Effect of Vitamin A on Iron Bioavailability in Sponge Cakes

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ABSTRACT

The current investigation aimed to study the possibility of preparing sponge cake product fortified with different levels of blanched carrots and ferrous sulphate. Iron bioavailability also evaluated using depletion repletion technique. Trials had been made by using different levels of blanched carrots 10%, 20%, 30% and 40%, and also fortified with ferrous sulphate at levels of 4, 6, 8, 10 and 12 mg/100 g edible portion. The obtained data showed significant differences in moisture, crude protein, crude fiber, and carotene contents of sponge cakes. Biological results showed that group of rats fed on sponge cakes enriched with 30% blanched carrots and fortified with ferrous sulphate at level of 10 mg had increased blood haemoglobin, haematocrit level, TIBC, serum iron and organs weight, which indicated high absorption and bioavailability of iron. Also there were non significant sensorial differences between all sponge cakes samples before and After fortification with ferrous sulphate.

INTRODUCTION

Several studies have suggested that lack of vitamin A in human and experimental animal may result in anemia (Mejia *et al.,* 1979). They indicated that vitamin A deficiency alters the metabolism of iron. In wheat and the most other grains, β-carotene is present in only a trace amount (Heinon *et al.*, 1989).

Carrots is a very important source of vitamin A. Total carotenoides in carrots are 16000 – 20000 (IU), (El-Gharably, 1993).

Iron deficiency is responsible for anemia hypochronic, microcytic, growth failure, hyperactivity (Nelson, 1994).

When experimental subject is fed a diet deficient in both retinol and carotene, plasma levels fall and the body pool shrinks to less than half the control value (Isselbacher *et al.*, 1994).

Studies in both human and laboratory animals have shown that vitamin A deficiency can contribute to nutritional anemic and vitamin A supplementation can have positive effects on iron status (Suharno and Muhilal, 1996).

Viteri (1999) stated that iron supplementation is a public health strategy designed for the prevention of iron deficiency and its consecutive anemia. Brabin *et al.* (2001) found that the percentage of deaths due to anemia was comparable for reports from highly malaria's area in Africa.

Therefore this investigation was undertaken to:

1- Manufacture sponge cakes from wheat flour substituted with blanched carrots (as a source of vitamin A) at different percentages 10%, 20%, 30% and 40%, fortified with ferrous sulphate at levels of 4, 6, 8, 10 and 12 mg/100 g.
2- Evaluate iron bioavailability of sponge cakes fortified with ferrous sulphate and its relation with vitamin A content.

MATERIALS AND METHODS

Materials:

Wheat flour (*Triticum vulgare*), 72% extraction rate, variety Sakha 69, was obtained from Sakha Agricultural Research Center.

- Carrots (*Daucus carota*) and other materials, *e.g.*, commercial grade crystal sucrose, baking powder, eggs and vanillin were obtained from local market, Mansoura, Egypt. Carrots were prepared by carefully washing and blanched by steaming for about 10 minutes, then smashed.
- Ferrous sulphate and vitamins used in this study were purchased from Sigma Chem. Co., Cairo.

Methods:

Preparation of sponge cakes:

Sponge cakes were manufactured from 100% wheat flour (control) and wheat flour with 10%, 20%, 30% and 40% blanched carrots using the formulae, 225 g wheat flour, 150 g sugar, 20 g baking powder, 10 g vanillin and 7 eggs (385 g).

Physical evaluation of sponge cakes:

Sponge cakes samples were packed in polyethylene bags after one hour of cooling and subjected to the following determinations according to the method described by Abd El-Magied (1991)

a) Thickness (cm).

b) Weight (g).

c) Volume (cm^3).

Chemical analysis:

Moisture, crude protein, crude fat, crude fiber, and ash content were determined according to the methods outlined in AOAC (1995), while total carbohydrates were calculated by difference.

Iron was determined according to the method of Pearson (1970) using the atomic absorbation method (Pye Unicum Model 3300) at Chemistry Department, Faculty of Science, Mansoura University, Egypt.

Vitamin A (as carotenoids) was determined according to the method described by Wettesten (1957).

Sensory evaluation:

Sponge cakes were cut after cooling into slices and the sensory evaluation was assesed by 15 panelists as described by McCullough *et al* (1986).

Bioavailability of iron:

Depletion repletion method for the determination of iron bioavailability was carried out according to Ranhotra *et al.* (1983).

Animals experiments:

Animals:

Weanling male albino rats of about 23 days old with an average weight (45-50 g) were housed individually in wire bottomed cages, temperature and humidity were maintained at 25°C and 60%, respectively. Lighting was regulated to provide 12 hrs light and 12 hrs darkness. Food and deionized water were provided ad libitum.

The composition of the basal depletion diet was as follows:

Casein 11.20%, corn oil 13.30%, starch 66.50%, cellulose 4.00%, salt mixtures (iron free) 4.00%, vitamin mixtures 1.00%. The composition of free iron mineral mixtures and vitamin mixtures were recommended by the American Institute of Nutrition (AIN, 1977).

Blood analysis:

Five ml intravenous blood were withdrawn from each animal, 1 ml was collected in a tube containing EDTA (ethylene diaminetetraacetic acid) as anticoagulant and shaked well for the determination of haemaglobin and haematocrit value. The rest of the sample (4 ml) were collected in sterilized dry centrifuge tubes, left to colt, and the serum were separated after centrifugation for 10 min at 300 rpm, then the serum was kept frozen at -20°C in clean dry plastic tubes for the determination of serum iron, total iron binding capacity (TIBC), and detection of the level of vitamin A.

Depletion and repletion assay:

All animals were fed on the free iron depletion diet for six weeks until the blood haemoglobin (HB) level dropped to about 8-9 mg/100 ml. Blood samples were collected from the tested rats throughout the experiment.

The depleted rats were fed on fortified cakes. Rats were weighted weekly. Food intake was recorded daily. At the end of the experiment after four weeks, rats were sacrified. The blood haemoglobin concentration was determined using the cyanmethemoglobin procedure, also haematocrit is defined as the volume occupied by erythrocytes in a given volume of blood, and serum iron was determined using 2, 2 dipyredyl method as recommended by Dacie and Lewis (1984). While the total iron binding capacity (TIBC) was measured according to the method described by The International Committee for Standardization in Haematology (1978).

Statistical analysis:

Chemical composition, physical, organoleptic and biological evaluation were statistically analyzed using analysis of variance and of the least significant difference as mentioned by Steel and Torrie (1980). Significant differences were determined at the $P < 0.05$ level. All the analyses were carried out in triplicates.

RESULTS AND DISCUSSION

Chemical composition:

The chemical composition of wheat flour, blanched carrot, and sponge cakes with and without blanched carrot at levels of 10%, 20%, 30% and 40% are shown in Table (1). Data indicated that significant differences were observed among wheat flour and blanched carrot in their moisture, crude protein, crude fat, crude fiber, ash, total carbohydrate, vitamin A, and iron contents. Also significant differences were observed in moisture, crude protein, crude fiber and vitamin A contents of sponge cakes enriched with blanched carrots at different levels. However, non significant differences were observed in crude fat and iron content of sponge cakes enriched with 20%, 30% and 40% blanched carrots. Blanched carrot had significantly higher moisture, crude fiber, vitamin A and iron contents (89.20%, 7.8%, 33.00 and 7.0 mg%, respectively) as compared with other samples. These findings are coincided with those reported by Ismail *et al.* (2000).

Fortification:

It was found that the content of iron in sponge cakes was present in small amount. Therefore, sponge cakes were fortified with ferrous sulphate at levels of 4, 6, 8, 10 and 12 mg/100 g.

Results given in Table (2) represented the quantity (g) of food intake, body weight gain and haemoglobin levels before and after fortification with ferrous sulphate during depletion repletion period. It could be noticed that body weight gain in group of rats fed on sponge cakes made from wheat flour and sponge cakes of wheat flour substituted with 10%, 20%, 30% and 40% carrots fortified at a level of 10 mg of ferrous sulphate were 25.00, 25.55, 25.80, 26.70 and 25.46 g, respectively, which had significantly a good results. These results confirmed previous observations in experimental animals (Meija *et al.*, 1979), who showed an association between vitamin A nutritional status and anemia.

Also data in the same Table show the improvement in haemoglobin levels for all the tested groups of rats fed with fortified sponge cakes with ferrous sulphate, in this respect sponge cakes made from wheat flour or wheat flour substituted with blanched carrots at different levels recorded significantly higher levels of blood haemoglobin than unfortified samples throughout the repletion assay.

It could be noticed that sponge cakes with or without substitution of blanched carrots at different levels had significantly good results of haemoglobin at a level of ferrous sulphate of 10 mg/100 g and increasing the level of ferrous sulphate to 12 mg/100 g decreased haemoglobin level.

Also data revealed that sponge cakes substituted with 30% blanched carrots and fortified with ferrous sulphate significantly showed the best result with using the best level of ferrous sulphate of 10 mg/100 g.

These results are coincided with those reported by Mejia and Chew (1988) and Suharno and Muhilal (1996), who indicated that the presence of vitamin A can improve the haematological condition of anemia and increase the haemoglobin level.

Also it could be observed that sponge cakes containing 40% blanched carrots had less amount of blood haemoglobin as compared with sponge cakes containing 30% blanched carrots. This may be due to the increasing levels of fibers.

The present results are in accordance with those reported by Reinhold *et al.* (1975), Ismail-Beigi *et al.* (1977) and Guthrie (1983), they indicated that high fiber or cellulose in the diet decrease the utilization of iron or iron availability

It could be noticed from results in Table (3) that the haematocrit levels of basal diet group were significantly the highest (44.90%), while the other groups of rats fed with diet (free from iron) were in decrement slope throughout the depletion period, while after repletion period a marked difference was found among all samples. In this respect group of rats fed on sponge cakes (control) was significantly the lowest level of haematocrit, while sponge cakes substituted with 30% blanched carrots was significantly the highest at all levels of ferrous sulphate.

These results are corresponding with those reported by Mejia and Chew (1988) and Bloem *et al.* (1989), who indicated that rats fed with samples fortified with iron plus vitamin A increased the haematocrit levels in blood, they also found a significant positive correlation between haematocrit and vitamin A levels of preschool anemic children. The same Table shows that serum iron concentration of rats fed with sponge cakes (control 100% wheat flour) was significantly the lowest after depletion and repletion period, while group of rats fed on sponge cakes enriched with 30% blanched carrots was significantly the highest at all fortification levels of ferrous sulphate. In this concept, our results are in agreement with those reported by Mejia *et al.* (1979); Bloem *et al.* (1989) and Roodenburg *et al.* (1995), they indicated that vitamin A has been shown to affect iron status in humans and the deficiency in vitamin A has been shown to affect iron status in humans and the deficiency in vitamin A reduced the levels of serum iron.

Table 1 Chemical composition of wheat flour, blanched carrot and sponge cakes made from wheat flour and its blends (D.W.B.).

Samples	Moisture %	Crude protein %	Crude fat %	Crude fiber %	Ash %	Total carbohydrate %	Vitamin A (mg/100 g)	Iron (mg/100 g)
Wheat flour (WF)	10.60^{a}	9.65^{a}	1.00^{a}	0.54^{a}	0.60^{a}	88.21^{a}	1.07^{a}	1.30^{a}
Blanched carrot (BC)	89.20^{b}	6.20^{b}	1.20^{b}	7.8^{b}	4.90^{b}	79.90^{b}	33.00^{b}	7.00^{b}
Sponge cake (Control)	19.10^{c}	20.52^{c}	3.00^{c}	1.06^{c}	1.20^{c}	74.22^{c}	1.43^{c}	4.50^{c}
Sponge cake 90% WF + 10% BC	21.52^{d}	19.07^{d}	3.08^{d}	1.23^{d}	1.39^{c}	75.23^{d}	3.69^{d}	4.75^{c}
Sponge cake 80% WF + 20% BC	23.43^{e}	17.65^{e}	3.12^{e}	2.[illegible]^{e}	1.94^{d}	75.27^{d}	6.94^{e}	5.00^{d}
Sponge cake 70% WF + 30% BC	25.76^{f}	16.21^{f}	3.13^{e}	2.57^{f}	2.31^{e}	75.78^{e}	10.20^{f}	5.25^{d}
Sponge cake 60% WF + 40% BC	27.84^{ab}	14.77^{ab}	3.16^{e}	3.15^{ab}	2.48^{e}	76.44^{f}	13.46^{ab}	5.30^{d}

WF, Wheat flour; BC, Blanched carrots; D.W.B., dry weight basis.
Means values in the same column marked with the same letter are not significantly different (P>0.05).

Table 2. Effect of feeding with sponge cake and its blends before and after fortification with ferrous sulphate at different levels on body weight gain and blood haemoglobin levels (Hb) g/100 ml.

Group	$FeSO_4$ level	Food intake (mg)	Body weight gain (g)	Haemoglobin after depletion	Haemoglobin during repletion			
					First week	Second week	Third week	Fourth week
Group of basal diet	-	247^{a}	16.2^{a}	14.87^{a}	14.91^{a}	14.93^{a}	15.01^{a}	15.20^{a}
Sponge cakes (Control) 100% WF	0	276^{b}	19.3^{b}	9.30^{b}	10.17^{b}	10.53^{b}	10.90^{b}	11.00^{b}
	4	312^{c}	22.51^{c}	9.55^{c}	11.00^{c}	12.10^{c}	12.43^{c}	13.50^{c}
	6	305^{d}	23.29^{d}	9.68^{c}	11.07^{c}	12.33^{d}	12.81^{d}	13.97^{d}
	8	280^{b}	24.88^{e}	9.75^{d}	11.21^{d}	12.63^{e}	13.90^{e}	14.16^{e}
	10	366^{e}	25.00^{f}	10.00^{e}	11.32^{d}	12.86^{f}	13.95^{e}	14.84^{f}
	12	315^{c}	24.80^{e}	9.69^{c}	11.30^{d}	12.63^{e}	13.91^{e}	14.65^{ef}
Sponge cakes 90% WF + 10% BC	0	356^{f}	22.32^{c}	9.88^{d}	10.15^{b}	10.36^{ab}	10.69^{f}	11.10^{b}
	4	337^{ab}	23.84^{ab}	10.01^{e}	11.00^{c}	12.89^{f}	13.36^{abc}	13.53^{c}
	6	298^{cd}	24.50^{e}	10.10^{f}	11.55^{e}	13.51^{cd}	13.97^{e}	14.10^{e}
	8	265^{bd}	25.37^{f}	10.15^{f}	11.67^{e}	13.62^{cd}	14.43^{ab}	14.86^{f}
	10	254^{ed}	25.55^{ef}	10.20^{ab}	12.00^{f}	13.85^{abc}	14.59^{bd}	15.00^{cd}
	12	315^{c}	25.63^{ef}	10.20^{ab}	12.00^{f}	13.54^{cd}	14.56^{bd}	14.83^{f}
Sponge cakes 80% WF + 20% BC	0	300^{d}	22.48^{c}	9.54^{c}	10.77^{ab}	11.00^{ec}	11.10^{ef}	11.15^{b}
	4	280^{b}	23.66^{ab}	9.73^{c}	11.50^{e}	12.31^{d}	12.48^{c}	12.57^{ab}
	6	317^{c}	24.39^{ed}	10.50^{e}	11.85^{ed}	13.28^{ef}	13.53^{cd}	13.65^{bd}
	8	270^{bd}	24.97^{e}	10.11^{f}	12.00^{f}	13.60^{cd}	14.59^{bd}	14.82^{f}
	10	257^{ed}	25.80^{ef}	10.15^{f}	12.10^{f}	13.95^{ed}	14.55^{bd}	15.00^{cd}
	12	320^{ef}	25.00^{f}	9.98^{e}	12.10^{f}	13.57^{ed}	14.40^{ab}	15.00^{cd}
Sponge cakes 70% WF + 30% BC	0	319^{ef}	22.94^{bd}	9.95^{e}	10.84^{ab}	10.95^{ec}	11.00^{ef}	11.15^{b}
	4	290^{cd}	23.64^{ab}	10.00^{e}	12.00^{f}	13.10^{bd}	13.55^{cd}	13.57^{c}
	6	339^{abc}	24.77^{e}	10.10^{f}	12.10^{f}	13.15^{bd}	14.44^{ab}	14.84^{f}
	8	277^{b}	25.29^{f}	10.25^{ab}	12.30^{cd}	13.96^{ed}	15.00^{a}	15.46^{ec}
	10	330^{ec}	26.70^{abc}	10.30^{ab}	12.50^{bd}	14.00^{ed}	15.20^{ed}	15.60^{ed}
	12	295^{cd}	26.69^{abc}	10.13^{f}	12.50^{bd}	13.82^{abc}	14.58^{bd}	15.44^{ec}
Sponge cakes 60% WF + 40% BC	0	342^{bc}	23.00^{d}	9.52^{c}	10.91^{ef}	11.05^{ec}	12.80^{d}	11.09^{b}
	4	275^{b}	23.32^{d}	9.53^{c}	11.25^{d}	12.37^{d}	12.94^{bc}	13.52^{c}
	6	315^{c}	24.55^{e}	9.81^{d}	11.63^{e}	12.64^{e}	13.59^{cd}	14.09^{e}
	8	287^{df}	25.00^{f}	9.99^{e}	12.06^{f}	13.57^{cd}	14.46^{ab}	15.10^{cd}
	10	316^{c}	25.46^{f}	10.00^{e}	12.25^{cd}	13.96^{cd}	15.00^{a}	15.48^{ec}
	12	263^{bd}	24.90^{e}	9.87^{d}	11.34^{d}	13.22^{ef}	14.55^{bd}	15.45^{ec}

WF, Wheat flour; BC, Blanched carrots; D.W.B., dry weight basis.

On the other hand, data in the same Table showed that sponge cakes (control 100% wheat flour) unfortified with ferrous sulphate was significantly the lowest level of TIBC after depletion and repletion periods (60.37 and 73.90 µg/dl, respectively), while sponge cakes enriched with 30% blanched carrots and fortified with ferrous sulphate at a level 10 mg/100 g was significantly the highest before and after repletion period (75.34 and 92.55 µg/dl, respectively).

So, in this concern, Mejia and Arroyave (1982) reported that improving vitamin A nutrition results in both increases in serum iron and (TIBC).

Liver, kidney, spleen and heart were weighted and the results scorded as shown in Table (4) and the ratio between organ weight and body weight was calculated.

It was found that group of rats fed on sponge cakes enriched with 30% blanched carrots fortified with ferrous sulphate at a level of 10 mg/100 g recorded significantly the highest value of organs weight, and consequently had the highest ratio value, while group of rats fed on sponge cakes (control 100% wheat flour) before fortification with ferrous sulphate was significantly the lowest values of all organs weight.

These results are in accordance with those obtained by Staab *et al.* (1984) and Abo-Zeid (1998) who stated that liver, spleen, heart and kidney weights were higher in groups fed with iron and vitamin A, also they found that vitamin A involved in regulation of iron released from the liver.

Baking tests of sponge cakes made from wheat flour (control) and wheat flour substituted with 10%, 20%, 30% and 40% blanched carrots before and after fortification with ferrous sulphate at level of 10 mg/100 g are presented in Table (5). Data showed that a significant increase in sponge cakes weight took place when increasing the addition level of blanched carrots before and after baking. While the weight of all sponge cakes samples under study were significantly decrease during baking. This is due to the loss of water during baking process. Also significant increase in thickness of all samples with a percentages ranged from 100% in sponge cakes enriched with 40% blanched carrots before and after fortification with ferrous sulphate to 240% in sponge cakes (control) before fortification and 235% in both sponge cakes (control) and sponge cakes enriched with 10% blanched carrot after fortification. This may be due to the effect of temperature during the baking process which caused an extension of gases produced from learning agents, *i.e.*, sodium carbonate. These results agree with those reported by Abd El-Magied (1991). On the other hand, volume after baking showed significant decrease by increasing the levels of blanched carrots added except that of samples enriched with 10% and 20% blanched carrots before and after fortification with ferrous sulphate which showed non-significant difference.

Data in Table (6) showed non significant differences in crust colour, crumb colour, flavour, moistness, tenderness and softness between sponge cakes samples enriched with 20% and 30% blenched carrots before and after fortification. Also there was non significant differences in crust colour, taste and

Table 3. Estimation of haematocrite value (HCT), iron serum level, and total iron binding capacity (TIBC) after depletion and repletion period.

Groups	$FeSO_4$ level	Depletion period				Repletion period			
		HB	HCT	Iron	TIBC	HB	HCT	Iron	TIBC
Group of basal diet	-	14.87^{a}	44.90^{a}	194.30^{a}	90.21^{a}	15.20^{a}	45.50^{a}	196.54^{a}	94.60^{a}
Sponge cakes (Control) 100% WF	0	9.30^{b}	27.35^{b}	87.81^{b}	60.37^{b}	11.00^{b}	33.20^{b}	160.34^{b}	78.90^{b}
	4	9.55^{c}	26.89^{c}	88.98^{c}	63.12^{c}	13.50^{c}	37.10^{c}	165.25^{c}	79.36^{b}
	6	9.68^{d}	27.56^{d}	88.10^{c}	70.82^{d}	13.97^{d}	38.20^{d}	170.39^{d}	82.44^{c}
	8	9.75^{e}	27.38^{b}	89.54^{d}	73.44^{e}	14.16^{cd}	39.75^{e}	177.81^{e}	85.72^{d}
	10	10.00^{f}	28.11^{e}	90.51^{e}	74.31^{f}	14.84^{ed}	41.96^{f}	186.27^{f}	87.41^{e}
	12	9.69^{d}	28.22^{f}	91.30^{f}	72.29^{ab}	14.65^{ed}	41.60^{f}	187.75^{f}	88.48^{e}
Sponge cakes 90% WF + 10% BC	0	9.88^{ab}	26.96^{ec}	90.25^{e}	62.37^{abc}	11.10^{b}	38.42^{d}	170.93^{d}	80.11^{f}
	4	10.01^{f}	26.80^{c}	90.35^{e}	65.66^{cd}	13.53^{c}	38.00^{ef}	173.82^{be}	82.28^{c}
	6	10.10^{cd}	27.57^{d}	91.14^{f}	69.27^{ef}	14.00^{cd}	41.10^{ab}	175.55^{fe}	83.21^{c}
	8	10.15^{cd}	27.25^{b}	91.57^{f}	72.38^{ab}	14.86^{ed}	41.85^{f}	180.48^{ed}	85.84^{d}
	10	10.20^{ec}	28.21^{f}	91.99^{ed}	73.19^{e}	15.00^{e}	42.95^{cd}	189.74^{de}	86.47^{bd}
	12	10.20^{ec}	27.47^{bd}	92.00^{ed}	75.10^{bd}	14.95^{ed}	42.80^{cd}	190.66^{bd}	88.50^{e}
Sponge cakes 80% WF + 20% BC	0	9.54^{c}	26.94^{ec}	92.49^{ab}	63.50^{c}	11.20^{b}	38.19^{d}	180.87^{ed}	81.34^{f}
	4	9.73^{e}	27.75^{ed}	92.77^{ab}	67.42^{ec}	12.87^{f}	39.31^{ef}	184.38^{ce}	82.84^{c}
	6	10.05^{f}	28.15^{e}	92.95^{ab}	70.45^{d}	13.65^{c}	41.35^{ab}	188.93^{de}	84.91^{d}
	8	10.11^{cd}	28.20^{abc}	93.00^{cd}	73.71^{e}	14.92^{cd}	42.60^{abc}	190.62^{bd}	87.17^{e}
	10	10.15^{cd}	28.32^{ef}	93.21^{cd}	74.18^{f}	15.10^{e}	43.53^{ec}	191.47^{bd}	91.80^{ef}
	12	9.96^{ef}	28.53^{cd}	93.71^{cd}	74.53^{f}	15.00^{e}	43.31^{ec}	192.69^{ef}	91.80^{ef}
Sponge cakes 70% WF + 30% BC	0	9.95^{ef}	27.70^{ed}	94.22^{ef}	65.94^{cd}	11.35^{b}	39.00^{ef}	191.19^{bd}	82.74^{c}
	4	10.00^{f}	27.91^{ab}	93.39^{cd}	69.35^{ef}	13.57^{c}	40.18^{bd}	193.21^{ef}	85.33^{d}
	6	10.10^{cd}	28.52^{cd}	94.86^{bd}	69.52^{ef}	14.87^{ed}	42.65^{cd}	194.77^{cd}	86.76^{bd}
	8	10.25^{ec}	27.41^{bd}	93.66^{cd}	73.17^{c}	15.46^{e}	43.12^{ec}	196.15^{ab}	88.45^{e}
	10	10.30^{bd}	28.51^{cd}	95.72^{ec}	75.34^{bd}	15.60^{e}	44.95^{de}	198.28^{ec}	92.56^{ec}
	12	10.13^{cd}	27.78^{ed}	95.57^{ec}	75.20^{bd}	15.54^{e}	44.70^{de}	197.16^{abc}	92.50^{ec}
Sponge cakes 60% WF + 40% BC	0	9.52^{c}	26.90^{ec}	94.00^{ef}	69.15^{ef}	11.59^{b}	38.00^{d}	193.64^{ef}	82.26^{c}
	4	9.53^{c}	27.73^{ed}	94.30^{ef}	70.48^{d}	13.30^{c}	39.00^{ef}	194.77^{cd}	83.38^{c}
	6	9.91^{ef}	28.57^{cd}	95.01^{ec}	73.29^{c}	14.89^{ed}	41.00^{ab}	196.00^{ab}	85.15^{d}
	8	9.95^{ef}	27.18^{abc}	95.97^{abc}	74.72^{f}	15.10^{e}	41.70^{f}	196.32^{ab}	86.60^{bd}
	10	10.00^{f}	28.55^{cd}	96.00^{abc}	75.13^{bd}	15.50^{c}	42.80^{abc}	197.54^{abc}	90.33^{cd}
	12	9.87^{ab}	27.19^{abc}	95.00^{ec}	75.00^{bd}	15.48^{e}	42.80^{abc}	197.99^{abc}	90.30^{ed}

WF, Wheat flour; BC, Blanched carrots; HB, haemoglobin (normal value = 12-15 g/100 ml); HCT, haematocrit (normal value = 39-45%), Normal serum iron, (185-200 µg/dl); Normal serum TIBC, (25-95 µg/dl).

Table 4. Effect of feeding on fortified sponge cakes on organs weight of rats.

Group	Storage period	Body weight	Liver	Ratio	Kidney	Ratio	Spleen	Ratio	Heart	Ratio
Group of basal diet		124^{a}	2.80^{a}	0.023	0.59^{a}	0.00475	0.36^{a}	0.00290	0.48^{a}	0.00387
Sponge cakes (Control) 100% WF	0	130^{b}	2.90^{b}	0.022	0.63^{b}	0.00484	0.39^{b}	0.00300	0.53^{b}	0.00408
	4	130^{b}	3.77^{c}	0.029	0.65^{b}	0.00500	0.44^{c}	0.00338	0.61^{c}	0.00469
	6	132^{c}	4.15^{d}	0.031	0.69^{c}	0.00523	0.56^{d}	0.00424	0.67^{d}	0.00508
	8	136^{d}	4.20^{d}	0.031	0.73^{d}	0.00537	0.58^{e}	0.00426	0.69^{e}	0.00507
	10	138^{e}	4.30^{e}	0.031	0.76^{e}	0.00551	0.61^{f}	0.00442	0.69^{e}	0.00500
	12	130^{b}	4.15^{d}	0.032	0.75^{e}	0.00577	0.61^{f}	0.00469	0.67^{d}	0.00505
Sponge cakes 90% WF + 10% BC	0	135^{d}	3.55^{f}	0.026	0.70^{c}	0.00519	0.56^{d}	0.00415	0.63^{f}	0.00467
	4	135^{d}	3.81^{bd}	0.028	0.71^{c}	0.00526	0.59^{ab}	0.00437	0.64^{d}	0.00474
	6	138^{e}	4.20^{d}	0.030	0.71^{c}	0.00514	0.60^{ab}	0.00435	0.67^{e}	0.00486
	8	141^{f}	4.48^{ab}	0.032	0.75^{e}	0.00532	0.60^{ab}	0.00426	0.68^{ab}	0.00482
	10	150^{ab}	4.55^{be}	0.030	0.78^{f}	0.00520	0.63^{abc}	0.00420	0.70^{d}	0.00467
	12	149^{ab}	4.49^{ab}	0.030	0.70^{c}	0.00470	0.62^{f}	0.00416	0.66^{c}	0.00443
Sponge cakes 80% WF + 20% BC	0	131^{b}	3.86^{bd}	0.029	0.75^{e}	0.00573	0.57^{e}	0.00435	0.60^{c}	0.00458
	4	139^{e}	3.92^{cd}	0.028	0.79^{ab}	0.00568	0.60^{ab}	0.00432	0.61^{d}	0.00439
	6	139^{e}	4.10^{ef}	0.029	0.81^{cd}	0.00583	0.62^{f}	0.00446	0.66^{ab}	0.00475
	8	145^{bd}	4.50^{be}	0.031	0.84^{ef}	0.00579	0.64^{cd}	0.00441	0.71^{ef}	0.00490
	10	149^{ab}	4.65^{ec}	0.031	0.87^{ec}	0.00584	0.65^{cd}	0.00436	0.72^{ab}	0.00483
	12	149^{ab}	4.65^{ec}	0.031	0.83^{ef}	0.00557	0.65^{cd}	0.00436	0.70^{c}	0.00470
Sponge cakes 70% WF + 30% BC	0	140^{f}	4.20^{d}	0.030	0.85^{bd}	0.00607	0.60^{ab}	0.00429	0.60^{ab}	0.00429
	4	143^{ec}	4.30^{e}	0.030	0.89^{be}	0.00622	0.60^{ab}	0.00420	0.70^{ab}	0.00490
	6	150^{ab}	4.60^{ec}	0.031	0.89^{be}	0.00593	0.64^{cd}	0.00427	0.70^{cd}	0.00467
	8	152^{ef}	4.75^{abc}	0.031	0.90^{abc}	0.00592	0.67^{be}	0.00441	0.74^{cd}	0.00487
	10	156^{be}	4.95^{abc}	0.032	0.92^{ed}	0.00590	0.69^{ec}	0.00442	0.75^{ab}	0.00481
	12	150^{ab}	4.90^{abc}	0.033	0.88^{be}	0.00587	0.68^{ec}	0.00453	0.70^{c}	0.00467
Sponge cakes 60% WF + 40% BC	0	131^{b}	3.95^{cd}	0.030	0.84^{ef}	0.00640	0.56^{d}	0.00427	0.60^{f}	0.00458
	4	138^{e}	4.10^{ef}	0.030	0.85^{bd}	0.00616	0.57^{e}	0.00413	0.63^{f}	0.00457
	6	140^{f}	4.10^{ef}	0.029	0.86^{bd}	0.00614	0.59^{ab}	0.00421	0.63^{f}	0.00450
	8	147^{cd}	4.15^{d}	0.028	0.89^{be}	0.00605	0.59^{ab}	0.00401	0.64^{d}	0.00435
	10	150^{ab}	4.20^{d}	0.028	0.93^{ed}	0.00620	0.60^{ab}	0.00400	0.66^{d}	0.00440
	12	148^{cd}	4.05^{ef}	0.027	0.89^{be}	0.00601	0.60^{ab}	0.00405	0.66^{d}	0.00446

WF, Wheat flour; BC, Blanched carrots; D.W.B.
Means values in the same column marked with the same letter are not significantly different (P>0.05).

Table 5. Quality characteristics of sponge cakes and its blends before and after fortification with ferrous sulphate at level of 10 mg/100 g.

Quality parameters	Before fortification					After fortification				
	Sponge cakes and its blends					Sponge cakes and its blends				
	100% WF	90% WF + 10% BC	80% WF + 20% BC	70% WF + 30% BC	60% WF + 40% BC	100% WF	90% WF + 10% BC	80% WF + 20% BC	70% WF + 30% BC	60% WF + 40% BC
Before baking:										
Thickness (cm)	2	2	2	2	2	2	2	2	2	2
Weight (g)	600.40^{a}	603.50^{b}	605.80^{c}	608.60^{d}	609.70^{e}	600.50^{a}	603.70^{b}	605.70^{c}	608.50^{d}	609.80^{e}
After baking:										
Thickness (cm)	6.80^{a}	6.70^{b}	6.20^{c}	5.30^{d}	4.00^{e}	6.70^{a}	6.70^{a}	6.20^{b}	5.30^{c}	4.00^{d}
Increase of thickness %	240^{a}	235^{b}	210^{c}	165^{d}	100^{e}	235^{a}	235^{a}	210^{b}	165^{c}	100^{d}
Weight (g)	564.70^{a}	566.30^{b}	569.50^{c}	573.8^{d}	575.80^{e}	564.90^{a}	566.20^{b}	569.60^{c}	573.80^{d}	575.90^{e}
Water loss %	5.95^{a}	6.16^{b}	5.99^{a}	5.72^{c}	5.56^{d}	5.93^{a}	6.21^{b}	5.96^{a}	5.70^{c}	5.56^{d}
Volume (cm^3)	1661^{a}	1654^{b}	1651^{b}	1642^{c}	1627^{d}	1660^{a}	1653^{b}	1651^{b}	1642^{c}	1626^{d}

WF, Wheat flour; BC, Blanched carrots.
Means values in the same column marked with the same letter are not significantly different ($P>0.05$).

Table 6. Mean sensory scores of sponge cakes and its blends before and after fortification with ferrous sulphate at level of 10 mg / 100 g.

Characteristics	Before fortification					After fortification				
	Sponge cakes and its blends					Sponge cakes and its blends				
	100% WF	90% WF + 10% BC	80% WF + 20% BC	70% WF + 30% BC	60% WF + 40% BC	100% WF	90% WF + 10% BC	80% WF + 20% BC	70% WF + 30% BC	60% WF + 40% BC
Colour:										
Crumb color 10	8.3^{a}	8.7^{b}	8.8^{b}	8.9^{b}	8.4^{a}	8.2^{a}	8.6^{b}	8.9^{c}	8.9^{c}	8.3^{a}
Crust 10	8.3^{a}	8.5^{a}	8.8^{b}	8.8^{b}	8.4^{a}	8.2^{a}	8.4^{a}	8.6^{b}	8.7^{b}	8.3^{a}
Flavor 10	18.0^{a}	18.6^{b}	19.4^{c}	19.4^{c}	18.5^{b}	17.9^{a}	18.6^{b}	19.4^{c}	19.3^{c}	18.5^{b}
Taste	17.0^{a}	17.0^{a}	17.4^{b}	17.5^{b}	16.4^{c}	17.0^{a}	16.9^{a}	17.3^{b}	17.5^{b}	16.3^{c}
Texture:										
Moistness 10	7.9^{a}	8.5^{b}	8.3^{b}	8.3^{b}	7.4^{c}	7.8^{a}	8.5^{b}	8.3^{b}	8.2^{b}	7.3^{c}
Tenderness 20	17.5^{a}	17.7^{a}	18.2^{b}	18.3^{b}	17.0^{c}	17.6^{a}	17.7^{a}	18.3^{b}	18.3^{b}	17.0^{c}
Softness 10	8.5^{a}	9.0^{b}	8.8^{c}	8.7^{c}	8.0^{d}	8.5^{a}	9.1^{b}	8.7^{a}	8.7^{a}	7.9^{c}
Total 100	85.50	88.0	89.60	89.90	84.20	85.20	87.80	89.50	89.60	83.90

WF, Wheat flour; BC, Blanched carrots.
Means values in the same column marked with the same letter are not significantly different (P>0.05).

tenderness between sponge cakes (control 100% wheat flour) and sponge cakes enriched with 10% blanched carrots before and after fortification. It could be noticed that there was non significant sensorial differences between all samples before and after fortification with ferrous sulphate.

It can be concluded that sponge cakes samples substituted with 30% blanched carrots fortified with ferrous sulphate at level of 10 mg/100 g was high in blood haemoglobin, haematorit level, TIBC, serum iron, and organs weight which indicates high absorption and bioavailability of iron, and did not affect baking results or organoleptic properties.

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الملخص العربى

تاثير فيتامين أ على مدى الإستفادة الحيوية للحديد فى الكيك الإسفنجى

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نظراً لأهمية إنتاج مخبوزات ذات قيمة غذائية عالية وخاصة تلك التى يتم تناولها بكثرة ؛ فقد إستهدف هذا البحث دراسة إمكانية إعداد كيك إسفنجى مدعم بمستويات مختلفة من الجزر المسلوق وكبريتات الحديدوز ؛ وذلك بغرض التغلب على نقص فيتامين أ والحديد فى هذا النوع من المخبوزات ، إلى جانب تقييم مدى الإستفادة الحيوية للحديد بإستخدام تكنيك الـ depletion repletion، وقد إستخدم فى التجارب مستويات مختلفة من الجزر المسلوق (١٠% ، ٢٠% ، ٣٠% ، ٤٠%) مع إضافة مستويات مختلفة أيضاً من كبريتات الحديدوز (٤ ، ٦ ، ٨ ، ١٠ ، ١٢ مجم / ١٠٠ جرام) . وقد أظهرت النتائج المتحصل عليها وجود إختلافات معنوية فى الرطوبة والبروتين الخام والألياف الخام وكمية الكاروتين بالكيك الإسفنجى المدعم ، كما أوضحت نتائج الدراسة الحيوية أن الفئران المغذاة على الكيك الإسفنجى المدعم بـ ٣٠% جزر مسلوق و ١٠ مجم كبريتات حديدوز قد تميزت بإرتفاع هيموجلوبين الدم ومستوى الهيموكريت haematocrit وسعة إرتباط الحديد الكلى TIBC وحديد السيرم ووزن الأعضاء بما يدل على زيادة الإستفادة الحيوية وإمتصاص الحديد ، ولم يلاحظ من نتائج الدراسة وجود إختلافات معنوية فى الخواص الحسية بين كل عينات الكيك الإسفنجى سواء قبل أو بعد التدعيم بكبريتات الحديدوز .