Effect of Pomegranate and Sugarcane Molasses on Iron Deficiency Anemia in Experimental Rats

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Abstract

Iron deficiency (ID) is the most prevalent underlying cause of anemia, accounting for half of all cases worldwide. Therefore this study aimed to assess the ability of Pomegranate and Sugarcane molasses to treat iron deficiency anemia (IDA) that induced by high fiber diet (Cellulose) in rats. 40 female albino rats divided into eight groups (5 rats in each group): group 1 were fed on basal diet and served as control group, group 2 were fed on anemic diet and keep as anemic control group. Group 3 were fed on anemic diet with 1% iron sulphate. Group 4 and group 5 were fed on diet group 3 with 5% and 10% sugarcane molasses, respectively .Group 6 and group 7 were fed on diet group 3 with 5% and 10% pomegranate molasses, respectively. Group 8 were fed on diet group 3 with 10 % mixed molasses (1:1). After one month. Nutritional, biological and hematologic evaluations of tested rat groups were estimated. The results indicated that high fiber diet induced a significant decrease in the Hb, Hct % and ferritin, while TIBC was increased. Complete blood count was affected by high fiber diet. But, a supplemented diet with pomegranate and sugarcane molasses reversed such changes and improved the anemic biomarkers. Moreover the best result was found in the group treated with pomegranate molasses followed by sugarcane molasses.

Keywords: : Iron deficiency anemia , pomegranate molasses and sugarcane molasses, rats.

INTRODUCTION

Iron is an essential element and is controlled primarily by dietary intake, intestinal absorption and iron recycling **(Shah et al., 2021)**. Iron is required for various cellular functions including DNA synthesis, oxygen transport and mitochondrial energy generation **(Crielaard et al., 2017)**. anemia is a decrease in number of red blood corpuscles (RBCs) or less than the normal quantity of hemoglobin in the blood. It can include a decrease in oxygen-binding ability of each hemoglobin molecule due to deformity or lack in numerical development as in some other types of hemoglobin deficiency **(Panninx et al., 2013)**. The most common cause of anemia worldwide is iron deficiency. IDA characterized by small erythrocyte size and low hemoglobin levels **(Govindappagari and Burwick.,2019)**. Iron-deficiency anemia is another global nutritional problem occurring as a complication of nutritional and absorption disorders and is observed frequently over ages **(Makrides et al., 2003)**. IDA is an important public health problem affecting around 1.6 billion people **(McLean et al., 2009)**. IDA severely affects the lives of young children and premenopausal women (particularly those of low-income or in developed countries **(McLean et al .,2009)**. Higher rates were found in females, younger and older persons, patients with gastrointestinal diseases, pregnant women and women with a history of menometrorrhagia, and users of aspirin or antacids **(Levi et al ., 2016)**. Iron-deficiency anemia has been strongly related with insufficient iron intake, decreased absorption, blood loss , increased systemic requirements for iron such as in pregnancy **(Brissot et al ., 2018)**. IDA related to a deficiency in micronutrients and severity of infectious and inflammatory disease **(Gautam et al ., 2008)**. IDA can affect the quality of your life by lowering your energy level . The most

common symptoms of IDA are lassitude, tiredness, ringing in ears, paleness, reduced immunity, impaired growth, watery conjunctivae, taste disorder, spoon nails, ice craving and glossitis **(Pasricha et al ., 2010)**. Synthesis of Hb and red blood cells will not occur if iron supply is inadequate **(Milman ., 2011)**. Diet is of the utmost importance in the treatment of anemia. Dietary iron can be found in two forms: haem and non-haem iron. Haem iron is easily absorbable and arises from haemoglobin (Hb) and myoglobin in the form of animal meat, poultry and fish. Non haem iron is mostly found in plant food but is not as easily absorbable. Compounds such as phytate, oxalate, polyphenols and tannins, which are found in plants, diminish the uptake of non-haem iron, as do some drugs, such as proton pump inhibitors **(Hallberg et al ., 1987)** and **(Schönfeldt et al ., 2016)** , Ascorbic acid, citrate and gastric acid, conversely, facilitate iron absorption. **(Teucher et al ., 2004)** and **(Gulec et al ., 2014)**. Addition of Iron to Staple Foods , Several studies have shown that, especially in low-income countries, iron food fortification, referring to the addition of iron alone or with other micronutrients during food processing, was a safe and cost-effective way of preventing ID despite some technical difficulties related to undesirable changes in the food, such as alterations in appearance and taste **(Field et al ., 2021)** . thus various commonly consumed foods have been fortified in addition to formula, mainly cereals **(Bates et al ., 2020)** , but also wheat flour **(Biemi and Ganji ., 2021)** , maize flour **(Garcia-Casal et al ., 2018)**, rice **(Mahapatra et al ., 2021)** , soy sauce or fish sauce **(Da Silva et al ., 2021)** , salt **(Larson et al ., 2021)** and candies **(Dewi and Mahmudiono ., 2021)**. The aim of present study was to assess the effects of different forms of molasses to treat iron deficiency anemia induced by anemic diet such high fibre diet. Pomegranate molasses is a thick syrup made from pomegranate juice , The juice is boiled for more than six hours in order to obtain a concentrated substance called “molasses.” **(Chalfoun-Mounayar et al., 2012)**.

Pomegranate molasses, which is concentrated pomegranate juice and it may be higher in antioxidants than the juice , it is one of the best foods to increase haemoglobin, Hemoglobin levels, hematocrit percent levels, and RBCs count all increased significantly when pomegranate molasses was consumed **(Chalfoun-Mounayar et al., 2012)**. Pomegranate is a rich source of anthocyanins, ellagitannins and other phenolic compounds which are already proved to have antioxidant and antitumoral activity **(Perez - Vicente et al. 2004)**. sugar cane molasses, also referred to as the final effluent of sugar refinement is a dense, darkly coloured substance teeming in minerals **(Wang et al ., 2011)**. Molasses contains iron and its absorption enhancers, such as sulphur, fructose and copper, which make it a potential dietary supplement for IDA **(Jain and Venkatasubramanian., 2017)**. Molasses from sugarcane is a rich source of antioxidant materials including protection against oxidative DNA damage **(Asikin et al .,2013)**.

Pomegranate molasses was analyzed for 24.4% moisture, 0.2% protein , trace ash , total phenolic content of pomegranate molasses was about 52.6 mg GAE/g and total sugar were determined betweend 44.80 - 65.30 g/100g **(Yılmaz et al ., 2007)**. Sodium and potassium concentrations in pomegranate molasses were 148 and 20 mg/kg, respectively . Calcium and magnesium concentrations were 280 and 20 mg/kg, respectively. Zinc and Iron concentrations were 7.14 and 15.8 mg/kg, respectively. Copper and manganese concentrations were .61 and .23 mg/kg, respectively . Phosphorus concentrations were 15.57 mg/kg **(Fadavi et al ., 2005)**. Pomegranate molasses were found to have total acidity between 5.11-9.83 g/100 g. According to the pomegranate molasses standard, titration acidity must be minimum 7.5% (Anonymous., 2001). It determined the antioxidant activity of pomegranate molasses was 85.91% **(Orak ., 2009)**.

Suger Cane molasses contained dry matter (DM) 76.8 ± 1.02 % , Ash was 11.7 % of DM , crude protein content 6.7 ± 1.8 % of DM and Total sugars was 62.3 % of DM .The amount of sucrose was 60.9 ± 4.4 % of DM , Glucose and fructose were 5.3 ± 2.7 and 8.1 ± 2.8% of DM, respectively. Starch, dextran, levan, and araban were 2.2% of DM .Other analyzed sugars (galactose, raffinose, arabinose, and xylose) were almost undetectable, and even the sum of maximum values was lower than 1% of DM in cane molasses **(Olbrich ., 2006)**. Differences were also observed in organic acids such Lactic acid was 6.1 ± 2.8% of DM, Aconitic acid was found only in cane molasses (1.4% of DM on average), Other analyzed acids (acetic, butyric, propionic, citric, malic, formic, glycolic, and oxalic) were poorly represented in cane molasses .The total sum of acids ranged from 2.4% to 18.7% of DM in cane molasses **(Kung et al., 2018)**. Copper and manganese were 36 and 35 mg/kg, respectively . iron and Zinc were 249 and 13 mg/kg ,respectively **(Curtin ., 1973)**. the total phenolic content was expressed as 7.60 mg GAE/g extract **(Iqbal et al ., 2017)** . sugarcane molasses exhibited high antioxidant effect activity with value of 1.9 mg TE/g extract **(Ali et al., 2019)**. Feeding experiment was also conducted to study the effect of pomegranate and suger Cane molasses against iron deficiency anemia.

Materials and Methods

Materials

Sugarcane Molasses purchased from Agricultural Research Center (ARC), Giza , Egypt . All the nutrient ingredients needed for the preparation of the basal diet (AIN 93-G) according to the nutritional requirements of rats and to the preparation of the diet were purchased from the El-Gomhorya Company for Trading Drugs and Chemicals, Cairo, Egypt. Sugar and corn oil were purchased from Ministry of Agriculture. The chemicals used in this study were

acquired from the El-Gomhoriya Company for Trading Drugs and Chemicals, Cairo, Egypt. Kits and Medical Instruments were purchased from the Gamma Trade Co., for Pharmaceutical and Chemical, Dokki, Egypt.

Animals: Forty female albino rats, Sprague Dawley Strain, weighing (102 ± 2 g) were obtained from National Research Center, Dokki, Egypt.

Methods:

Preparation of pomegranate molasses

Fresh pomegranate fruit (Punicagranatum L.) was purchased from Agricultural Research Center (ARC), Giza , Egypt . Pomegranate fruits were washed and peeled manually . the arils were homogenized in the blender without water. The resultant filtered using muslin cloth to obtain clear pomegranate juice . The juice is boiled for more than six hours in order to obtain a concentrated substance called "molasses." according to **(Chalfoun-Mounayar et al., 2012)**.

Rat groups and experimental diets

Animals:

Forty female albino rats weighing (102 ± 2 g) were obtained from National Research Center, Dokki, Egypt. Rats were housed individually in wire cages at a room temperature maintained at 25 ± 2 ºC and kept under healthy conditions. The animals were

acclimatized to laboratory conditions for one week before start the experiment. Rats were fed a basal diet and water supply was given ad-libitum.

To induce iron deficiency anemia in the experimental rats the method of **(Bushnell.,1992)** was used. Rats were fed on iron free diet with 20 % cellulose for 2 weeks. blood samples were obtained from the eye vein of different rats to estimate Heamoglobin (Hb) to ensure the occurrence of IDA compare with the basal diet control group.

Diets and rat groups

This evaluation consists of 8 experimental rat groups fed on the following diets:

Control group (G1) : Rats were fed on Basal diet was prepared according to (Reeves et al., 1993), it consists of 20% casein, 5 % oil, 5 % Fiber, 10% sugar, 3.5 % mineral mixtures, 1 % vitamin mixture and 50.5 g Corn starch.

Anemic control group (G2) : Rats were fed on a were fed on diet free of iron and 20 % Fiber.

Group (3): Anemic rats were fed on anemic diet and 1% iron sulphate.

Group (4): Anemic rats were fed on anemic diet with 1% iron sulphate and 5 % sugarcane molasses.

Group (5): Anemic rats were fed on anemic diet with 1% iron sulphate and 10% sugarcane molasses.

Group (6): Anemic rats were fed on anemic diet with 1% iron

sulphate and 5 % pomegranate molasses.

Group (7): Anemic rats were fed on anemic diet with 1% iron sulphate and 10% pomegranate molasses.

Group (8): Anemic rats were fed on anemic diet with 1% iron sulphate and 10 % from both of pomegranate and sugarcane molasses by equal proportion (1:1)

During the experiment, rats' weight was recorded weekly, food intake and food loss were projected daily, after one month, rats were fasted overnight then before being sacrificed under ether anesthesia and blood samples were collected from each rat in two tubes, one centrifuged to obtain the serum. Serum will carefully separate and transferred into dry clean Eppendorf tubes and kept frozen at-20ºc for analysis that described according to **(Schermer.,1967)**. Organs including, liver, heart and spleen were collected and weighted.

Total feed intake, body weight gain, feed efficiency ratio and relative organs weight (ROW %) were calculated **(Chapman et al., 1959)** according to the following equations:

Body Weight Gain = Final weight (g) - Initial weight (g)

Feed Efficiency Ratio(FER) = Gain in body weight (g) / Feed intake (g)

Relative organs weight (ROW %) = Organ weight / Final body weight x 100

Biochemical blood analysis:

Complete blood count(CBC) was calculated using automatic cell count using a hematological analyzer (Exigo Eos Vet, Sweden) **(Walencik and Witeska., 2007)**. Hemoglobin (Hb) and hematocrit (HCT) levels were measured using methods of **(Drabkin .,1949)** and **(McInory .,1954)**, respectively . Red blood cells and white blood cells were count according to (**Fischbach and Dunning .,2009)**. Serum ferritin and total iron-binding capacity (TIBC) were

measured follow the method of **(Yamanishi et al.,2003)** and **(White et al., 1986)**, respectively.

Statistical analysis:

Results were expressed as (Mean± SD). Differences between groups were tested for significance using a one-way analysis of variance (ANOVA test) $P \leq (0.05)$ using SPSS statistical software, version 20 according to **(Armitage and Berry .,1987)**.

Results and Discussion

Nutritional tested parameters:

Results in Table (1) indicated that, initial body weight of all group after adaptation on basal diet were nearly and with no significant differences. At the end of experiment periods, the final body weights of anemic rats (G2) had (117.8 g) lower than those of control group (G1) had (195 g).

anemic rats fed on basal diet and with 1% iron sulfate (G3) , anemic rats feed on diet group 3 with sugarcane molasses , pomegranate molasses and mixed molasses (G4, G5 , G6 ,G7 and G8) had increased final body weight than those of the anemic control group (G2) ranging from (181.4 g to 192.2 g) .

The obtained results illustrated that the body weight gain at the end of experiment periods for the control group (G 1) had (92.3 g) , while anemic control group (G 2) was (14.9 g) . while anemic rats fed on basal diet and with 1% iron sulfate (G3) , anemic rats feed on diet group 3 with sugarcane molasses , pomegranate molasses and mixed molasses (G4, G5 , G6 ,G7 and G8) ranging from (79.4 g to 89 g) increase gain in body weight compared of G2 . From these results; obvious that anemic rats (G1) gradually dropped in body weight gain.

The obtained results illustrated that the feed intake (FI) at the end of experiment periods for the control group (G 1) had (2200 g/ month) , while Feed intake (FI) results revealed a significant decrease in the anemic control group (G2) to (1750 g /month) . anemic rats fed on basal diet with 1% iron sulfate (G3) , anemic rats feed on diet group 3 with sugarcane molasses , pomegranate molasses and mixed molasses (G4, G5 , G6 ,G7 and G8) had increased feed intake ranging from (1950 g / month to 2250 g / month) . The group treated with sugarcane molasses (5%) and pomegranate molasses (5%) in a (G4 and G 6) had the greatest mean value of FI (2250 g / month) .

The feed efficiency ratio data (FER) showed a considerable decrease in the anemic control group (G2) had (0.009 %). The FER of all treated groups improved significantly, ranging from (0.037 % to 0.045 %). The finding of this study reports that treatment with iron sulfate, sugarcane molasses, pomegranate molasses and mixed molasses improved the weight gain which helped to reverse the feed intake compared to untreated anemic rats. Poor appetite is highly prevalent among anemic rats that lead to loss of body weight **(Wilson et al ., 2005)**.

Table (1) : Body weight gain (BWG) , feed intake (FI) and feed efficiency ratio (FER %) of tested rat groups :

Groups of rats	Initial BWT (g)	Final BWT (g)	BWT gain (g)	FI (g)	FER %
G1: Control	102.7± 5^{b}	195±6^{a}	92.3±3^{a}	2200±20^{b}	0.042^{a}
G2: Anemic control	102.9±7^{a}	117.8±3^{g}	14.9±2^{e}	1750±35^{e}	0.009^{b}
G3: 1% Iron sulphate	102.3±10^{b}	190±5^{c}	87.7±4^{b}	1950±33^{d}	0.045 ^{a}
G4: 5% Sugarcane molasses	103.2±12^{a}	192.2±8^{b}	89±5^{a}	2250±40^{a}	0.040 ^{a}
G 5: 10% Sugarcane molasses	101.7±8^{c}	182.8±7^{f}	81.1±4^{c}	2180±25^{b}	0.037 ^{a}
G 6: 5% Pomegranate molasses	102.8±7^{a}	185.8±10^{e}	83±3^{c}	2250±55^{a}	0.037 ^{a}
G7: 10% Pomegranate molasses	102±6^{c}	181.4±12^{f}	79.4±2^{d}	2000±20^{d}	0.040 ^{a}
G 8: 10% Pomegranate and sugarcane molasses(1:1)	101±8^{d}	188.2±11^{d}	87.2±5^{b}	2130±40^{c}	0.041 ^{a}

Each value represents the mean ± SD. Means with the different superscript letters in the same column were significantly different (P≤0.05)

Findings of relative liver weight (%) in table (2) showed that the control group(G1) mean value was higher than the anemic control group (G2), with a significant difference between them. The relative liver weight (%) of all treated groups increased significantly, ranging from 3.86 to 4.31 . The group treated with pomegranate molasses 10 % (G 7) had the greatest best results of liver weight (%) (4.31) followed by pomegranate molasses 5% (4.27).

In terms of relative heart weight (%), the control group (G1) was less than the anemic control group, with a significant difference. In addition, the treated groups experienced a significant reduction in relative heart weight (%) that varied from 0.54 to 0.44 . The group treated with pomegranate molasses 10 % (G 7) had the greatest best results of heart weight (%) (0.44) followed by pomegranate molasses 5% (0.46).

The mean value of the control group (G1) was less than that of the anemic control group (G2), with a significant difference between them, according to the results of relative spleen weight (%). The relative spleen weight (%) of all treatment groups decreased significantly, ranging from 0.62 to 0. 39. The group treated with pomegranate molasses 10 % (G 7) had the greatest best results of spleen weight (%) (0.39) followed by pomegranate molasses 5% (0.44).

The liver and spleen are the main organs of iron storage and play an important role in iron metabolism **(Standa et al ., 1997)**. therefore, the low iron contents of the liver and spleen in rats with IDA indicated severe depletion of storage iron, which was similar to the results of a study by **(Kasai et al ., 2003)** . The heart in the anemia model group(G2) was significantly higher than that in the normal control group (G1)which indicated that iron deficiency led to cardiac hypertrophy **(Tangeda et al ., 2016)**. A significant decrease

in the liver coefficient was observed in the anemia model group (G1) , which was consistent with the result that reported **(Zhang et al.,2016)** and indicated that iron deficiency caused a decrease in liver volume. A possible reason is that, when there is iron deficiency, DNA synthesis in the liver is inhibited, which results in slower development of the liver **(Siimes and Dallman ., 1974)**. Spleen hypertrophy was observed in the anemia model group (G1) , for which the reason was that iron deficiency resulted in cell

proliferation by activating spleen cells **(Kuvibidila and Porretta ., 2003)**.

Table (2) : relative organs weight % (liver, heart and spleen) for tested rats:

Groups of rats	Relative organs weight%		
	Liver	Heart	Spleen
G1: Control	4.51 ±0.8[a]	0.31 ± 0.02[c]	0.29 ±0.02[d]
G2: Anemic control	2.88 ±0.6[c]	0.69 ±0.05[a]	0.71 ±0.05[a]
G3: 1% Iron sulphate	3.86 ±0.3[b]	0.54 ±0.04[a]	0.62 ±0.03[a]
G4: 5% Sugarcane molasses	3.95 ±0.2[b]	0.51 ±0.02[b]	0.52 ±0.02[b]
G 5: 10% Sugarcane molasses	4.13 ±0.4[a]	0.47 ±0.03[b]	0.51 ±0.05[b]
G 6: 5% Pomegranate molasses	4.27 ±0.3[a]	0.46 ±0.04[b]	0.44 ±0.07[c]
G7: 10% Pomegranate molasses	4.31 ±0.9[a]	0.44 ±0.02[c]	0.39 ±0.01[c]
G 8: 10% Pomegranate and sugarcane molasses(1:1)	4.11 ±0.5[a]	0.48 ±0.03[b]	0.48 ±0.02[b]

Each value represents the mean ± SD. Means with the different superscript letters in the same column were significantly different (P≤0.05)

Hematological parameters

The results in Table (3) indicated that the Hemoglobin (Hb) and Hematocrit (HCT) levels was lower in anemic rats (G2) compared with those of control group (G1) . The anemic rats fed on basal diet with 1% iron sulphate (G3) , anemic rats feed on diet group 3 with sugarcane molasses , pomegranate molasses and mixed molasses (G4, G5 , G6 ,G7 and G8) had significantly higher serum hemoglobin (Hb) and Hematocrit (HCT %) levels compared with anemic group (G2) . The amelioration by sugarcane and pomegranate molasses was occurred to the near normal values of control group . This means that molasses has protective effect. The

group treated with pomegranate molasses 10 % (G 7) had the greatest best results of Hb level (14.73 g/dl) and HCT level (46.8 PCV %) followed by the group treated with pomegranate molasses 5 % (G 6) that Hb level (14.6 g/dl) and HCT level (43.5 %). The enhanced change in hematological parameters in the group given pomegranate molasses as a protective agent could be owing to the fact that pomegranate is a good source of iron (which is needed to make hemoglobin) and phenolic compounds, which are antioxidants and free radical scavengers **(Rosenblat et al., 2006)**. Hemoglobin (Hb) was lower in anemic rats (G2) The reason was that iron deficiency led to a decrease in functional iron in circulation in the blood, which resulted in a decrease in the Hb content **(Matsumoto et al ., 2016)**. HCT value in the anemia model group (G 2) were significantly lower than those in the normal control group (G1) ($p < 0.05$). because HCT level has positively correlated with Hb **(Tang al ., 2014)** .

Table (3): Hemoglobin (Hb) and Hematocrit(HCT) levels of tested rat groups :

Groups of rats	Hb (g/dL)	HCT (PCV %)
G1: Control	15 ±0.2[a]	46.9 ±0.3 [a]
G2: Anemic control	8.3 ±0.5[c]	33.6 ±0.23[d]
G3: 1% Iron sulphate	13.63 ±0.4[b]	40.5 ±0.25 [c]
G4: 5% Sugarcane molasses	13.8 ±0.4 [b]	41.4 ±0.15[c]
G 5: 10% Sugarcane molasses	14.2 ±0.3 [b]	43 ±0.4 [b]
G 6: 5% Pomegranate molasses	14.6 ±0.12[a]	43.5 ±0.5 [b]
G7: 10% Pomegranate molasses	14.73 ±0.15[a]	46.8 ±0.7 [a]
G 8: 10% Pomegranate and sugarcane molasses(1:1)	14.2 ±0.11 [b]	43 ±0.3 [b]

Each value represents the mean ± SD. Means with the different superscript letters in the same column were significantly different ($P \leq 0.05$)

Results in Table (4) showed that The anemic group (G2) exhibited significantly lower Serum Iron, ferritin levels and higher TIBC levels in comparison with the control group (G1) because it was always fed with a low-iron diet **(Zhang et al ., 2016)**. The anemic rats fed on basal diet with 1% iron sulphate (G3) , anemic rats feed on diet group 3 with sugarcane molasses , pomegranate molasses and mixed molasses (G4, G5 , G6 ,G7 and G8) had significantly higher Serum Iron, ferritin levels and lower TIBC levels compared with anemic group (G2) . The group treated with pomegranate molasses 10 % (G 7) had the greatest best results of Serum Iron (112.1 µg/dl) , ferritin level (115.2 ng /ml) ,TIBC (185.6 µg /dl) followed by the group treated with pomegranate molasses 5 % (G 6) that Serum Iron (110.2 µg/dl) and ferritin level level (106 ng /ml) and TIBC (190.4 µg /dl). TIBC is usually elevated when total body iron stores are low, a possible sign of iron deficiency anemia **(Rifai and Ridker., 2003)**. the Serum ferritin content was lowest in the anemia model group (G2) and highest in the control group (G1), which was consistent with the report by **(Wang et al.,2014)** . normally, a positive relationship exists between Serum ferritin content and serum iron **(Bailey et al ., 2015)**.Usually, Serum Iron, ferritin levels and TIBC reflect the status of iron during its circulation in the blood **(Inocent et al ., 2008)** .

Table (4): Serum Iron, ferritin levels and total iron-binding capacity (TIBC) of tested rat groups:

Groups of rats	serum Iron (µg/dl)	Serum ferritin (ng /ml)	TIBC(µg /dl)
G1: Control	112.5± 25^{a}	130.5± 9.2 ^{a}	170.40 ±6.5^{f}
G2: Anemic control	75 ± 23^{f}	88 ±4.3^{e}	246.2±3.5 ^{a}
G3: 1% Iron sulphate	103 ±30^{e}	129 ± 5^{a}	225.5±5.4^{b}
G4: 5% Sugarcane molasses	105.0 ±16^{d}	99 ±2.5^{d}	201.4±7.5^{c}
G 5: 10% Sugarcane molasses	107.0 ±21^{c}	95 ±6^{d}	190.5 ±8.2^{d}
G 6: 5% Pomegranate molasses	110.2 ± 15^{b}	106 ±9^{c}	190.4±6.7^{d}
G7: 10% Pomegranate molasses	112.1 ±13^{a}	115.2 ± 7.7^{b}	185.6±5.4^{e}
G 8: 10% Pomegranate and sugarcane molasses(1:1)	108.2 ±20^{c}	102.5 ±6.8^{c}	195.7 ±10^{d}

Each value represents the mean ± SD. Means with the different superscript letters in the same column were significantly different (P≤0.05)

Results in Table (5) indicated that the Red blood cells count (RBC) and white blood cell (WBC) levels was lower in anemic rats (G2) compared with those of control group (G1) . The anemic rats fed on basal diet with 1% iron sulphate (G3) , anemic rats feed on diet group 3 with sugarcane molasses , pomegranate molasses and mixed molasses (G4, G5 , G6 ,G7 and G8) had significantly higher RBC and WBC compared with anemic group (G2) . The amelioration by sugarcane and pomegranate molasses was occurred to the near normal values of control group (G1). The group treated with pomegranate molasses 10 % (G 7) had the greatest best results of RBC (5.83 million /cm) and WBC (5500 thousands/ cm) . a sufficient number of RBC is necessary to maintain the normal acid–base balance of the body **(Carley., 2003)**.

Table (5): Red blood cells count (RBC) and white blood cell (WBC) levels of tested rat Groups:

Groups of rats	RBC (millions /cm)	WBC (thousands/ cm)
G1: Control	6.03 ±0.22[a]	5.570±0.06[a]
G2: Anemic control	4.86 ± 0.12[c]	4.100 ±0.15[c]
G3: 1% Iron sulphate	5.03±0.25[b]	5.101 ±0.08[b]
G4: 5% Sugarcane molasses	5.24±0.16[b]	5.200±0.07[b]
G 5: 10% Sugarcane molasses	5.37±0.14[b]	5.303 ±0.18[b]
G 6: 5% Pomegranate molasses	5.16 ±0.09[b]	5.401 ±0.15[b]
G7: 10% Pomegranate molasses	5.83 ±0.23[a]	5.500 ±0.09[b]
G 8: 10% Pomegranate and sugarcane molasses(1:1)	5.12 ±0.30[b]	4.700 ±0.08[b]

Each value represents the mean ± SD. Means with the different superscript letters in the same column were significantly different (P≤0.05)

Results in Table (6) showed that (MCV) and (MCHC) levels was lower in Rats fed on anemic diet (G 2) compared with those of Rats fed on basal diet (control group (G1). The anemic rats fed on basal diet with 1% iron sulphate (G3) and anemic rats feed on diet group 3 with sugarcane molasses , pomegranate molasses and mixed molasses (G4, G5 , G6 ,G7 and G8) had significantly higher on mean corpuscular volume (MCV) and mean corpuscular hemoglobin concentration (MCHC) levels compared with anemic group (G2). The group treated with pomegranate molasses 10 % (G 7)had the greatest best results of MCV (90 ft) followed by the group treated with pomegranate molasses 5 % (G 6) that MCV level (89 ft) , then the group treated with sugarcane molasses 10% (G 5) had (87 ft) . while The group treated with pomegranate molasses 5 % (G 6) had the greatest best results of MCHC level (33.5 g/dl) followed by the group treated with sugarcane molasses 5 % (G 4) (33.3 g / dl). The enhanced change in MCV and MCHC in the group given pomegranate molasses as a protective agent .

Decreased MCHC can roughly represent the presence of hypochromia, which is common in patients with moderate and severe anemia **(Simbaqueba et al ., 2013) .**MCV and MCHC in the anemic group (G2) were significantly reduced ($p < 0.05$) in comparison with the normal control group(G1). In fact, owing to iron deficiency, the Hb content in RBC was reduced, which resulted in a decrease in cell volumes **(Bunyaratvej et al ., 1993).**

Table (6) : Mean corpuscular volume (MCV) and mean corpuscular hemoglobin concentration (MCHC) levels of tested rat groups :

Groups of rats	MCV (ft)	MCHC (g/dl)
G1: Control	91.7 ±0.52 [a]	34 ±0.12 [a]
G2: Anemic control	72 ±0.7[d]	24.7 ±0.23[c]
G3: 1% Iron sulphate	85 ±0.8[b]	33 ±0.27 [a]
G4: 5% Sugarcane molasses	82 ±0.23[c]	33.3 ±0.12 [a]
G 5: 10% Sugarcane molasses	87 ±0.25[b]	31.5 ±0.151 [b]
G 6: 5% Pomegranate molasses	89 ±0.18 [b]	33.5 ±0.16 [a]
G7: 10% Pomegranate molasses	90 ±0.21 [a]	31.4 ±0.11 [b]
G 8: 10% Pomegranate and sugarcane molasses(1:1)	85.5 ±0.25 [b]	33.02 ±0.30 [a]

Each value represents the mean ± SD. Means with the different superscript letters in the same column were significantly different ($P \leq 0.05$)

Conclusion

Foods high in fiber limit the absorption of iron from meals that may lead to iron deficiency anemia. This study recommends by using pomegranate and sugar cane molasses to improve the condition of iron deficiency anemia. Results showed that there are no significant differences between using level 5% or level 10% of pomegranate and sugar cane molasses. Therefore, it is economically recommended to use pomegranate and sugar cane molasses at level 5%. Pomegranate and sugar cane molasses increased Hb, HCT, RBC, WBC, MCV and MCHC values of serum iron profile so it can protect or cure IDA.

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الملخص العربي

تأثير دبس الرمان ودبس قصب السكر على الفئران المصابة بانيميا نقص الحديد

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يعتقد أن نقص الحديد هو السبب الأساسي الأكثر شيوعًا للإصابة بالأنيميا حيث يُفترض أن نصف حالات فقر الدم العالمية تعزى إلى نقص الحديد. تهدف هذه الدراسة لقياس قدرة دبس الرمان ودبس قصب السكر على علاج انيميا نقص الحديد الناجم عن اتباع نظام غذائي غني بالألياف (السليلوز) في الفئران. تم تقسيم ٤٠ من اناث الفئران الى ٨ مجوعات (٥ فئران في كل مجموعة) . المجموعة الاولى تركت كمجموعة ضابطة وتغذت علي علائق متزنة ، المجموعة الثانية تغذت على النظام الغذائي الاساسي الخالى من الحديد (نظام غذائي مصاب بفقر الدم) دون اي اضافات كمجموعة تحكم مصابه بانيميا نقص الحديد ، تم تغذية المجوعة الثالثة على نفس العليقة المستخدمة لاحداث الانيميا ويضاف عليها كبريتات الحديد بنسبة ١٪ ، تم تغذية المجموعة الرابعة والمجموعة الخامسة على نظام غذائي الخاص بالمجموعة الثالثة يحتوي على ٥٪ و ١٠٪ دبس قصب السكر على التوالي ، تم تغذية المجموعة السادسة والمجموعة السابعة على نظام غذائي الخاص بالمجموعة الثالثة يحتوي على ٥٪ و ١٠٪ دبس الرمان على التوالى ، تم تغذية المجوعة الثامنة على نظام غذائي الخاص بالمجموعة الثالثة ويضاف خليط بنسبة متساوية (١:١) من دبس الرمان ودبس قصب السكر ويضاف بنسبة ١٠ % من وزن العليقة. بعد شهر واحد من نهاية التجربة ؛ تم تقدير التقييمات الغذائية والبيولوجية والدموية لمجموعات الفئران المختبرة. أشارت النتائج إلى أن النظام الغذائي الغني بالألياف أدى إلى انخفاض كبير في نسبة الهيموجلوبين و نسبة الهيموتيكريت والفريتين ، بينما زادت القدرة الكلية للحديد على االارتباط و تأثر تعداد الدم الكامل بالنظام الغذائي الغني بالألياف. ولكن النظام الغذائي الغنى بدبس الرمان وقصب السكر عكس هذه التغييرات وحسن المؤشرات الحيوية لفقر الدم. علاوة على ذلك، تم العثور على أفضل نتيجة في المجموعة المعالجة بدبس الرمان تليها دبس قصب السكر.

الكلمات المفتاحية : انيميا نقص الحديد ، دبس الرمان ، دبس قصب السكر ، الفئران.