J. Agric. Sci. Mansoura Univ., 27 (9): 6063 - 6070, 2002

BIOAVAILABILITY OF IRON IN CONCENTRATED SUGAR CANE JUICE PRODUCED IN EGYPT

Masoud, M. S.
Central Lab. For Food and Feed .Agricultural Research Center.Giza, Egypt

ABSTRACT

The present work was carried out to evaluate the bioavailability of iron present in concentrated sugar cane juice (CSCJ) produced in Egypt.

A number of 70 samples of CSCJ were analyzed for iron by using atomic absorption flame photometer .

Weanling male albino rats were used to determine the availability of iron in CSCJ compared with ammonium ferric citrate (AFC) Amount of iron from different sources were offered to cover the requirements. Improvement in Hb concentration was 1.96 % with (AFC) alone. The apparent digestibility of iron was 77.86 % for the above mentioned treatment.

Feeding rats on diets where the main source of iron was CSCJ gave negative Hb and negative apparent digestibilities results. The study indicated that iron in CSCJ is not only unavailable but it is suggested that factors present in CSCJ hinder the use of available iron from other sources which are well known to have high iron availability.

INTRODUCTION

In Egypt CSCJ is produced as a by-product of sugar industry, and is used for alcohol production, as a binder in animal feed industry, for the production of fodder yeast and for human consumption. Small factories produce CSCJ (Golden syrup) for human consumption from concentrated sugar cane. It was reported that Egypt produced 52297 tons of CSCJ on the year 1996-1997 (El Ammari *et.al.*, 1998). The CSCJ is used for human consumption as it is or as an ingredient in some sweetened products.

In Egypt it is believed that CSCJ nutritionaly is a good source for iron. No published work could be traced on the iron content and its availability of CSCJ produced in Egypt.

The purpose of the present study is to investigate the iron concentration in concentrated sugar cane juice collected from different locations in different governorates in Egypt and its availability.

MATERIALS AND METHODS

Concentrated sugar cane juice (CSCJ):

A number of 70 samples of CSCJ were collected from Cairo Governorate (Shoubra, Abassia , Heliopolis and Nasr city), Kalubia Governorate (Kalub) and Giza Governorate(Abokorkas, El-Badrasheen and El Hawamdia) .

Sugar Cane juice:

Sugar cane juice was prepared using suger cane available in Giza Governorate which was squeezed using wooden squeezer to determine the amount of iron to be compared by CSCJ content.

Animals:

20 weanling male Albino rats, with an average weight of 75 g (from Nasr Co. for pesticides, Egypt) were housed individually in plastic cages. Five rats were allocated for each treatment. They were fed on the experimental diets from day one to day four as a pre-experimental period then after 3 hours fasting they were fed from day five to day nine on the same diet as an experimental period presented in Table 1.

Faeces were collected from the start of the experimental period till the end of the experiment. Samples of blood were drawn from eyes of the rats at the beginning and the end of the experimental period. Water was allowed during the whole period. Three hours fasting period at the end of the pre-experimental period and the end of the experimental period was practised.

Experimental diets and treatments:

Three different amounts of iron (being 186.6, 117.1 and 60.98 mg Fe /Kg concentrated sugar cane juice were incorporated in diets for treatments 2,3and 4 respectively ,on expense of sucrose and part of starch

Diet (1): a reference diet was formulated according to Eggum (1973) with a mineral mixture containing ammonium ferric citrate to supply 19 mg Fe/kg diet with a total 35 mg Fe/kg diet.

Diet (2):containing 35 mg Fe/ kg diet as follows :

19.0 mg Fe /kg diet representing 54.29 % of dietary iron was supplied by 101.8 g CSCJ obtained from sample no. (68) containing 186.6 mg Fe / kg while 16.0 mg Fe/kg representing 45.71 % of dietary iron was obtained from feed ingredients.

Diet (3): containing 35.0 mg Fe / kg diet as follows:

19.0 mg Fe /kg diet representing 45.71 % of dietary iron was supplied by 162.3 g CSCJ obtained from sample no. (69) containing 117.1 mg Fe /kg while 16.0 mg Fe /kg representing 45.71 % of dietary iron obtained from feed ingredients.

Diet (4): containing 35.0 mg Fe/ kg diet as follows :

9.9 mg Fe/kg diet representing 28.29 % of dietary iron was supplied by 162.3 g CSCJ obtained from sample no. (70) containing 60.98 mg Fe/kg. Also 9.1 mg Fe / kg diet was obtained from ammonium ferric citrate representing 26.0% of dietary iron to increase the iron up to the level of the reference diet. While 16.0 mg Fe / Kg representing 45.71 % of dietary iron was obtained from feed ingredients.

Measurements:

Food intake of every rat was calculated during the experimental period.

Iron concentration in feed ingredients, concentrated sugar cane juice and faeces was determined using Atomic Absorption Flame Photometer (perkin Elmer Model 3300) according to A.O.A.C. (1990) .

Hemoglobin concentration (Hb): in blood samples was determined according to Decie and Lewis (1975).

Percent of changes in blood Hb was calculated as follows:

$$\frac{\text{Blood Hb at the end of the experiment - Blood Hb at the start}}{\text{Blood Hb at the start}} \times 100$$

Apparent digestibility of iron was calculated as follows :

$$\frac{\text{mg Fe in food - mg Fe in faces}}{\text{mg Fe in food}} \times 100$$

Table (1) Composition and calculated Fe content of the experimental diets.

	diet 1	diet 2	diet 3	diet 4
G / kg				
Sucrose	74.0			
Starch	674.0	646.2	585.7	585.7
Concentated sugar cane juice (CSCJ)[4]	-	101.8	162.3	162 3
Maize oil	44.0	44.0	44.0	44.0
Cellulose	44.0	44.0	44.0	44.0
Casein	111.0	111.0	111.0	111.0
Min. mixture[1]	38.0	-	-	38.0
Min. mixture-Fe[2]	-	38.0	38.0	-
Vitamin mixture [3]	15.0	15.0	15.0	15.0
Total	**1000.0**	**1000.0**	**1000.0**	**1000.0**
Iron from ammonium ferric citrate (AFC)	19.0	-	-	9.1*
Iron from (CSCJ)	-	19.0	19.0	9.9
Iron from ingredients	16.0	16.0	16.0	16.0
Total mg Fe/kg diet	35.0	35.0	35.0	35.0

(1) Mineral mixture------------------According to Eggum (1973)
(2) Mineral mixture – Fe--------------The same as 1, excluding AFC
(3) Vitamin mixture -----------------According to Eggum (1973)
(4)Concentrated sugar cane juice used in experimental diets were those No.68, 69 and 70 shown inTable 2 for diets 2,3 and 4.
*(5) * ammonium ferric citrate (AFC.) added to cover 9.1 mg Fe/kg diet.*
(6) Diet 2: containing 186.6 mg Fe / Kg from 101.8 g CSCJ.
(7) Diet 3: containing 117.1 mg Fe / Kg from 162.3 g CSCJ.
(8) Diet 4: containing 9.9 mg Fe / Kg (162.3 g) from CSCJ (containing 60.98 mg Fe / kg).

Table (2): Fe content of the experimental diets and its source.

Treatment No.	Total Fe mg/kg	Fe sources in the experimental diets						Amount of CSCJ used g/ kg
		CSCJ		Feed ingredients		AFC		
		mg/kg diet	% of total Fe	mg/ kg diet	% of total Fe	mg/ Kg diet	% of total Fe	
1	35.0	-	-	16.0	45.71	19.0	54.29	-
2	35.0	19.0	54.29	16.0	45.71	-	-	101.8
3	35.0	19.0	54.29	16.0	45.71	-	-	162 3
4	35.0	9.9	28.29	16.00	45.71	9 1	26.0	162.3

AFC : Ammonium ferric citrate.
CSCJ : concentrated sugar cane juice .
All feed ingredient were analyzed for Fe content. Calculations were made for Fe content of every diet's ingredients.
Ammonium Ferric citrate (A.F C) was added to increase the added Fe to the level of diet's

RESULTS AND DISCUSSION

(1) Iron in concentrated sugar cane juice and sugar cane juice :

Iron concentration in 70 samples taken from different localities ranged from 25.37 sample (9)to 186.6 mg Fe /Kg sample (68) (Table 3).

The sugar cane juice produced by squeezing sugar cane in wooden squeezer (to prevent any iron contamination of the juice) contained 10 mgFe /Kg.

The wide range of iron concentration in concentrated sugar cane juice may be due to contamination from iron squeezers as well as different sugar cane breeds and different cultivation localities.

Table 3: Iron concentration in concentrated sugar cane juice ought from different localities

Place	No. of sample	Fe mg / Kg concentrated sugar cane juice
SHOUBRA	1	26.93
	2	26.50
	3	27.31
	4	33.13
	5	33.97
	6	30.59
	7	32.56
	8	35.74
	9	25.37
	10	25.64
	11	33.18
	12	33.42
	13	48.18
	14	46.51
	15	26.44
ABASSIA	16	29.30
	17	34.48
	18	34.66
	19	36.21
	20	38.83
	21	56.28
	22	51.19
	23	92.92
	24	71.20
	25	104.2
	26	101.05
KALUOB	27	43.49
	28	39.14
	29	54.78
	30	45.36
ABO KORKAS	31	105.66
	32	105.16
	33	84.48
	34	83.93
	35	97.43
	36	98.21
HELIOPLIS	37	72.07
	38	73.08
	39	53.99
	40	49.28
	41	60.93
	42	58.23
	43	68 75
	44	64.05

Table (3): Continue

NASR CITY	45.	101.01
	46.	102.01
	47.	34.49
	48.	45.44
	49.	42.62
	50.	47.31
	51.	47.83
	52.	43.71
	53.	58.52
	54.	56.26
	55.	52.08
	56.	86.06
	57.	78.85
EL-HAWAMDIA	58.	92.28
	59.	103.50
	60.	102.65
	61.	44.37
	62.	105. 82
	63.	92.76
	64.	82.55
	65.	38.44
	66.	38.82
	67.	10.00
	68.	186.6
	69.	117.1
	70.	60.98

(2) Effect of feeding concentrated sugar cane juice with different iron content on changes in blood Hb concentration:

The percentage of changes in blood Hb concentration in the different treatments are shown in Table (4). When iron sources in the rat diet were from food ingredients (16.0 mg Fe / Kg =45.71% of total iron) and ammonium ferric citrate (AFC) (19.76 mg Fe/Kg = 54.29% of total iron in the diet), having a total iron supply of 118.35 mg Fe / Kg, [treatment 1] , blood Hb concentration increased by +1.96% being the highest increase in the present experiment. Changes in blood Hb in the three treatments were negative, being – 13.74, -16.69 and –10.41 % respectively. For treatments 2 and 3 having the same concentration of iron (i.e. 35.0 mg Fe /Kg diet, respectively) and also the same contribution to iron from concentrated sugar cane juice (Ca 54.29 %), the results of Hb were highly negative. Treatment 4 having the lowest decrease in Hb concentration (-10.41%) .

Feeding diet 4 caused decrease of –10.41 % in blood Hb concentration. In treatment 4, CSCJ were added on the expense of sucrose and part of the starch , the other components were the same as treatment 3. The recommended requirements being 35mg Fe /Kg diet NRC (1978). The only factor that may have influenced the availability of Fe in treatment 4 is the addition of concentrated sugar cane juice.

Table (4): Average of Hb, changes % and apparent digestibility of Fe of rats feed CSCJ as a source of Fe compared to those fed AFC

	Concentrated sugar cane juice % Fe (CSCJ)	Ammonium ferric citrate % Fe (AFC)	Changes in Hb concentration %	Apparent Fe digestibility %
1	-	54.29	+ 1.96	+77.86
2	54.29	-	-13.74	-24.40
3	54.29	-	-16.69	-29.64
4	28.29	26.0	-10.41	-18.49

(3) Effect of feeding concentrated sugar cane juice with different iron content on the apparent digestibility of iron:

The apparent digestibility of iron (AD Fe) is shown in Table 4. It can be noticed that the AD Fe for treatment 1 using the reference diet was the highest when compared with other treatments, being 77.86 %, when using AFC as the main source of iron (composing about 54.29% of total iron in diet 1)

The apparent digestibilities of iron (AD Fe) in treatments 2 and 3 were negative, where concentrated sugar cane juice supplied iron in addition to the content of food ingredients This emphasis that iron in concentrated sugar cane juice is poorly digested.

When concentrated sugar cane juice was added to contribute 28.29 % of the total iron in diet 4, while AFC contributed 26.0 % the AD Fe was reached to – 18.49%. It is rational to assume that the negative digestibility may be due to the inclusion of CSCJ in treatment 4. This could be interpretated in (a) iron in concentrated sugar cane juice seems to be in a form poorly digested and / or (b) factors found in concentrated sugar cane juice that negatively affect the digestibility of iron .

Most of the work carried out on iron availability, used the changes in heamoglobin concentration (Fritz *et al.*, 1970), or the relative bioavailability value, i.e. hemoglobin concentration of different levels of reference salt ($FeSO_4 .7H_{2O}$) compared to the hemoglobin concentration in the sample. Also tracing techniques using ^{59}Fe has been reported In literature (Pla and Fritz, 1970, Gislason *et al.*, 1992and Ammerman *et al.*, 1967).

In the present work two measures used, i.e. changes in Hb concentration and iron digestibility. The comparison of the two measures (Table 4) gave almost the same trend.

CONCLUSION

From the results obtained in the present study it is clear that we have put the bioavailability of iron in concentrated sugar cane juice in our consideration . Moreover, the results obtained give the impression that other factors in concentrated sugar cane juice may hinder the use of the available iron from other sources, with different plan of nutrition and different management conditions. More detailed work in this respect is required.

ACKNOWLEDGEMENT

The author would like to thank Microbiologist M. Eassawy for performing the blood analysis.

REFERENCES

A.O.A.C.(1990). Official Methods Analysis of the Associated of Official Analytical Chemists. (Edited by Kenneth Helrich) Arlington. Virginia. USA.

Ammerman, C. B.; J. M. Wing; B. G. Dunandnt; W. K. Robertson; J. P. Feaster and L. R. Arrington (1967). Utilization of inorganic iron by ruminants as influenced by form of iron and iron status of the animal. J. Animal Sci., 26:404.

Decie, J.V. and lewis, S.M. (1975). Practical hematology. Fifth edition Churchill Livingston, Edinburgh, London and New York, 241-246.

Eggum B. O. (1973). Study of certain factors influencing protein utilization in rats and pigs. Ph.D.Thesis Institute of animal science and royal veterinary and Agriculture University Copenhagen.

El-Ammari, T.S.; M. A. Osman and Yousreia S. Metwally. (1998). An economie study of production and marketing golden syrup in Egypt, J.Agric Sci. Mansoura Univ., 23(8). August,1998.

Fritz J. C. G. W. Pla.; J. Roberts; J. W. Boehne and E. L. Hore (1970). Biological in animals of iron from common dietary sources. J. Agric. Food Chem., 18:647.

Gislason, J. B.; J. B. Lonnerdal and L. Hamlraeus (1992). Iron absorption deffers in piglets fed extrinsically and intrinsically ^{59}Fe - Labeled Sow's milk J. Nutrition, 122 : 1287.

NRC (1978). Nutrient requirements of laboratory animals - Thired revirsed edition number 10. National Academy of Sciences Washington, D.C. 1978.

Pla., G. W. and J. C. Fritz (1970). Availability of iron. J. Assoc. off Anal. Chem., 53:791.

الإتاحة البيولوجية للحديد الموجود في عصير قصب السكر (العسل الأسود) المنتج في مصر

محمد سيد مسعد مسعود

المعمل المركزى للأغذية والأعلاف مركز البحوث الزراعية - الجيزة

تهدف الدراسة التي أجريت إلى قياس درجة الإتاحة البيولوجية للحديد في العسل الاسود المنتج في مصر .
وأستخدم لذلك فئران تجارب جنس البينو لتقدير الإتاحة البيولوجية للحديد بالمقارنة بسترات الأمونيوم الحديدية
كان التحسين في تركيز الهيموجلوبين ١,٩٦ % وكانت النسبة الهضمية الظاهرية للحديد +٧٧,٨٦% عند تغذية الفئران على غذاء مدعم بسترات الأمونيوم الحديدية فقط أما إضافة سترات الأمونيوم الحديدية المضاف إليها العسل الأسود فقد نتج عنها نقص في نسبة الهيموجلوبين .
عند تغذية الفئران على غذاء المصدر الرئيسي للحديد به هو العسل الأسود أعطت تحسنا سالبا في نسبة الهيموجلوبين وكذلك نسبة هضمية ظاهرية للحديد سالبة .
أوضحت الدراسة أن الحديد الموجود في العسل الأسود ليس فقط غير متاح بيولوجيا ولكن قد يكون هناك عوامل اخرى تؤثر على الإتاحة البيولوجية للحديد في الغذاء حتى لو اشتمل على مصادر أخرى معروف أنها ذات درجة إتاحة بيولوجية عالية .