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) 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 density lipoprotein, Triiodothyronine, Trijodothyronine, Thyrroxine, 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 density lipoprotein, Triiodothyronine, Thyrroxine, 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 (nicacin, 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 a 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 carotenoids (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 rez-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 (Peí 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 1 litre 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°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).

Chemical 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 spectrometry, 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 adaptation 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; Group3: 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 (8.00±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). Beets 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 anthropoystins 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-Barrachina 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 of the 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** |
| Control         | 8.4±0.16   | 6.4±0.34    | 6.5±0.14      | 6.0±0.28       |
| Orange          | 8.7±0.25   | 8.0±0.22    | 8.0±0.35      | 8.1±0.14       |
| Guava           | 8.7±0.16   | 8.2±0.35    | 7.9±0.20      | 8.2±0.43       |
| Strawberries    | 8.8±0.60   | 8.5±0.35    | 8.3±0.32      | 8.2±0.32       |
| Pomegranate     | 8.8±0.47   | 7.9±0.43    | 7.8±0.41      | 8.1±0.43       |
| OA              | 6.74±0.12  | 6.8±0.22    | 8.5±0.16      | 8.04±0.13      |

Values expressed as mean: standard deviation in each row having different a, b,… 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 vitamin A. 18% of the RDA of iron, 6% of potassium, 5% of magnesium, and 2% calcium and zinc (True et al., 1979). The iron content of potatoes ranged between 29.87 and 157.96 mg/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 C (Kwee et al., 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, and 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 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 (Bryan Thompson 2011).

| Table 2. Vitamin C, folate, iron and copper content of fruit/vegetable mix drinks |
|---------------------------------|--------------|---------------|---------------|----------------|
| **Samples**                     | **V.C mg/100 ml** | **Folate mcg/100ml** | **Iron mg/100g** | **Copper mcg/100g** |
| Guava                           | 43.9±0.02     | 6.4±0.01      | 4.02±0.02      | 0.09±0.002      |
| Orange                          | 27.6±0.03     | 39.5±0.02     | 3.37±0.00      | 0.19±0.001      |
| Pomegranate                     | 76.3±0.02     | 15.89±0.02    | 4.32±0.00      | 0.26±0.001      |
| Strawberry                      | 60.8±0.02     | 28.3±0.01     | 4.45±0.00      | 0.13±0.000      |

Values expressed as mean: standard deviation in each row having different a, b,… 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 groups 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 rat 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**

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

Values expressed as mean± standard deviation in each row having different a, b,c... litters indicating significance in difference; FER: Food Efficiency 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 compared to the normal rats. That confirms the decrease in Hematocrit and hemoglobin due to iron deficiency (Enika et al., 2008).

**Lipid profile of iron deficient 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, G:6 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 contributed 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 (Kuwowska 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 (Esmailzadeh 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 deficient rats received fruit/vegetable drink

<table>
<thead>
<tr>
<th>Groups</th>
<th>Cholesterol µmol/l</th>
<th>Triglyceride µmol/l</th>
<th>HDL µmol/l</th>
<th>LDL µmol/l</th>
<th>VLDL µmol/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1: Normal control</td>
<td>55.61±1.41</td>
<td>64.59±2.37</td>
<td>21.78±0.29</td>
<td>4.29±1.38</td>
<td>29.54±0.46</td>
</tr>
<tr>
<td>G2: Iron deficiency</td>
<td>95.1±1.41</td>
<td>398.39±3.91</td>
<td>14.59±0.52</td>
<td>20.36±0.38</td>
<td>60.15±0.87</td>
</tr>
<tr>
<td>G3: Iron deficiency +Fe</td>
<td>74.95±1.48</td>
<td>100.93±2.65</td>
<td>16.59±0.53</td>
<td>12.48±0.52</td>
<td>45.88±0.72</td>
</tr>
<tr>
<td>G4: Strawberry</td>
<td>63.83±1.25</td>
<td>84.28±1.59</td>
<td>18.71±0.45</td>
<td>6.81±0.42</td>
<td>38.31±0.58</td>
</tr>
<tr>
<td>G5: Orange</td>
<td>61.84±1.39</td>
<td>80.23±1.34</td>
<td>17.21±0.52</td>
<td>8.16±0.60</td>
<td>36.47±0.55</td>
</tr>
<tr>
<td>G6: Guava</td>
<td>65.96±2.18</td>
<td>86.47±0.98</td>
<td>18.74±0.47</td>
<td>7.92±2.10</td>
<td>39.30±0.81</td>
</tr>
<tr>
<td>G7: Pomegranate</td>
<td>65.81±2.52</td>
<td>85.13±1.30</td>
<td>17.21±0.52</td>
<td>7.86±0.63</td>
<td>38.70±0.69</td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>Groups</th>
<th>Total antioxidant capacity µmol/l</th>
<th>Total oxidant capacity µmol/l</th>
<th>Liver iron content U/g</th>
<th>Thyroxine (T4) ng/ml</th>
<th>Triiodothyronine (T3) ng/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal control</td>
<td>1.69±0.03</td>
<td>0.23±0.02</td>
<td>895.99±20.99</td>
<td>84.76±1.00</td>
<td>4.16±0.05</td>
</tr>
<tr>
<td>Iron deficiency</td>
<td>1.10±0.06</td>
<td>0.43±0.16</td>
<td>417.46±14.05</td>
<td>194.38±1.27</td>
<td>12.51±0.02</td>
</tr>
<tr>
<td>Deficiency + Fe</td>
<td>1.35±0.04</td>
<td>0.42±0.03</td>
<td>761.02±33.12</td>
<td>71.81±1.62</td>
<td>4.17±0.07</td>
</tr>
<tr>
<td>Strawberry</td>
<td>1.55±0.04</td>
<td>0.29±0.03</td>
<td>807.03±15.17</td>
<td>79.65±0.79</td>
<td>4.17±0.01</td>
</tr>
<tr>
<td>Orange</td>
<td>1.57±0.03</td>
<td>0.29±0.02</td>
<td>818.17±12.43</td>
<td>80.89±1.19</td>
<td>4.16±0.03</td>
</tr>
<tr>
<td>Guava</td>
<td>1.48±0.03</td>
<td>0.35±0.01</td>
<td>765.11±9.10</td>
<td>76.45±1.08</td>
<td>4.16±0.02</td>
</tr>
<tr>
<td>Pomegranate</td>
<td>1.51±0.03</td>
<td>0.35±0.03</td>
<td>783.33±10.71</td>
<td>77.61±0.55</td>
<td>4.15±0.03</td>
</tr>
</tbody>
</table>

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