

Case Report

Synergistic effects of red beet (*beta vulgaris*) and calorie-restricted diet on iron deficiency anemia and metabolic syndrome in reproductive-age women

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Abstract

Iron deficiency anemia (IDA) is prevalent among women of childbearing age, often worsened by metabolic syndrome and restrictive diets like veganism. This case explores the effects of red beetroot juice supplementation alongside a hypocaloric diet in a 32-year-old obese vegan woman with IDA and metabolic syndrome. A 12-week intervention included a 1200 kcal/day diet with three main meals and three snacks, each containing 250 ml of fresh red beetroot juice. Anthropometric measures, body composition, blood pressure, hemoglobin, ferritin, soluble transferrin receptor, lipid profile, fasting glucose, and insulin were assessed at baseline, week 4, week 8, and week 12. Significant improvements ($P < 0.05$) were observed in weight, BMI, waist-to-hip ratio, and fat mass, alongside increased fat-free mass and total body water. Hemoglobin and ferritin normalized, while soluble transferrin receptor levels decreased, indicating improved iron metabolism. Blood pressure, fasting glucose, insulin, LDL, triglycerides, and total cholesterol declined, whereas HDL increased. Red beetroot juice, combined with a calorie-restricted diet, shows promise in managing obesity, metabolic syndrome, and IDA in vegan individuals. Further research is needed to establish long-term effects and optimize supplementation strategies.

Keywords: red beetroot, iron deficiency anemia, metabolic syndrome, calorie-restricted diet

Introduction

Iron deficiency anemia (IDA) is one of the most prevalent health problems experienced by reproductive-age women, affecting about 30% worldwide [1]. Conditions like this have been credited with severe health implications in terms of chronic fatigue, impaired performance in cognitive functioning, and potential for work loss. These disadvantages are even enhanced in individuals who follow restrictive eating habits, where a vegan dietary pattern has already been linked to lower levels of ferritin compared to omnivorous patterns [2, 3]. Strict vegan diets, with low iron bioavailability (a general estimate of 5% for iron absorption), require a higher daily iron intake to meet physiological needs [4].

Although gastrointestinal bleeding and menstruation are the major causes of IDA in women, inadequate dietary iron intake and impaired absorption also contribute significantly to its pathogenesis [5]. The presence of metabolic syndrome (MetS), characterized by obesity, dyslipidemia, hypertension, and insulin resistance [6], further complicates the management of IDA. MetS is reported to disrupt iron metabolism and is associated with increased levels of inflammatory markers known to negatively impact iron homeostasis [7, 8].

Emerging evidence highlights the potential of dietary interventions, particularly those including bioactive compounds, to address both IDA and MetS. Red beet (*Beta vulgaris*) is a nutrient-dense root vegetable that has been gaining attention for its potential to improve iron absorption and metabolic profiles [9, 10].



Rich in dietary nitrates, betaine, and iron, red beet is proposed to facilitate hemoglobin synthesis while mitigating oxidative stress [11].

This study will determine the synergistic effects of a calorie-restricted diet combined with red beet juice supplementation on IDA and MetS parameters. It will fill the gap in the literature and offer a non-pharmacological strategy for managing these conditions.

Case report

The participant is a 32-year-old obese vegan female who agreed to participate in this study and signed a consent form before data collection. She has maintained a strict plant-based diet, although she allows for the occasional plain Greek yogurt. She presents with a history of an IDA that was diagnosed five years ago. She reports having to discontinue her iron supplement therapy due to profound gastrointestinal side effects; hence, her disease has gone untreated since the time of diagnosis. Furthermore, she meets the diagnostic criteria for MetS according to the National Cholesterol Education Program Adult Treatment Panel III guidelines (NCEP-ATP III) [12]; that is, her abdominal circumference is >88 cm, fasting blood glucose (FBG) >100 mg/dL, levels of triglycerides (TG) are >150 mg/dL and her HDL-cholesterol is <50 mg/dL.

Her clinical assessment revealed the following basal characteristics: weight = 84 kg, height = 164 cm, and body mass index (BMI) = 31.2 kg/m², classifying her as obese. Anthropometric measurements showed an abdominal circumference of 105 cm, a hip circumference of 115 cm, and a waist-to-hip ratio (WHR) of 0.9. Body composition indicated fat mass (FM) as 38.2%, fat-free mass (FFM) as 61.8%, and total body water (TBW) as 42.5% (Table 1).

Laboratory findings confirmed her history of IDA, with hemoglobin levels of 9 g/dL, ferritin levels of 7 ng/mL and soluble transferrin receptor (sTfR) of 8.8 mg/l. Metabolic parameters were compatible with MetS: FBG was 114 mg/dL, TG was 175 mg/dL, HDL-cholesterol was 35 mg/dL, and TC was 275 mg/dL. Her blood pressure readings were 138/82 mmHg, indicating pre-hypertension according to standard classification (Table 1).

The confluence of metabolic and nutritional challenges calls for an individualized dietary and lifestyle intervention plan. The proposed intervention must focus not only on her iron deficiency, offset by intolerance to supplements that run against her dietary preference, but also on components of MetS: glycemic con-

Table 1: Baseline characteristics of the patient.

Parameter	Baseline Value
Weight (kg)	84
Height (cm)	164
BMI (kg/m ²)	31.2
Abdominal circumference (cm)	105
Hip circumference (cm)	115
WHR	0.9
Fat mass (%)	38.2
Fat free mass (%)	61.8
Total body water (%)	42.5
Hemoglobin (g/dl)	9
Ferritin (ng/ml)	7
sTfR (mg/l)	8.8
Fasting blood glucose (mg/dl)	114
Insulin (mIU/L)	10.3
Triglycerides (mg/dl)	175
HDL (mg/dl)	35
LDL (mg/dl)	155
Total cholesterol (mg/dl)	275
SBP (mmHg)	138
DPB (mmHg)	82

Note: BMI – Body mass index; WHR – Waist to hip ratio; sTfR – Soluble transferrin receptor; HDL – High-density lipoprotein cholesterol; LDL – Low-density lipoprotein cholesterol; SBP – Systolic blood pressure; DBP – Diastolic blood pressure.

trol, improvement of the lipid profile, optimization of body composition—a holistic approach incorporating medical nutrition therapy, increased physical activity, and behavioral changes.

Material and methods

Estimation of energy requirements

Before designing the intervention diet, a detailed dietary and medical history was taken from the patient, and her energy needs were estimated.

The energy needs were estimated by using the formula of 30–35 Kcal/day per kg of the patient's ideal body weight (IBW) [13]. The IBW was calculated using the Hamwi method [14], and it was 56 kg. Based on this,

the estimated energy requirement (EER) was between 1,680 and 1,960 Kcal/day. These calories were distributed as 55% carbohydrates, 20% protein and 25% fat [15]. As a result of this, the macronutrient requirements were arrived at as 231–269.5 g/day for carbohydrates, 84–98 g/day for protein and 46.7–54.4 g/day for fat. This macronutrient distribution was to raise plant-based protein intake and to manufacture complete proteins—equivalent in quality to animal proteins—by merging grains, legumes, nuts, and seeds.

Intervention

The patient was subjected to a 12-week intervention, following a 1,200 Kcal/day weight-reduction diet that had been planned for a vegan lifestyle but was adapted to include plain Greek yogurt as the sole animal-derived source of protein she would accept. The distribution of calories was 55% from carbohydrates, 20% protein, and 25% fat, which corresponded to 165 g/day of carbohydrates, 60 g/day of protein, and 33 g/day of fat.

Daily dietary was divided into three major meals and three snacks, with each snack composed of 250 ml freshly squeezed red beetroot juice. The patient was requested to freshly prepare the juice daily to keep its nutritious value. The distribution of calories was about 270 Kcal for breakfast, 400 Kcal for lunch, 250 Kcal for dinner, and 98 Kcal per snack. The diets were carefully planned to reflect a balanced vegan dietary pattern but with the inclusion of Greek yogurt. A sample one-day dietary plan is given in Table 2.

Monitoring and evaluation

The progress of the patient was monitored using anthropometric measurements and assessment of body composition at baseline (week 0) and at weeks 4, 8, and 12. The former included the measurements of body weight, abdominal and hip circumferences, and waist-to-hip ratio (WHR). With respect to the latter, a bioelectrical impedance analysis device, InBody 770, was used to measure fat mass (FM), fat-free mass (FFM), and total body water (TBW). Also, biochemical

Table 2: One day of the interventional 1200 Kcal weight-reducing diet, including the red beetroot juice snack.

Meal	Food Items	Calories (Kcal)	Carbs (g)	Protein (g)	Fat (g)
Breakfast	- 1 slice whole-grain toast (30 g)	70	13	3	1
	- 2 Tbsp almond butter	200	0	14	16
Total		270	13	17	17
Snack 1	- 1 cup (250 ml) red beetroot juice	98	22	2	0
	- 1 cup cooked quinoa (185 g)	222	39	8	3
Lunch	- 1 cup steamed broccoli	50	10	4	0
	- ½ avocado	80	4	1	7
	- 1 tsp olive oil	45	0	0	5
Total		397	53	13	15
Snack 2	- 1 cup (250 ml) red beetroot juice	98	22	2	0
	- ½ cup lentil soup (240 g, made with vegetable stock)	65	10	4	1
Dinner	- ½ small sweet potato (65 g, roasted)	50	12	1	0
	- 1 cup plain Greek yogurt, 0 fat	132	14	19	0
Total		247	36	24	1
Snack 3	- 1 cup (250 ml) red beetroot juice	98	22	2	0
Daily total		1208*	168*	60	33

Note: * – The total energy exceeded the target of 1200 Kcal by 8 Kcal, and the carbohydrate intake exceeded the calculated grams per day by 3 grams. This slight increase in both total energy and carbohydrate intake falls within the normal acceptable range, which allows for deviations of 20–30 Kcal and ±5 grams of carbohydrates.

markers such as hemoglobin, ferritin, sTfR, FBG, insulin, and lipid profile (total cholesterol, HDL, LDL, and triglycerides) were measured at each four-week follow-up. Systolic and diastolic blood pressure values were also recorded at these follow-up visits.

The patient was reminded by telephone at least two days before each scheduled visit to fast for 8–12 hours and come in the morning for blood sample collection. Laboratory testing was conducted in a diagnostic laboratory housed in the same building as the nutrition clinic.

All data collected including anthropometric, body composition, blood pressure, and laboratory results was recorded in an Excel sheet. These were then ana-

lyzed to find out the changes that occurred during the 12 weeks intervention.

The changes that took place in these parameters over time are summarized in Table 3.

Statistical analysis

All the continuous variables were summarized using SPSS version 25 by doing descriptive statistics in order to produce the means, standard deviations, standard errors of the means, variances, and range with regard to differences between the maximum and minimum values. The t-statistics were also calculated as the difference between values divided by the standard

Table 3: Changes in the anthropometric, body composition, blood pressure and biochemical results over time.

Parameter	Baseline	Week 4	Week 8	Week 12
Anthropometric measurements				
Weight (kg)	84	80	75.5	71
Height (cm)	164	-	-	-
BMI (kg/m ²)	31.2	29.7	28.1	26.4
Abdominal circumference (cm)	105	98.5	94	87.5
Hip circumference (cm)	115	112.5	110	108.5
WHR	0.9	0.87	0.85	0.81
Body composition analysis				
FM (%)	38.2	36.2	33.2	29.6
FFM (%)	61.8	63.8	66.8	70.4
TBW (%)	42.5	45.6	48.8	51.5
Biochemical analysis				
Hemoglobin (g/dl)	9	11.2	12	12.8
Ferritin (ng/ml)	7	13	18	22
sTfR (mg/l)	8.8	6.5	5.1	3.8
Fasting blood glucose (mg/dl)	114	108	95	80
Insulin (mIU/L)	10.3	9.5	8.7	7.2
Triglycerides (mg/dl)	175	145	136	120
HDL (mg/dl)	35	40	48	55
LDL (mg/dl)	155	144	137	132
Total cholesterol (mg/dl)	275	255	220	178
Blood pressure				
SBP (mmHg)	138	130	125	118
DBP (mmHg)	82	80	75	72

Note: BMI – Body mass index; WHR – Waist to hip ratio; FM – Fat mass; FFM – Fat-free mass; TBW – Total body water; sTfR – Soluble transferrin receptor; HDL – High-density lipoprotein cholesterol; LDL – Low-density lipoprotein cholesterol; SBP – Systolic blood pressure; DBP – Diastolic blood pressure.

error ($t = \text{Difference}/\text{S.E.}$). For the comparison of anthropometric measures, body composition analysis, blood pressure, and laboratory results over time, the t-score and degrees of freedom ($n - 1$) were used. A p-value of ≤ 0.05 is considered statistically significant.

Results

The baseline data and subsequent measurements at 4-week intervals are summarized in Table 3 and Table 4, which present the descriptive statistics and the

levels of significance for changes observed across the intervention period.

The results revealed significant reductions ($P < 0.05$) in weight, BMI, abdominal circumference, hip circumference, WHR, and FM after 12 weeks of intervention. Conversely, FFM and TBW showed significant increases, reflecting improvements in body composition over time. Hemoglobin and serum ferritin levels improved significantly compared to baseline values, reaching normal levels by the end of the intervention. Additionally, soluble transferrin receptor (sTfR) levels significantly decreased, indicating improved iron metabolism

Table 4: Descriptive statistics with calculated t-statistics and p-values for anthropometric measurements, body composition analysis, blood pressure, and biochemical results over the course of the intervention.

Variable	Minimum	Maximum	Range	Mean	S.E.M	SD	Variance	t-statistics	P-value
Anthropometry									
Weight (kg)	71	84	13	77.6	2.8	5.6	31.6	4.64	0.019
BMI (kg/m ²)	26.4	32.1	5.7	29.1	1.2	2.4	5.9	4.75	0.018
WC (cm)	87.5	105	17.5	96.3	3.7	7.4	54.4	4.73	0.018
HC (cm)	108.5	115	6.5	111.5	1.4	2.9	8.2	4.64	0.019
WHR	0.81	0.9	0.09	0.8	0.02	.004	0.001	4.50	0.020
Body composition analysis									
FM (%)	29.6	38.2	8.6	34.3	1.9	3.7	14.0	4.53	0.020
FFM (%)	61.8	70.4	8.6	65.7	1.9	3.7	14.0	4.53	0.020
TBW (%)	42.5	51.5	9.0	47.1	2.0	4.0	15.2	4.50	0.02
Biochemical analysis									
Hb (g/dl)	9.0	12.8	3.8	11.3	0.8	1.6	2.7	4.75	0.018
Ferritin (ng/ml)	7	22	15	15	3.2	6.5	42.0	4.69	0.018
sTfR (mg/l)	3.8	8.8	5	6.1	1.1	2.1	4.6	4.55	0.020
FBG (mg/dl)	8	114	34	99.3	7.5	15.1	227.6	4.53	0.020
Insulin (mIU/L)	7.2	10.3	3.1	8.9	0.7	1.3	1.7	4.43	0.021
TG (mg/dl)	120	175	55	144	11.6	23.1	534.0	4.74	0.018
HDL (mg/dl)	35	55	20	44.5	4.4	8.8	77.7	4.54	0.020
LDL (mg/dl)	132	155	23	142	5.0	10.0	99.3	4.60	0.019
TC (mg/dl)	178	275	97	232	21.3	42.6	1812.7	4.55	0.020
Blood pressure									
SBP (mmHg)	118	138	20	127.8	4.2	8.4	70.9	4.55	0.020
DBP (mmHg)	72	82	10	77.3	2.3	4.6	21.0	4.35	0.022

Note: BMI – Body mass index; WHR – Waist to hip ratio; FM – Fat mass; FFM – Fat-free mass; TBW – Total body water; Hb – Hemoglobin; sTfR – Soluble transferrin receptor; FBG – Fasting blood glucose; TG – Triglycerides; HDL – High-density lipoprotein cholesterol; LDL – Low-density lipoprotein cholesterol; TC – Total cholesterol; SBP – Systolic blood pressure; DBP – Diastolic blood pressure; SD – Standard deviation; S.E.M – Standard error of the mean. $P \leq 0.05$ was considered significant.

and reduced iron deficiency after 12 weeks of intervention. Lipid profile parameters also demonstrated significant improvements. The LDL-C, triglycerides, and total cholesterol levels decreased significantly ($P < 0.05$), reaching normal ranges. HDL-C levels elevated significantly, leading to a better cardiovascular risk profile. Both the systolic and diastolic blood pressure decreased significantly throughout the intervention course and returned to normal values at the end of it based on age- and sex-matched reference ranges.

These results show that the intervention had a positive effect on anthropometric measurements, body composition, biochemical parameters, and blood pressure regulation during the 12-week period.

Discussion

These 12-week intervention results highlight the strength of the intervention regarding the combination of a calorie-restricted diet and red beetroot juice in improving anthropometric measures, body composition, metabolic parameters, and IDA. These results further support the inclusion of specific dietary elements, such as red beetroot juice, within weight management interventions, metabolic syndrome interventions, and programs aimed at improving iron status indicators, including hemoglobin and ferritin.

Interventions resulted in significant reductions in weight, BMI, abdominal and hip circumferences, WHR, and FM but increases in FFM and TBW. These changes are indicative of an improvement in body composition and are consistent with previous evidence showing calorie restriction as the contributor to fat loss but spared lean mass [16].

The potential effects of red beetroot juice on body composition are most likely due to bioavailable constituents like dietary nitrates, betalains, and antioxidants that improve metabolic performance along with reduced inflammation [11]. It has been given an account by Lee et al. [17] in such a way that betalains stimulated antioxidant defenses along with mitochondrial functions that promote competent lipid metabolism and energy consumption.

The elevation observed in hemoglobin and serum ferritin levels, associated with a decrease in sTfR, suggests a positive effect of red beetroot juice on iron metabolism. Its high bioavailability of iron and contribution to the synthesis of heme were discussed by Lotfi et al. [18] and Babarykin et al. [11]. The antioxidant property of beetroot is also abundant with antioxi-

dants, which alleviate oxidative stress and have been shown to be detrimental to iron metabolism [19]. Moreover, obesity-related inflammation, which adversely affects iron handling, may also be counterbalanced by increased antioxidant consumption, resulting in improved outcomes in IDA [20].

Complementary findings by Costa et al. [21] that natural polyphenols and vitamin C contained in red beetroot enhanced non-heme iron absorption offer even more mechanisms to explain the improvements that have been observed in iron status. The decrease in sTfR levels mirrors an improvement in iron mobilization and metabolic efficiency [22].

The intervention also showed important benefits with regard to lipid profiles, decreases in LDL cholesterol, triglycerides, and total cholesterol, and an increase in HDL cholesterol. All these changes reflect a more favorable cardiovascular risk profile. Both systolic and diastolic blood pressure significantly decreased to reach normal values at the end of the study.

The cardiovascular benefits of red beetroot are well-documented. Jonvik et al. [23] elaborated that dietary nitrates are converted to nitric oxide (NO) in the body, which enhances vascular function and promotes vasodilation to support blood pressure regulation. Moreover, the antioxidative properties of betalains counter oxidative stress, which is contributed to by major dyslipidemia and hypertension in metabolic syndrome sufferers [24].

The bioactive compounds in red beetroot play a critical role in its observed effects on metabolic syndrome and IDA. Betalains and polyphenols offer anti-inflammatory and antioxidative benefits, protecting against oxidative damage to lipids and proteins, as reported by Milton-Laskibar et al. [25]. These protective mechanisms bolster cellular functions, including lipid oxidation and glucose metabolism, processes that are often impaired in metabolic disorders [11]. Nitrate-derived NO further improves vascular function, oxygen delivery, and energy efficiency during exercise [25, 26], which could account for the changes in body composition and lipid metabolism observed in the current study.

Conclusion

In conclusion, the combination of a calorie-restricted diet and red beetroot juice in the present intervention promises to be a multifaceted approach in the management of obesity, metabolic syndrome, and IDA.

It is consistent with the literature underlining the nutritional and therapeutic values of red beetroot. More studies are warranted to establish the long-term effects of such interventions and to determine the optimum dosage and timing for a broader range of the population.

Conflict of interest

The author declares no conflict of interest.

References

- World Health Organization. Prevalence of Anaemia in Women and Children, 2021.
- Śliwińska A, Luty J, Aleksandrowicz-Wrona E, Małgorzewicz S. Iron status and dietary iron intake in vegetarians. *Adv Clin Exp Med* 27:1383-1389, 2018.
- MacLean B, Sholzberg M, Weyand AC, Lim J, Tang G, Richards T. Identification of women and girls with iron deficiency in the reproductive years. *Int J Gynaecol Obstet* 162:58-67, 2023.
- Institute of Medicine (US). Panel on Micronutrients. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. Washington (DC): National Academies Press (US), 2001.
- Shokrgozar N, Golafshan HA. Molecular perspective of iron uptake, related diseases, and treatments. *Blood Res* 54:10-16, 2019.
- Mohamed SM, Shalaby MA, El-Shiekh RA, El-Banna HA, Emam SR, Bakr, AF. Metabolic syndrome: Risk factors, diagnosis, pathogenesis, and management with natural approaches. *Food Chem Adv* 3: 100335, 2023.
- González-Domínguez Á, Visiedo-García FM, Domínguez-Riscart J, González-Domínguez R, Mateos RM, Lechuga-Sancho AM. Iron metabolism in obesity and metabolic syndrome. *Int J Mol Sci* 21:5529, 2020.
- Ali NB, Dibley MJ, Islam S et al. Overweight and obesity among urban women with iron deficiency anaemia in Bangladesh. *Matern Child Nutr* 17:e13102, 2020.
- Cotoraci C, Ciceu A, Sasu A, Hermenean A. Natural Antioxidants in Anemia Treatment. *Inter J Mol Sci* 22: 1883, 2021.
- Skolmowska D, Głabka D, Kołota A, Guzek D. Effectiveness of dietary interventions to treat iron-deficiency anemia in women: A Systematic review of randomized controlled trials. *Nutrients* 14: 2724, 2022.
- Babarykin D, Smirnova G, Pundinsh I, Vasiljeva S, Krumina G, Agejchenko V. Red beet (*Beta vulgaris*) impact on human health. *J Biosci Med* 7: 61-79, 2019.
- Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III). *JAMA* 285: 2486-2497, 2001.
- Metropolitan Life Insurance Company. Metropolitan height and weight tables. *Stat Bull Metrop Insur Co.* 64:1-9, 1983.
- Peterson CM, Thomas DM, Blackburn GL, Heymsfield SB. Universal equation for estimating ideal body weight and body weight at any BMI. *Am J Clin Nutr* 103:1197-1203, 2016.
- Austin GL, Ogden LG, Hill JO. Trends in carbohydrate, fat, and protein intakes and association with energy intake in normal-weight, overweight, and obese individuals: 1971-2006. *Am J Clin Nutr* 93:836-843, 2011.
- Wu X, Zhang C, Liang Z, Liang Y, Li Y, Qiu J. Exercise combined with a low-calorie diet improves body composition, attenuates muscle mass loss, and regulates appetite in adult women with high body fat percentage but normal BMI. *Sports (Basel)* 12:91, 2024.
- Lee HS, Choi SM, Lim SH, Choi C-I. Betanin from beetroot (*Beta vulgaris* L.) regulates lipid metabolism and promotes fat browning in 3t3-l1 adipocytes. *Pharmaceuticals* 16: 1727, 2023.
- Lotfi M, Azizi M, Tahmasbi W and Bashiri P: The effects of consuming 6 weeks of beetroot juice (*Beta vulgaris* L.) on hematological parameters in female soccer players. *J Kermanshah Univ Med Sci* 22:e82300, 2018.
- Chen L, Zhu Y, Hu Z, Wu S, Jin C. Beetroot as a functional food with huge health benefits: Antioxidant, antitumor, physical function, and chronic metabolomics activity. *Food Sci Nutr* 9:6406-6420, 2021.
- Tarancon-Diez L, Iriarte-Gahete M, Sanchez-Mingo P et al. Impact of obesity on iron metabolism and the effect of intravenous iron supplementation in obese patients with absolute iron deficiency. *Sci Rep* 15: 1343, 2025.
- Costa APD, Hermes VS, Rios AO, Flôres SH. Minimally processed beetroot waste as an alternative source to obtain functional ingredients. *J Food Sci Technol* 54:2050-2058, 2017.
- Al-About N. Effect of red beetroot (*beta vulgaris* L.) intake on the level of some hematological tests in a group of female volunteers. *ISABB J Food and Agric Sci* 8:10-17, 2018.
- Jonvik KL, Nyakayiru J, Pinckaers PJ, Senden JM, van Loon LJ, Verdijk LB. Nitrate-rich vegetables increase plasma nitrate and nitrite concentrations and lower blood pressure in healthy adults. *J Nutr* 146:986-993, 2016.
- Kapil V, Khambata RS, Robertson A, Caulfield MJ, Ahluwalia A. Dietary nitrate provides sustained blood pressure lowering in hypertensive patients: a randomized, phase 2, double-blind, placebo-controlled study. *Hypertension* 65:320-327, 2015.
- Milton-Laskibar I, Martínez JA, Portillo MP. Current knowledge on beetroot bioactive compounds: role of nitrate and betalains in health and disease. *Foods* 10:1314, 2021.
- Clifford T, Howatson G, West DJ, Stevenson EJ. The potential benefits of red beetroot supplementation in health and disease. *Nutrients* 7:2801-2822, 2015.