of the country and consumed in fairly constant amounts so that fortification levels can be calculated accurately (135–146 g per day in recent survey conducted by the researchers). In the present research programme rice flour was fortified with iron and zinc (60 mg/kg) and bioavailability of these minerals was determined in a study among children of 7-11 years of age (Hettiarachchi *et al.,* 2004). Children absorbed 92 µg of iron from a meal made out of 25 g of fortified rice flour. This represents about 13% of the estimated absorbed requirement (0.7 to 0.8 mg) of iron in this age group (Institute of Medicine, 2001.). Total absorption from added zinc constitutes approximately 11-17% of the zinc needs of an 8 year old child (Institute of Medicine, 2001). Given these favorable preliminary results on bioavailability, more formalized sensory testing on fortified flour at multiple levels of enrichment was indicated. Therefore, the present study was conducted in order to evaluate the total effects (physical and sensory characteristics) of micronutrients added to rice flour under specific conditions and at different levels, with a view to assess the most suitable level of fortification of rice flour for the population in Sri Lanka. This study took into account the ambient storage conditions and food preparation / processing procedures.

Methods

Three levels of fortification were considered in the study. Technically, the lowest level (60 mg/kg) was derived from the fortification level we used for the bioavailability study, and that represents the level recommended for wheat flour fortification in Guatemala (Raunhardt & Bowly, 1996). Long term usage has reported that this fortification level is possible without significant changes in quality. In addition, multiples of this level was selected (80 and 100 mg/ kg) to study the effects at significant fortification levels. The fortificants, ferrous sulfate and zinc oxide were obtained from Dr. Paul Lohmann; Na_2EDTA from AKSONOBEL and folate from Glaxo-Welcome. All these minerals were of food grade and approved as being safe for use. Grade 2 brown country rice (well polished, 6-8% weight reduction on polishing) was powdered to 300-500 mesh size using an electric grinder, and a tumble laboratory blender with 5.0 kg capacity was used to mix the fortificants and flour. Preparation of the experimental flour was done at the NRL and stored at ambient condition. Temperature ranged from 30^o-40^o C and relative humidity of 80.0% or above. These flours were subjected to evaluations at baseline, and after one, two, and three months of storage. Duplicate fortified and control flour (non-fortified) samples were tested for sensory evaluation by experienced taste panelists (n=13), in the laboratory. Initially and at monthly intervals, three commonly consumed rice flour dishes were prepared. Pittu is a flat small 'droplet' prepared by mixing rice flour and coconut and steamed on a pre-heated water pan. String hoppers are thin noodles made out of preheated rice flour and then steamed. Aluwa is sweet cake made from rice flour mixed with treacle/ sugar and water, cooked and spreaded on a board. The formulae used in this study are commonly practiced by rural Sir Lankan people. For the sensory evaluation, meals were prepared at NRL using these standard recipes. Table 1 summarized the composition of the food and their methods of preparation. The sensory evaluation panel was convened to test one type of food at one level of fortification on nine days; on each day either 60mg/kg, 80mg/kg or 100 mg/kg and the control were tested. The sensory evaluation was based on testing for multiple sample difference in quality attributes following the procedures used in India (Indian standards, 1971). Panelists evaluated the coded meals based on taste, color, odor, and acceptability, using a hedonic scale of -5 to +5, with 0 being the value assigned to the control food made with unfortified flour. Panelists were also invited to make comments on the evaluation forms. In addition to the above, the technicians responsible for preparing the foods kept records of their observations on the characteristics of the uncooked flour during their preparations.

Statistical Analysis

Analysis of variance (ANOVA) with multiple post hoc testing (Fisher's PLSD) was used to determine the level of differences between meals, different levels of fortification, and sensory characteristics as the primary outcome variable. Statistical analysis was carried out using SPSS version 10.0 (SPSS Inc., Chicago). Descriptive statistics are expressed as the mean ± standard deviation. P-values less than 0.05 were considered to be significant.

Results

Dough quality and final food characteristics

The external characteristics of cooked food items showed that all flours had similar properties to the control after one month of storage. Since the flour was made up of country brown rice there was no obvious darkness or discoloration due to oxidation of ferrous sulfate. However, when the flour was stored for more than two months, black spots were observed in string hoppers and aluwa. There is no obvious sign of surface dehydration, resulting in stiff-textured products or sticky consistency.

Sensory characteristics

The ANOVA results for the sensory evaluation trials are presented in Tables 2 through 5. Mean sensory score of zero indicated that there was no difference in the characteristics of the sample made with fortified flour compared with the unfortified control. A positive score indicated that the characteristics of fortified flour meals were more favourable compared the control.

Acceptability of meals

Acceptability of all foods remained positive during the whole period of storage (table 2).

Nevertheless, compared with the baseline the acceptability was declined over storage time although there was no consistency in the direction of change. A significant difference in acceptability of Pittu over Aluwa (p=0.028) was observed during the course of the trial.

Odour and texture of meals

Compared with the control meals, there was a significant difference in odour of Pittu over Aluwa (p=0.009); and String hoppers (p=0.013). Further the ordour of meals made with 80 mg/kg fortificanr level was significantly different from that of the meals of 60 mg/kg (p=0.046). Significant difference between the first month and the second month was observed in all 3 meals (p=0.004). Even though, the odour deteriorated over time, it still remained positive compared with the unfortified meal. Texture of the meals did not show any significant differences over the type of food (p=0.434), duration of storage (p=0.306), and level of fortification (p=0.385).

Taste of meals

Taste of meals made of 80 mg/kg was more acceptable than 60 mg/kg (p=0.019) and 100 mg/kg (p=0.001) to the panelists. There was no significant difference in taste between type of meals (p=0.991) and duration of storage (p=0.735).

Discussion and Conclusions

The projected amounts of iron and zinc that would be absorbed at the given rice flour consumption levels and proposed fortification level were shown in Table 6 and Table 7 shows the WHO recommended daily iron and zinc intake for individuals on a diet where the bioavailability of these micronutrients are low. Thus, enriching flour might meet more than one half of young children's recommended daily iron intake, and less than one-quarter of young children's recommended daily zinc intake. These levels probably overestimate the impact of fortification on young children because the rice flour consumption data are for average per capita intakes, and young children most likely consume less rice flour than the average.

The sensory evaluation results showed that fortification of rice flour is acceptable and level of fortification could be increased from the level that we used (60 mg/kg) It was quite clear during the sensory evaluation trial of our study that the quality of flours did not deteriorate much from the control with time although, rancidity of ferrous sulfate was evident in a previous study on wheat flour fortification in Sri Lanka (Gooneratne *et al.,* 1996). This study revealed that wheat flour fortified with NaFeEDTA and ferrous fumarate became less acceptable sooner than the other flours (i.e. reduced iron and electrolytic iron). But in our trial as we did a multiple micronutrient fortification i.e. ferrous sulfate with Na_2EDTA, zinc oxide and folic acid sensory characteristics could be expected to be different from previous wheat flour trial. The effect of rancidity/ discoloration of ferrous sulfate may have been masked by presence of Na_2EDTA.

The quality of flour although deteriorated with time, the taste, texture and acceptability was within the desired limits at the third month of storage as well. This effect was clearly seen at 60mg/kg fortification level also (Hettiarachchi *et al.,* 2004). The ambient flour storage conditions in Sri Lanka are harsh, with high temperatures and humidity. Flour storage under such conditions requires relatively rapid consumption. Indeed, the normal distribution system is such that flour reaches shops within six weeks and is consumed within three months of being milled. It can be concluded that the odour, acceptance and texture of meals made out of rice flour with 80 mg/kg fortification level were no different from that of 60 mg/kg fortification. In addition, meals of 80 mg/kg fortification were significantly tastier. Therefore, 80 mg/kg would be a more appropriate degree of fortification of rice flour with iron and zinc as it would also provide more absorbable iron and zinc from meals.

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Table 1: Main ingredients and method of preparing the meals

Name of product	Main ingredients (ratio)	Method of preparation
String hoppers	flour: water (approx. 2:3)	mixed and steamed 8 min
Pittu	flour: water: coconut (5:2:1)	mixed and steamed 10 min
Aluwa	flour: water: tricle (5:2:1)	cooking 10 min at 85° C

Table 2: Acceptability of meals [1]

Product	Sensory attribute	Mean sensory value			
		0 month	1 month	2 month	3 month
60 mg/kg	S. Hoppers	1.41	1.06	0.53	0.31
	Pittu	2.00	1.44	1.00	0.92
	Aluwa	1.18	0.77	0.44	0.31
80 mg/kg	S. Hoppers	1.53	1.41	1.05	0.85
	Pittu	1.83	1.22	1.11	1.54
	Aluwa	1.39	1.17	0.90	0.92
100 mg/kg	S. Hoppers	1.47	1.29	1.16	0.69
	Pittu	2.11	1.44	1.05	0.69
	Aluwa	1.44	0.94	0.32	0.39

[1] There is a significant difference in acceptability of Pittu over Aluwa (p=0.028)

Table 3: Texture of meals[1]

Product	Sensory attribute	Mean sensory value			
		0 month	1 month	2 month	3 month
60 mg/kg	S. Hoppers	2.06	1.06	0.84	0.69
	Pittu	1.39	0.94	0.68	0.62
	Aluwa	1.53	1.12	1.00	0.82
80 mg/kg	S. Hoppers	1.06	0.94	0.84	0.62
	Pittu	1.44	1.28	0.94	1.00
	Aluwa	1.56	1.17	1.05	1.15
100 mg/kg	S. Hoppers	1.12	1.06	0.84	0.08
	Pittu	1.61	1.44	0.74	0.69
	Aluwa	1.50	1.27	0.74	0.54

[1] There is no interaction in texture with food or duration or degree of fortification

Table 4: Odour of meals[1]

Product	Sensory attribute	Mean sensory value			
		0 month	1 month	2 month	3 month
60 mg/kg	S. Hoppers	1.77	1.12	1.05	0.85
	Pittu	2.17	1.56	1.05	1.08
	Aluwa	0.94	0.53	0.63	0.69
80 mg/kg	S. Hoppers	1.65	1.12	1.00	0.69
	Pittu	1.67	1.39	1.37	2.08
	Aluwa	1.39	1.28	1.21	1.23
100 mg/kg	S. Hoppers	1.82	1.47	1.16	0.54
	Pittu	2.06	1.83	1.37	0.92
	Aluwa	0.83	0.78	0.42	0.39

[1] There is a significant difference in odour of Pittu over Aluwa (p=0.009); and String hoppers (p=0.013); 80 mg/kg meals were significantly different from meals of 60 mg/kg (p=0.046); Meals of second month were significant from meals at the end of first month (p=0.004)

Table 5: Taste of meals[1]

Product	Sensory attribute	Mean sensory value			
		0 month	1 month	2 month	3 month
60 mg/kg	S. Hoppers	1.41	1.00	0.74	0.46
	Pittu	2.17	1.44	0.95	0.92
	Aluwa	1.47	0.94	0.58	0.39
80 mg/kg	S. Hoppers	1.41	1.18	0.95	0.92
	Pittu	1.69	1.31	1.11	1.39
	Aluwa	1.28	1.83	1.20	1.23
100 mg/kg	S. Hoppers	1.47	1.06	0.68	0.62
	Pittu	1.50	1.22	0.47	0.54
	Aluwa	0.89	0.56	0.37	0.08

[1] There is a significant difference in taste of meals made from 80 mg/kg from 60 mg/kg (p=0.019) and 100 mg/kg (p=0.001)

Table 6: Average iron intake and zinc intake (mg/day) based on average daily rice flour consumption and proposed iron and zinc content of fortified rice flour

Daily rice flour consumption (g/day) = 140.7 g/d

Fortification level	mg iron/ zinc	mg absorbable (projected)*	
		Iron	Zinc
60 mg/kg	08.44	514.84µg	1173.16µg
80 mg/kg	11.26	686.86µg	1565.14µg
100 mg/kg	14.07	858.27µg	1955.73µg

*Based on bioavailability study (3) on rice flour fortified with iron and zinc at 60 mg/kg; where absorption from 25g of meal – iron 6.1% and zinc 13.9%

Table 7: WHO recommended daily iron and zinc intake for individuals on a low bioavailable diet

Group	iron intake (mg/day)*	zinc intake (mg/day)**
Children	0.71	9.6- 11.2
Male	1.05	9.8
Female	1.46	14.0

* FAO/ World Health Organization report 1988.
** Report of a Joint FAO/WHO/UNU Expert Consultation.1985.