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Effect of Fruit/Vegetable Drink from Potato Skin Water Extract, Beetroots and Fruit Juice Combinations on Iron Bioavailability in Iron Deficient Rats

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ABSTRACT

Iron deficiency anemia is common and major health problems. Therefore it is a concern in all developing and industrialized countries. This study was aimed to investigate the effect of potato skin water extract, beetroots and fruit fresh juice (Orange, strawberry, guava and pomegranate) combinations on iron availability in iron deficiency of rats. Sprague-Dawley rats were randomly divided into seven equal groups: Group1:Normal group: (received basal diet); Group2: Iron deficient group through iron-deficiency; Group3: Iron deficient group treated with iron supplement; Group4: Iron deficient group treated with iron supplement with potato strawberry drink; G5: Iron deficient group treated with iron supplement with potato orange drink; G6: Iron deficient group treated with iron supplement with potato Guava drink; G7: Iron deficient group treated with iron supplement with potato/pomegranate drink. Fe, Cu, folate and vitamin C were determined in drinks. Hemoglobin, hematocrit, Fe was assessed in serum and liver, total iron binding capacity, ferritin, cholesterol, triglycerides, High density lipoprotein, Low denesty lipoprotein, Triiodothyronine, Thyroxine, Total Antioxidant Capacity and Total Oxidant Capacity were estimated in serum. Results indicated that the combinations of potato water extract and fruit juice were more effective than supplement alone for improving Fe in serum and liver Hemoglobin, hematocrit haematocrit, Fe was assessed in serum and liver., total iron binding capacity, ferritin, cholesterol, triglycerides, Low denesty lipoprotein, Triiodothyronine, Thyroxine, Total Antioxidant Capacity and Total Oxidant Capacity. Potato/orange treatment showed the highest hemoglobin level (13.55±0.15 g%); however Potato/strawberry was the effective in Fe elevation (15.78±0.35 µmol/l), ferritin (84.13±1.46 ng/ml) and lowering of the UIBC (55.79±1.51 µmol/l). The findings suggest that the combination of potato skin water extract and fruit juices is an effective treatment with iron supplement for Iron Deficiency Anemic rats.

Keywords: Potato skin; Beetroots; Iron bioavailability; Iron Deficiency; Fruits; Antioxidants.

INTRODUCTION

Anaemia is presented as a global health problem affecting both developed and developing countries with major impact on human health as well as economic and social development (Soliman *et al* 2016). World Health Organization indicates iron deficiency (ID) as one of the "Top Ten Risk Factors contributing to Death".

Potato peel has gained attention as a strong natural antioxidant in food due to its polyphenols high content, which was recorded to be 10 times higher than their flesh concentration (Malmberg and Theander, 1984). Potato peel extracts has presented as a rich source of polyphenolic antioxidants reduced hyperglycemia, oxidative stress, and overall food intake in diabetic rats when fed at 10% of their diet (Singh *et al.,* 2005a). Skin-on potatoes are indicated as a good source of iron and potassium Vitamin C (ascorbic acid) is the predominant vitamin in potatoes (Rahman *et al.,* 201; Narcy *et al*., 2006). Also several B vitamins are present (niacin, folic acid, riboflavin, thiamin, and pyridoxine) and potatoes can be characterized as a good source of vitamin B6 (pyridoxine). potato peels extract ameliorated oxidative damage to human erythrocyte and rat erythrocytes membranes (Singh and Rajini, 2008).

Beetroot is used for food purposes like pickles, juice and salad, rather than for producing sugar. Unlike the other fruits, sucrose is the main sugar in beetroot with only small amounts of fructose and glucose (Bavec *et al*., 2010). The brilliant red color of beetroots derives from high content of betalains. Betalains are used as natural colorants in food industry. Beet have also received an increasing attention due to its possible health benefits in humans, especially their anti-inflammatory; antioxidant activities (Georgiev *et al*., 2010); lipid peroxidation inhibition (Reddy *et al*., 2005). The beetroot juice also contributes to improve the haemoglobin in the blood. Beetroot can be stored easily, and it has low cost comparing to other iron rich vegetables.

Strawberries are referred to be a good source of vitamin C, folic acid (folates) and recently high content of various phenols (Proteggente *et al.,* 2002). Strawberry quality is also includes carbohydrates, minerals, organic acids – tartaric acid, malic acid and citric acid. Around 90% of strawberry organic acids are citric acid (Sturm *et al.,* 2003). Orange flavour is probably the most accepted flavour in the beverage industry and worldwide (Shaw and Moshonas, 1997). Citrus phenolics have an increased interest in the last few years because their contributes to the sensory quality of fruit and juice through their effect on colour, flavor, astringency, antioxidant activity, and bitterness (Sousa *et al*., 2004). Gardner *et al.,* (2000) stated vitamin C as the main antioxidant in orange juice. In fruit juices containing high ascorbic acid, antioxidant activity was found to be higher (except in case of *C. aurantium*). Guava (*Psidium guajava*) is a fruit with an exceptionally high ascorbic acid (AA) content, some iron (0.30–0.70 mg/100 g) and carotenes (200–400 IU/100 g) (Wilson, 1980). Guava juice used as a source of ascorbic acid showed marginal beneficial effects of small clinical significance on plasma ferritin concentrations and hemoglobin of indigenous children suffer from iron deficiency anemia fed diets rich in nonheme iron with phytic acid (Mona´rrez-Espino and Lo´pez-Alarco *et al*., 2011). Pomegranate is an referred as rich source of anthocyanins and other phenolic compounds, with a remarkable antioxidant activity (Gil *et al.,* 2000). The powerful antiatherogenic action of pomegranate juice has been recently evinced in healthy humans and in atherosclerotic mice (Kaplan *et al.,* 2001). Pomegranate is a substantial source of bioactive constituents, such as anthocyanins, ascorbic acid and other phenolic compounds (Peä Rez-Vicente *et al*., 2002). Pomegranate includes several other types of flavonoids (Sudheesh *et al.,* 1997). It has a high concentration of carotenoids, anthocyanins and vitamin C (George *et al*., 2009). Iron absorption can be highly affected by inhibitors and enhancers of iron

absorption in the diet. Ascorbic acid is significantly indicated to enhance iron absorption (davidsson *et al.*, 1994). Therefore; vitamin C is important for iron availability. Moreover; iron in the human diet tends to be limiting (Brown, 2008). An increase in demand occurred for red fruit juices, which could be considered as healthy fruit beverages due to their sensory and health benefits and a highly desirable approach to control iron deficiency is food fortification with absorbable forms of iron. The aim of this study was to investigate the effect of fruit/vegetable juice mix (composed of potato skin water extract, beet fresh juice with strawberry, orange, pomegranate or guava fresh juice) on the bioavailability of iron supplement in iron deficiency anemic rats.

MATERIALS AND METHODS

Materials: Potatoes, beet, strawberry, orange, guava, pomegranate, corn oil and starch were purchased from local market, Cairo, Egypt. Ferrous sulfate, casein, minerals mix, vitamins mix and cellulose were purchased from El-Nasr Pharm. and Chem. Ind. Comp. Cairo, Egypt.

Animals: Forty two male Sprague-Dawley albino rats weighing 150-165 g used in the present study were obtained from animal house of Agriculture Research Center, Giza, Egypt.

Preparation of fruit vegetable mixes:

Potatoes (*Solanum tuberosum L.*) (variety, Sponta) were washed with deionized water for five minutes, potato peels are removed through steam-peeling. 500 gm of potato skin was put in 1litre of boiling water for 3 minutes, cooled and left for two hours. Then, potato/water was drained through cheese cloth, into graduated cylinder. Every one liter of potato water was concentrated into 200 ml by heat treatment of uncovered stainless steel container at 70^{o}C. Beetroots were washed with deionized water for five minutes. Minced and pressed on strainer for obtaining juice. Orange juice was obtained by orange squeezing and straining. Strawberry, pomegranate, guava were mixed with water (4:1) for 2 minutes by blender. The experiment final drinks were prepared by mixing potato water, beet juice, fruit juice (strawberry, orange, guava or pomegranate) at ratio of (1:1:2).

Sensory evaluation:

Samples were scored by ten randomized volunteers. The test was carried out in terms of color, flavor, texture and overall acceptability as described by Zhang and Zhang (2007).

Chemicals analysis:

Vitamin C was determined according to the method described by Mazumdar and Majumder, (2003) using titrimetric estimation with 2, 6 dicholoro phenol dye solution. Folic acid was determined using UPLC (Waters H Class) - UV-Vis detector (Rahimi and Goodarzi, 2011). Fe and Cu were analyzed by electrothermal atomic absorption spectrometery, Perkin elmer Model 5100 as described by Kumpulainen *et al.,* (1983).

Animals and experimental design:

Forty two male Sprague-Dawley albino rats weighing 150-165 g received basal diet prepared following the composition description of the AIN-93G (Reeves *et al*., 1993) for one week for adaptation and ensuring normal behavior and growth. After one week adaptaion period, the rats were divided into two major groups: normal control group (n=6 rats) received basal diet) and iron deficient group (n=36 rats). All rats were housed in screen bottomed; stainless steel cages in a temperature (24+ 2 o C) with a 12 h light dark cycle all over the experimental period.

Iron deficiency induction:

Iron deficiency was induced by placing rats them on iron deficient diet (3 mg Fe/kg diet) for 30 days. At the end of iron depletion period, blood was taken from the tail of controls and Fe-deficient groups, hemoglobin and hematocrit were analyzed. Groups during treatments experimental period were designed as follows:

Group1:Non-anemic group (received basal diet); Group2: iron-deficiency anemic group; Group2: iron-deficiency anemic group treated only with ferrous sulphate (6 mg/kg body weight); Group4: Anemic group treated with potato/strawberry drink ferrous sulphate (6 mg/kg body weight); Group5: Anemic group treated with potato/orange drink with ferrous sulphate (6 mg/kg body weight); G6: Anemic group treated with iron supplement with potato Guava drink. ferrous sulphate (6 mg/kg body weight); G7: Anemic group treated with potato/ pomegranate drink with ferrous sulphate (6 mg/kg body weight); During the experiment, food consumed and body weights were recorded twice weekly. Different groups were biologically evaluated by determination of food consumption and body weight gain. FER was obtained by calculation according to Chapman *et al.,* (1950). At the end of the experiment period (60 days) overnight fasted rats were sacrificed. Blood samples were obtained by withdrawing using capillary micro tubes from the orbital plexus of veins in the inner canthus of eye. Blood was left at room temperature for 10 min to clot. samples were obtained centrifuged at 4000 rpm for fifteen min. and serum directly frozen at -18°C till analyses.

Biochemical analysis:

Hemoglobin concentration was measured calorimetrically by the cyanmethemoglobin method (Sigma Chemical, procedure No. 525). Hepatic iron was measured by the ferrozine reagent method as described by Erickson *et al.,* (1997). Hematocrit was estimated according to Vankampen and. Zijlstra (1961). Serum Total Cholesterol (TC) and Triglycerides (TG) were assessed as described by Watson (1960) and Wahlefeld (1974), respectively. Low Density Lipoprotein (LDL) cholesterol and High Density Lipoprotein (HDL) were following the method of Peace and Kaplan (1987). Very Low Density Lipoproteins (VLDL) cholesterol was obtained by calculation by dividing the triglyceride value by 2.2 as the value is in mmol/L (.Jul 6, 2018).

Iron ferrozine and iron TIBC were assessed using kits from DIACHEMLtd com. (H-1117 Budapest, Budafoki ut 111-113). Serum ferritin, Triiodothyronine (T3) and Thyroxine (T3) were measured using ELISA kits of GenWay Biotich, Inc. (6777 Nancy Ridge Drive San Diego, CA 92121). Total antioxidant capacity (TAC) was determined by colorimetric test for the quantitative determination. Total Oxidant Capacity (TOC) was assessed by enzymatic test for measurement of peroxides

in biological fluids. Both of TAC and TOC Kits were obtained from Labor Diagnostika Nord Gmbh & Co. KG.

Statistical analysis: Data presented as means ± SD. Computerized SPSS program version 20.0 software for Windows (SPSS Inc., Chicago, IL, USA) was used. One way analysis of variance (ANOVA) test ($p<0.05$) and Duncan's multiple range test were used for statistical analyzing.

RESULTS AND DISCUSSION

Sensory evaluation

One of the limiting factors for consumer acceptability is the sensory aspects. Therefore, the effect of supplementation of the vegetable mix drinks with orange, guava, strawberry and pomegranate on color, taste, odor, appearance, consistency and overall acceptability are represented in Table 1. No significant differences ($p<0.05$) were observed between fruit/vegetable mix drinks and control in color due to the beet root which provided all drinks with deep red color. Whereas significant differences ($p<0.05$) were observed between all fruit/vegetable mix drinks and control in other sensory attributes. Data revealed that drinks were positively affected by adding fruits as it enhanced all sensory properties compared to the control. Strawberry vegetable mix drink recorded the highest overall acceptability among drinks (8.34±0.19) followed by orange vegetable mix drink (8.16±0.12), pomegranate vegetable mix drink (8.04±0.23), then guava vegetable mix drink (8.004±0.13).

Citrus and beetroot juice are very highly valued for their nutritional value, pleasant flavor, refreshing juice and medicinal properties. Some fruits and vegetables have bitterness and an off flavor. Therefore, mixing of two or more vegetable and fruit juices for the preparation of nutritive ready-to-serve drinks is thought to be an economic and convenient alternative (Bhardwaj and Pandey, 2011). Beet root characterized by deep red color is the most common for human consumption, both raw as a juice or salad and cooked (Singh and Hathan, 2014). Strawberry acquires its characteristic taste from organic, acids sugars and phenolic compounds like anthocyanins and flavonols (Kader, 1991). Distinctive flavour and aroma is responsible for orange widely use in beverages and foods aromatizing (Moshonas, 1997). Guava juice has special flavor and viscosity aspects (Yen and Lin, 1998). Also pomegranates presented high levels of sensory attributes, antioxidant activity, high overall consumers liking (Carbonell-Barrachina1 *et al*., 2011).

Vitamin C, folate, iron and copper content of fruit/vegetable mix drinks:

Vitamin C, folate, iron and copper contents of fruit/vegetable mix drinks were analyzed and obtained results were tabulated in Table 2. Significant differences ($p<0.05$) were observed between all drinks in vitamin and mineral contents. Data show that supplementation vegetable mix drinks with pomegranate increased significantly ($p<0.05$) V.C content (76.3±0.02 mg/100 ml), followed by strawberry/vegetable mix drink (60.8±0.02 mg/100 ml). Whereas the highest folate level was in orange/vegetable mix drink (39.5±0.02 mcg/100ml) followed by strawberry vegetable mix drink (28.7±0.01 mcg/100ml) and pomegranate/vegetable mix drink (15.89±0.02 mcg/100ml), then guava vegetable mix drink (6.4±0.01 mcg/100ml). Regarding the drinks iron content, strawberry/vegetable mix recorded the highest iron content (4.45 ±0.00mg/100g), followed by pomegranate (4.32 ± 0.00 mg/100g) and guava (4.02±0.02mg/100g). Copper content showed the highest score in pomegranate vegetable mix drink followed by orange, strawberry then guava vegetable mix drink.

Table 1. Sensory aspects of fruit/vegetable mix drinks

	Color	Taste	Odor	Appearance	Consistency	OA
Control	8.4^{a}±0.16	6.4^{c}±0.34	6.5^{b}±0.14	6.0^{b}±0.28	6.8^{c}±0.22	6.74^{c}±0.12
Orange	8.7^{a}±0.25	8.0^{b}±0.22	8.0^{a}±0.45	8.1^{a}±0.14	8.8^{a}±0.25	8.16^{a}±0.12
Guava	8.7^{a}±0.16	8.2^{ab}±0.35	7.9^{a}±20.35	8.2^{a}±0.43	7.0^{c}±0.36	8.004^{b}±0.13
Strawberries	8.8^{a}±0.60	8.5^{a}±0.35	8.3^{a}±0.32	8.2^{a}±0.32	7.9^{ab}±0.16	8.34^{ab}±0.19
Pomegranate	8.8^{a}±0.47	7.9^{b}±0.43	7.8^{a}±0.41	8.1^{a}±0.43	7.6^{b}±0.32	8.04^{b}±0.23

Values expressed as mean± standard deviation **in each row having different a, b,c… litters indicating significance in difference; OA: Overall Acceptability**

According to the USDA nutrient database, 100 grams of potatoes contains 33% of the RDA of vitamin C and 12% for potassium, values of 14 and 18 pg/l00 g folate for raw potatoes, 18% of the RDA of potassium, 6% of iron, phosphorus and magnesium, and 2% calcium and zinc (True *et al*., 1979). The iron content of potatoes ranged between 29.87 and 157.96 1g/DW (Andre *et al.,* 2007). Copper ranges from 0.23 to 11.9mg/kg FW (Rivero *et al.,* 2003). Guava (*Psidium guajava L.*) is a very rich vitamin C source. Oranges also are rich in vitamin (Kwee and Chong, 1990). In addition to its rich content of vitamin C, strawberry contains folic acid, vitamin A, vitamin B1, vitamin B2, potassium, Selenium, magnesium, phosphorus Fe, calcium. Strawberry is highly recommended for pregnant women, for its very beneficial role in the formation of the hemoglobin levels of the blood (Wulandari *et al.,* 2017). The bioavailability of non-heme iron increases to a level similar to that of animal sources like meat meat when consumed with a considerable source (25 mg) of vitamin C in the same meal. The presence of certain vegetables or fruits rich in ascorbic acid cans double or triple the absorption of iron (Brian Thompson 2011).

Table 2. Vitamin C, folate, iron and copper content of fruit/vegetable mix drinks

Samples	V.C mg/100 ml	Folat mcg/100ml	Iron mg/100g	Copper mcg/100g
Guava	43.9^{b} ±0.02	6.4^{d} ±0.01	4.02^{ab} ±0.02	0.093^{a} ±0.002
Orange	27.6^{a} ±0.03	39.5^{a} ±0.02	3.37^{c} ±0.00	0.195^{a} ±0.001
Pomegranate	76.3^{a} ±0.02	15.89^{c} ±0.02	4.32^{a} ±0.00	0.26^{a} ±0.001
Strawberry	60.8^{a} ±0.02	28.7^{b} ±0.01	4.45^{a} ±0.00	0.13^{a} ±0.000

Values expressed as mean± standard deviation in each row having different a, b,c… litters indicating significance in difference; V.C: Vitamin C.

The finding of Table 3 showed weight gain (%) and food efficiency ratio (FER) of rat groups. Data show that healthy control group significantly decreased ($p<0.05$) weight gain (9.26±3.74%) and FER (0.02±0.01) when compared to other rat groups. Meanwhile, the anemic group (2) recorded the highest weight gain (99.67±18.38%). As shown in group 3 results, iron supplementation of anemic rats significantly decreased ($p<0.05$) weight gain% and FER (67.01±19.94 and 0.12±0.05), respectively. On the other hand, oral administration of anemic rat groups on fruit/vegetable mix drinks induced significant increase ($p<0.05$) in weight gain and FER compared to the normal control group and Iron deficiency anemic rats in group 3.

Results in Table 3 showed that the increase ratio in weight gain was faster in iron deficient group than the normal control over the experiment (9.00 ±5.48 and 108.00 ±20.99 gm, respectively). However relative decrease in weight gain was observed in treated grouped with insignificant differences. Also no significant decrease can be noticed in groups received fruit/vegetable drinks in Food Efficiency Ratio (FER).

Hemoglobin 9.60±0.23 g%, 28.83±0.71 g%, Fe 9.38±0.20 µmol/l and ferritin 52.97±0.65 ng/ml.

Effect of fruit/vegetable mixes on Hemoglobin, Hematocrit, Fe, Total Iron Binding Capacity, Unsaturated Iron Binding Capacity and ferritin:

Data in Table 4 showed that the normal control group recorded the highest levels of hemoglobin (14.10±0.25), hematocrit (42.37±0.73), Fe (17.38±0.44 µmol/l) and ferritin (88.48±2.80 mg/ml), meanwhile Total Iron Binding Capacity (TIBC) and Unsaturated Iron Binding Capacity (UIBC) (53.13±0.89 and 35.75±1.33 µmol/l), respectively compared to other rats groups. Iron deficiency group (G:2) showed a significant ($p<0.05$) decrease in hemoglobin, hematocrit, Fe and ferritin levels as recorded 9.60±0.23, 28.83±0.71, 9.38±0.20 µmol/l and 52.97±0.65 mg/ml, respectively, whereas a significant increase ($p<0.05$) in total iron binding capacity (TIBC) (70.72±1.37 µmol/l) and unsaturated iron binding capacity UIBC (61.34±1.57 µmol/l) compared to both normal and treated groups. On the other hand, hemoglobin, hematocrit, Fe and ferritin levels increased while, TIBC and UIBC decreased significantly ($p<0.05$) in group 3 after treated with iron supplement. Generally, oral administration of fruit/vegetable mix drinks significantly elevated ($p<0.05$) hemoglobin, hematocrit, Fe and ferritin and decreased TIBC and UIBC levels compared to untreated iron-deficient rats group.

Table 3. Food intake, weight gain and Food Efficiency Ratio (FER) for iron deficient rats received fruit/vegetable drinks

Groups	weight gain	Weight gain %	FER
G1: Normal control	9.00^{b}±5.48	9.26^{b}±3.74	0.02^{b}±0.01
G2: Iron deficiency	108.00^{a}±20.99	99.67^{a}±18.38	0.14^{a}±0.03
G3: Iron deficiency +Fe	80.00^{a}±19.71	67.01^{a}±19.94	0.12^{a}±0.05
G4: Strawberry	96.75^{a}±16.53	84.47^{a}±21.12	0.13^{a}±0.03
G5: Orange	78.00^{a}±14.05	70.86^{a}±22.64	0.11^{a}±0.03
G6: Guava	74.75^{a}±17.70	70.50^{a}±18.53	0.11^{a}±0.05
G7:Pomegranate	98.25^{a}±19.87	88.75^{a}±22.11	0.15^{a}±0.08

Values expressed as mean± standard deviation in each row having different a, b,c… litters indicating significance in difference; FER: Food Effeciency ratio

Haemoglobin and the other haematological indices and iron level in plasma were significantly lower in the iron-deficient rats group compared to normal rats (Enika Nagababu *et al.,* 2008). TIBC reflects the total transferrin concentration in plasma. Transferrin is the protein transports iron and regulates in serum during iron deficiency to maximize iron transportation from the intestine to tissues (Chua *et al.,* 2007). TIBC was significantly high in the iron deficient group comparing to the normal rats. That confirms the decrease in Hematocrit and hemoglobin due to iron deficiency (Enika *et al.,* 2008).

Table 4. Effect of fruit/vegetable mixes on Hemoglobin, Hematocrit, Fe, Total Iron Binding Capacity, Unsaturated Iron Binding Capacity and ferritin in iron deficient rats

Groups	Hemoglobin	Hematocrit	Fe µmol/l	Total iron binding capacity µmol/l	unsaturated iron binding capacity (UIBC)µmol/l	Ferritin ng/ml
G1: Normal control	14.10^{a}±0.25	42.37^{a}±0.73	17.38^{a}±0.44	53.13^{e}±0.89	35.75^{a}±1.33	88.48^{a}±2.80
G2: Iron deficiency	9.60^{e}±0.23	28.83^{d}±0.71	9.38^{e}±0.20	70.72^{a}±1.37	61.34^{a}±1.57	52.97^{d}±0.65
G3: Iron deficiency +Fe	12.38^{d}±0.30	37.20^{c}±0.88	14.30^{d}±0.53	62.10^{b}±1.12	47.80^{a}±1.87	75.59^{c}±1.83
G4: Strawberry	13.50^{b}±0.28	39.53^{b}±2.47	15.78^{b}±0.35	55.79^{d}±1.51	40.01^{a}±1.85	84.13^{b}±1.46
G5: Orange	13.55^{b}±0.15	40.70^{b}±0.48	15.60^{bc}±0.33	56.12^{d}±0.43	40.52^{a}±0.76	84.07^{b}±0.77
G6: Guava	13.13^{bc}±0.25	39.63^{b}±0.78	14.75^{d}±0.53	58.46^{c}±0.87	43.71^{a}±1.40	82.34^{b}±0.69
G7: Pomegranate	12.90^{c}±0.23	38.73^{bc}±0.69	15.00^{cd}±0.25	59.30^{c}±1.41	44.31^{a}±1.65	81.46^{b}±0.72

Values expressed as mean± standard deviation in each row having different a, b,c… litters indicating significance in difference.

Lipid profile of iron difecient rats received fruit/vegetable drink:

Regarding lipid profile as illustrated in Table 5, cholesterol, triglyceride, HDL, LDL and VLDL levels recorded the lowest significant ($p<0.05$) levels in the normal rats group compared to all iron deficient groups. Meanwhile, Iron deficient group (G: 3) showed significant increase ($p<0.05$) cholesterol, triglyceride, HDL, LDL and VLDL levels as recorded 95.1±41.41, 398.39±3.91, 65.35±0.29, 140.40±0.38 and 9.90±0.87 *µmol /l*, respectively compared to treated groups. As shown treated rats groups (G:4, G:5, G6 and G:7), the oral administration of fruit/vegetable drinks significantly decreased ($p<0.05$) lipid profile levels compared to Iron deficient group treated only with iron supplement.

Potato significantly lowers the cholesterol both in liver and in plasma and in the potentially atherogenic lipoproteins (LDL and VLDL) a decrease of cholesterol by -37% was observed (Robert *et al*., 2006).The cholesterol-lowering effect can be attributed to the fibers provided by potatoes (Mazur *et al*., 1990). Strawberry juice extracts have been reported significant inhibition in free radicals

(Wang and Jiao, 2000), and reduction in ox-LDL-induced proliferation of rat aortic smooth muscle cells (Chang *et al*., 2008). The cholesterol lowering effects may also attributed to the total dietary fiber content of the strawberry drink (8 g/day) (Nickel *et al*., 2009). Guava vitamin C intake was shown to be associated with increase of plasma ascorbic acid, high density lipoprotein-cholesterol and decrease in total cholesterol and triglyceride (Singh and Rastogi *et al*., 1997). Consumption of orange juice daily increased HDL-cholesterol concentrations, triacylglycerol concentrations by and folate concentrations; however decreased the ratio of LDL-HDL cholesterol (Kurowska *et al.,* 2000). Also consumption of concentrated pomegranate juice, significant reduced total cholesterol, LDL-cholesterol, LDL/ HDL cholesterol and total cholesterol/HDL-cholesterol. But, there were no significant changes in serum HDL-cholesterol level or triacylglycerol (Esmaillzadeh *et al*., 2004). However Antappanavar *et al.,* 2014 indicated that iron deficiency anemia in Indian adults is attended by abnormal serum lipid pattern, which responds significantly to iron therapy.

Table 5. Total cholesterol, triglyceride, HDL, LDL and VLDL of iron difecient rats received fruit/vegetable drink

Groups	Cholesterol µmol/l	Triglyceride µmol/l	HDL µmol/l	LDL µmol/l	VLDL µmol/l
G1: Normal control	55.61^{e}±1.41	64.99^{e}±2.37	21.78^{a}±0.29	4.29^{d}±1.38	29.54^{d}±0.46
G2: Iron deficiency	95.1^{a}±41.41	398.39^{a}±3.91	14.59^{d}±0.52	20.36^{a}±0.38	60.15^{a}±0.87
G3: Iron deficiency +Fe	74.95^{b}±1.48	100.93^{b}±2.65	16.59^{c}±0.53	12.48^{b}±0.52	45.88^{b}±0.72
G4: Strawberry	63.83^{cd}±1.25	84.28^{c}±1.59	18.71^{b}±0.45	6.81^{cd}±0.42	38.31^{c}±0.58
G5: Orange	61.84^{d}±1.39	80.23^{d}±1.34	17.21^{c}±0.52	8.16^{c}±0.60	36.47^{c}±0.55
G6: Guava	65.96^{c}±2.18	86.47^{c}±0.98	18.74^{b}±0.47	7.92^{c}±2.10	39.30^{c}±0.81
G7: Pomegranate	65.81^{c}±1.52	85.13^{c}±1.30	19.33^{b}±0.64	7.78^{c}±0.63	38.70^{c}±0.69

Values expressed as mean± standard deviation in each row having different a, b,c… litters indicating significance in difference.

Table 6 shows the effect of oral administration of fruit/vegetable mix drinks on Total antioxidant capacity (TAC), Total oxidant capacity (TOC), Liver iron content, Thyroxine (T4) and Triiodothyronine (T3) in anemic rats groups. Significant differences ($p<0.05$) were found between iron deficient groups and normal rats group. The normal group showed the highest total antioxidant capacity level (1.69±0.03 µmol/l) among all rats groups, however its level decreased significantly ($p<0.05$) in iron deficiency group (1.10±0.06 µmol/l). While the iron supplement caused significant increase ($p<0.05$) in TAC levels of group 3 rats (1.35±0.04 µmol/l) compared to positive control (G 2). Oral administration of fruit/vegetable drinks increased significantly ($p<0.05$) TAC in all treated groups (G:4, 5, 6 and 7) comparing to only iron supplement group. On the other hand, TOC level decreased significantly ($p<0.05$) in normal rats group compared to other groups. Meanwhile, iron deficient group recorded the highest TOC level (0.42±0.03 µmol/l). Oral administration of fruit/vegetable drinks decreased significantly ($p<0.05$) TOC in groups all treated groups comparing to only iron treated group.

Significant differences ($p<0.05$) were found in liver iron content between iron deficient groups and normal rats group. Normal group recorded 895.99±20.99 Ug/g, group 2 (417.46±14.05 Ug/g) and group 3 (761.02±33.12 Ug/g) for liver iron content. Comparing with only iron treated group, the oral administration of fruit/vegetable drinks significantly increased ($p<0.05$) liver iron content in treated iron deficient groups (strawberry, guava, orange and pomegranate) as recorded 807.03±15.17 Ug/g, 818.17±12.43 Ug/g, 765.11±9.10 Ug/g and 783.33±10.71 Ug/g, respectively. Furthermore, Thyroxine (T4) level.

It is not yet clear whether iron deficiency can also influence the level of oxidative stress and antioxidant defenses of the organism. Studies on human patients and rats offer limited and contradictory data on the influence of iron deficiency on oxidative stress . Kumerova *et al*., (1998) found an increased lipid peroxidation and decreased antioxidant defenses in human patients with iron deficiency anaemia. On the other hand, Acharya (1991) found that there was no evidence of an increased susceptibility of red blood cell count to lipid peroxidation in iron deficiency. High association was noted between antioxidant activity and red fruit juices' content of total anthocyanins (Alice Vilela and Fernanda Cosme 2016). Increased lipid peroxidation has been associated correlated with iron deficiency in human patients and rats (Kumerova *et al*., 1998), but the issue remains controversial (Acharya *et al*., 1991). Thyroid metabolism has shown to be impaired in iron deficiency anaemia. On the other hand both overt and subclinical hypothyroidism are associated with anemia and adding iron to thyroxine therapy improves both conditions comparing to thyroxine treatment alone (Soliman 2016).

Normal thyroid status is dependent on the presence of many trace elements e.g., iron, selenium, zinc and iodine, for both the metabolism and synthesis of thyroid hormones. thyroid functions can be impaired due to deficiencies of these elements (Eftekhari *et al*., 2007).

Table 6. Total antioxidant capacity, Total oxidant capacity, Liver iron content, Thyroxine (T4) and Triiodothyronine (T3) of iron difecient rats received fruit/vegetable drink

Groups	Total antioxidant capacity µmol/l	Total oxidant capacity µmol/l	Liver iron content Ug/g	Thyroxine (T4) ng/ml	Triiodothyronine (T3) ng/ml
Normal control	1.69^{a}±0.03	0.23^{c}±0.02	895.99^{a}±20.99	84.76^{a}±1.00	4.16^{a}±0.05
Iron deficiency	1.10^{e}±0.06	0.43^{a}±0.16	417.46^{e}±14.05	194.38^{e}±1.27	12.51^{a}±0.02
Deficiency + Fe	1.35d±0.04	0.42^{a}±0.03	761.02^{u}±33.12	71.81^{u}±1.62	4.17^{a}±0.07
Strawberry	1.55^{p}±0.04	0.29^{pc}±0.03	807.03^{pc}±15.17	79.65^{p}±0.79	4.17^{a}±0.01
Orange	1.57^{p}±0.03	0.29^{pc}±0.02	818.17^{p}±12.43	80.89^{p}±1.19	4.16^{a}±0.03
Guava	1.48^{e}±0.03	0.35^{ap}±0.01	765.11^{u}±9.10	76.45^{c}±1.08	4.16^{a}±0.02
Pomegranate	1.51^{pc}±0.03	0.35^{ap}±0.03	783.33^{cu}±10.71	77.61^{c}±0.55	4.15^{a}±0.03

Values expressed as mean± standard deviation in each row having different a, b,c… litters indicating significance in difference.

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تأثير مشروب الفواكه مع الخضروات من المستخلص المائي لقشور البطاطس مع عصير البنجر و الفاكهة على إتاحية الحديد في الفئران المصابة بنقص الحديد

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يعتبر نقص الحديد من المشكلات الصحية الشائعة. لذا فهي تشغل اهتمام كل من الدول المتقدمة و النامية. هدفت هذه الدراسة بحث تأثير مشروب مزيج الفواكه و الخضروات المكون من المستخلص المائي للبطاطس مع عصير جذور البنجر و عصير الفواكه (البرتقال و الفراولة و الجوافة و الرمان) على إتاحية الحديد في فئران التجارب المصابة بنقص الحديد.و قد قسمت الفئران كالتالي: مج١: المجموعة السليمة و التي تناولت الوجبة الساسية فقط؛ مج٢: المجموعة المصابة بنقص الحديد دون معاملة: مج٣ المجموعة المصابة بنقص الحديد و المعاملة الحديد بكبريتات الحديد كمكمل غذاائي: مج٤ المجموعة المصابة بنقص الحديد و المعاملة الحديد بكبريتات الحديد كمكمل غذاائي مع مشروب ١ (مستخلص البطاطس و عصير البنجر مع عصير البرتقال)؛ مج٥ المجموعة المصابة بنقص الحديد و المعاملة الحديد بكبريتات الحديد كمكمل غذاائي مع مشروب ١ (مستخلص البطاطس و عصير البنجر مع عصير الفراولة)؛ مج٦ المجموعة المصابة بنقص الحديد و المعاملة الحديد بكبريتات الحديد كمكمل غذاائي مع مشروب ١ (مستخلص البطاطس و عصير البنجر مع عصير الجوافة)؛ مج٧ المجموعة المصابة بنقص الحديد و المعاملة الحديد بكبريتات الحديد كمكمل غذاائي مع مشروب ١ (مستخلص البطاطس و عصير البنجر مع عصير الرمان). تم تقدير الحديد و النحاس و الفولات و فيتامين ج في المشروبات. و تم إجراء التحاليل البيولوجية بقياس الهيموجلوبين و الهيماتوكريت و الحديد في السيرم و الكبد. و السعة الكلية الرابطة للحديد (TIBC. و الفيريتين و الكوليستيرول و الجليسريدات الثلاثية و الكوليسترول منخفض الكثافة و مرتفع الكثافة و الثيروكسين و ترايأيودوثيورونين و السعة الكلية المضادة للأكسدة والسعة الكلية التأكسدية. وقد أشارت النتائج إلى فعالية المعاملات بمستخلص البطاطس مع عصائر الفاكهة و الحديد كمكمل غذائي في تحسين حالة الحديد في السيرم و الكبد. و كذلك تحسين حالة الفئران المصابة. هيموجلوبين و الفريتين و الهيماتوكريت. و تشير النتائج إلى فعالية مستخلص البطاطس مع عصائر البنجر و الفاكهة إلى زيادة إتاحية الحديد كمكمل غذائي في حالة نقص الحديد في فئران التجارب.