

Original Article

Therapeutic effects of NaFeEDTA-fortified soy sauce in anaemic children in China

Junsheng Huo¹ PhD, Jing Sun¹ BSc, Hong Miao¹ MSc, Bo Yu¹ MSc, Tao Yang¹ BSc, Zhaoping Liu¹ PhD, Chengqian Lu¹ MSc, Junshi Chen¹ PhD, Ding Zhang² MSc, Yuzhen Ma² BSc, Anxu Wang² BSc and Yongli Li² BSc

¹Institute of Nutrition and Food Hygiene, Chinese Academy of Preventive Medicine, Beijing, China

²Henan Center of Disease Control, Zhengzhou, China

The therapeutic effects of NaFeEDTA-fortified soy sauce on anaemic students were investigated. Three hundred and four iron-deficient anaemic school children (11-17 years) were randomly assigned to three treatment groups: control group (consuming non-fortified soy sauce), low-NaFeEDTA group (consuming fortified soy sauce, providing 5 mg Fe/day) and high-NaFeEDTA group (consuming fortified soy sauce, providing 20 mg Fe/day). Blood haemoglobin (Hb) levels were determined before and after 1 month, 2 months and 3 months of intervention. In addition, serum iron (SI), serum ferritin (SF), free erythrocytic porphyrin (FEP), total iron binding capability (TIBC) and transferrin (TF) were measured before and after consumption of soy sauce for 3 months. The results obtained herein show that the parameters measured were not changed remarkably within the 3-month intervention in the control group ($P < 0.05$). However, increased Hb, SI, SF and TF levels and decreased TIBC and FEP levels were observed in both the high-NaFeEDTA group ($P < 0.01$) and the low-NaFeEDTA group ($P < 0.05$). The effectiveness of iron intervention in the low-NaFeEDTA group and high-NaFeEDTA group had no statistical significance after 3 months. It was concluded that nutritional intervention for anaemic students using NaFeEDTA-fortified soy sauce could play a positive role in the improvement of iron status and control of anaemia.

Key words: China, food fortification, Henan, iron deficiency anaemia, NaFeEDTA, soy sauce.

Introduction

Compared with the commonly used iron salt fortificants, NaFeEDTA is characterised by a higher absorption rate in the human body, less adverse effects on the organoleptic profile and intrinsic nature of its food vehicles and less influence on the bioavailability of other minerals.^{1,2} As a result, increasing attention has been focused on the use of NaFeEDTA as a nutrient fortificant. Three major population-based intervention trials, in which NaFeEDTA was used as the iron fortificant, have been conducted:¹ (i) Garby and Areekul's 24-month population trial in Thailand in 1974, in which fish-sauce was selected as the carrier;^{3,4} (ii) Viteri *et al.*'s 20-month population trial using sugar as the carrier in an urban community in Guatemala in 1983;^{5,6} and (iii) Ballot's 24-month population trial in an urban community in South Africa in 1986, in which curry powder was selected as the carrier.^{7,8} These studies showed that administering NaFeEDTA-fortified foods results in a promising improvement in iron deficiency anaemia (IDA) among populations. However, among the three reported trials, only the third trial conducted by Ballot in South Africa was double-blinded.

Iron deficiency anaemia is an important and urgent nutritional problem, and food fortification is considered an indispensable approach eliminating IDA from China. Soy sauce is

a popular traditional condiment in China, making it a candidate for use as a carrier. The studies on soy sauce fortified with ferrous sulphate (FeSO_4) conducted by Dai in 1980s provided convincing results that the consumption of iron-fortified soy sauce improved iron status.⁹⁻¹⁰ Unfortunately, the organoleptic profiles of soy sauce fortified with FeSO_4 were not acceptable because of significant precipitation of the FeSO_4 . Our previous study reported that the absorption rate of iron in NaFeEDTA-fortified soy sauce was up to 10.51% in human subjects. It was higher than that of FeSO_4 , with an absorption rate of 4.73%, suggesting that this fortified food may play a significant role in supplementing iron and thereby protecting against IDA. To investigate the effects of NaFeEDTA-fortified soy sauce on IDA in Chinese populations, a therapeutic trial in juvenile students suffering from IDA was conducted. The results obtained herein will serve as a basis for conducting further population-based effectiveness

Correspondence address: Dr Huo Junsheng, Institute of Nutrition and Food Hygiene, 29 Nanwei Road, Beijing 100050, P. R. China.

Tel: +86 10 63034140; Fax: +86 10 63011875

Email: jshuo@mail.263.net.cn

Accepted 7 September 2001

Table 1. Daily food consumption and iron intake in surveyed students

School	Cereals		Vegetables	Non-staple foods		Condiments	
	Wheat	Rice		Meat and eggs	Salt†	Soy sauce	
School 1							
Weight (g)	527.1	119.9	249.0	15.3	11.8	11.0	
Iron (mg)	14.23	0.85	1.28	0.24	0.13	0.89	
% of total food		69.3‡	26.7	1.6		2.4§	
% of total iron		85.5‡	7.3	1.4		5.8§	
School 2							
Weight (g)	502.0	101.4	260.1	17.4	13.2	12.5	
Iron (mg)	13.55	0.72	1.34	0.28	0.13	1.08	
% of total food		66.6‡	28.7	1.9		2.8§	
% of total iron		83.5‡	7.8	1.6		7.1§	
School 3							
Weight (g)	516.5	109.2	263.3	17.1	12.4	13.0	
Iron (mg)	13.95	0.78	1.33	0.27	0.12	1.12	
% of total food		67.2‡	28.3	1.8		2.7§	
% of total iron		83.8‡	7.6	1.5		7.1§	

†Salt listed here did not include that contributed from soy sauce. Values represent: ‡wheat + rice; §salt + soy sauce.

Table 2. Anaemia prevalence in surveyed students in selected schools

Schools	No. students (11-17 years)		Anaemia prevalence (%)
	Boys	Girls	
School 1 (Control)	849	614	13.5
School 2 (Low NaFeEDTA)	766	634	22.6
School 3 (High NaFeEDTA)	601	544	11.0

Table 3. Effect of iron-fortified soy sauce on haemoglobin levels in students with anaemia (g/L, Mean \pm SD)

Groups	No.	Before intervention	1 month after intervention	2 months after intervention	3 months after intervention
Control	81	116.9 \pm 5.5	117.9 \pm 6.3	118.6 \pm 5.3	118.5 \pm 4.7
Low NaFeEDTA	82	115.4 \pm 5.1	117.2 \pm 8.5	128.4 \pm 7.0 ^{aa,bb}	135.7 \pm 8.5 ^{aa,bb}
High NaFeEDTA	77	116.1 \pm 5.1	124.0 \pm 10.6 ^{aa,bb}	131.6 \pm 11.6 ^{aa,bb}	140.0 \pm 9.5 ^{aa,bb}

Compared with haemoglobin levels before intervention: ^a $P < 0.05$; ^{aa} $P < 0.01$. Compared with the control group: ^b $P < 0.05$; ^{bb} $P < 0.01$.

intervention, with significant differences compared with those in the control group ($P < 0.01$). Two subjects in the low-NaFeEDTA group and one subject in the high-NaFeEDTA group were still suffering from anaemia at the end of the study, and other subjects had all recovered from anaemia. The prevalence of anaemia in the control group, however, was up to 69.5%. The results showed that iron-fortified soy sauce significantly increased Hb levels in students with anaemia.

Effect of iron-fortified soy sauce on serum iron concentrations in subjects

Serum iron concentrations did change significantly after the consumption of soy sauce by the control group. However, in

the low-NaFeEDTA and high-NaFeEDTA groups, SI concentrations were increased by 30 $\mu\text{g/dL}$ and 24 $\mu\text{g/dL}$, respectively, after 3 months of intervention (Table 4).

Effect of iron-fortified soy sauce on serum ferritin concentrations in subjects

There was no significant change in SF concentration in the control group before or after the consumption of soy sauce (Table 4). However, the SF concentrations of both the low-NaFeEDTA group and the high-NaFeEDTA group increased significantly after consuming iron-fortified soy sauce ($P < 0.01$). Furthermore, the SI concentrations in these two iron intervention groups were significantly higher than in the control group ($P < 0.01$).

The present study shows that NaFeEDTA-fortified soy sauce is highly effective in treating IDA. It presented evidence that this fortified soy sauce could be recommended for potential wider use in China. Based on the well-established processes in our Institute, NaFeEDTA made with the same specifications as products from other foreign companies is currently available. NaFeEDTA-fortified soy sauce has been approved for manufacture systemically in two big food industries by the Chinese Ministry of Health. In addition, NaFeEDTA-fortified soy sauce will be an acceptable condiment for the public in that its cost is only 20 cents higher than traditional soy sauce, per serving (500 mL). There is a promising future for IDA elimination in China through food fortification. To obtain further data supporting its effect on IDA and to put it into application sooner, however, it is necessary to carry out further studies on NaFeEDTA-fortified soy sauce, including large scale intervention trials in populations with high anaemia prevalence.

References

1. Hurrell RF. Preventing iron deficiency through food fortification. *Nutr Rev* 1997; 55: 210-222.
2. Hurrell RF, Ribas R, Davidsson L. Sodium iron EDTA as a food fortificant: Influence on zinc, calcium and copper metabolism in the rat. *Br J Nutr* 1994; 71: 85-93.
3. Garby L, Areekul S. Iron supplementation in Thai fish-sauce. *Ann Trop Med Parasitol* 1974; 64: 467-476.
4. Garby L. Condiments. In: Clydesdale FM, Wiemer KL, eds. *Iron Fortification of Foods*. Orlando, FL: Academic Press, 1985; 165-170.
5. Viteri FE, Alvares E, Torun B. Prevention of iron deficiency by means of iron fortification of sugar. In: Vnderwood BA, ed. *Nutrition Intervention Strategies in National Development*. New York: Academic Press, 1983; 287-314.
6. Viteri FE, Garcia-Ibanez R, Torun B. Sodium iron NaFeEDTA as an iron fortification compound in Central America. *Am J Clin Nutr* 1978; 32: 961-971.
7. Ballot DE, Macphail AP, Bothwell TH, Gillooly M, Mayet FG. Fortification of curry powder with NaFe (III) EDTA in an iron-deficient population: Report of a controlled iron-fortification trial. *Am J Clin Nutr* 1989; 49: 162-169.
8. Ballot DE, Macphail AP, Bothwell TH, Gillooly M, Mayet FG. Fortification of curry powder with NaFe (III) EDTA in an iron-deficient population: Initial survey of iron status. *Am J Clin Nutr* 1989; 49: 156-161.
9. Dai RT. Study on iron fortified soy sauce I. Primary study on FeSO₄ fortified soy sauce. *Acta Nutrimenta Sinica* 1984; 6: 149-153 (in Chinese).
10. Dai RT. Study on iron fortified soy sauce II. Absorption of iron fortified soy sauce in human. *Acta Nutrimenta Sinica* 1984; 6: 231-238 (in Chinese).
11. Wang XS, Yin T-A, Liu JP, Wang WG, Yan HC, Gao XL. *Methods for Evaluation of Nutritional Status in Humans*. Tianjin: Tianjin Science and Technology Press, 1989; 4-31 (in Chinese).
12. Wang XS. Methods for biochemical determinations. In: Wang XS, Yin TA, Liu JP, Wang WG, Yan HC, Gao XL, eds. *Methods for Evaluation of Nutritional Status in Humans*. Tianjin: Tianjin Science and Technology Press, 1989; 139-141.
13. Chen XC. *Applied Nutrition*. Beijing: Public Health House, 1984; 292-296 (in Chinese).
14. Ge KY. *The Dietary and Nutritional Status of Chinese Population in 1990s*. National Nutrition Survey, 1992, vol. 1. Beijing: People's Public Health House, 1996 (in Chinese).