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Original Research Article

Effect of supplementation of purslane/*Portulaca oleracea* in hyperglycemic subjects

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ABSTRACT

Background: *Portulaca oleracea* (Purslane) is an annual succulent medicinal plant grown all over the world containing diverse phytoconstituents. Several studies have reported its pharmacological effects like antihypertensive, anti-inflammatory, antioxidant, hypoglycemic, hypocholesterolemic, hypotriglyceridemic, neuro, hepato and nephro protective effects.
Methods: Dried *Portulaca oleracea* leaves were incorporated into common food adjunct popularly known as karampodi/spice powder in south India. This spice powder was used for supplementation studies for 90 days (3months) among hyper glycemic subjects after obtaining a written informed consent. Biochemical parameters such as fasting, post lunch blood glucose levels, glycosylated hemoglobin, lipid profile, i.e., total cholesterol, low density lipoprotein cholesterol, triglycerides, high density lipoprotein cholesterol, very low-density lipoprotein cholesterol, kidney function test, liver function test were assessed. Baseline information, their medical history and 24-hour dietary recall was elicited from the subjects through a pretested schedule.
Results: The results revealed that fasting, post lunch blood glucose levels, glycosylated hemoglobin, the total cholesterol levels and its fractions along with triglycerides were significantly decreased and HDL-C increased significantly in the test groups from pre-supplementation to during-supplementation and was stable at post-supplementation period.
Conclusions: The results indicated that the spice powder which was rich in several polysaccharides, polyunsaturated fatty acids and phytochemicals/phytonutrients when supplemented to hyperglycemic subjects had a strong hypoglycemic, hypocholesterolemic and hypotriglyceridemic effect.

Keywords: Cholesterol and its fractions, Diabetes mellitus, FBS/PBS sugar levels, Food adjunct, Glycosylated haemoglobin, Hyperglycemic, Medicinal, Supplementation

INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder characterized by hyperglycaemia with alterations in carbohydrate, protein, and lipid metabolism. It is considered as the most common endocrine disorder and results in deficient insulin production (type 1) or combined resistance to insulin action and the insulin-secretory response (type 2). Type 2 diabetes susceptibility varies to a great extent around the globe, with Pacific Islanders, Asian Indians, and Native Americans having a significantly higher risk of developing the disorder. Current global statistics shows that 463 million and 374 million individuals have diabetes and impaired glucose tolerance (IGT), a prediabetic condition. These numbers are estimated to increase upto 700 million people with diabetes and 548 million people with IGT by 2045, which represents a 51% increase compared to 2019. Recently,

appropriate hypoglycemic agents have been focused on plants used in traditional medicine, because some natural products in traditional medicine have better treatments than currently used drugs.[1]

In Iranian folk medicine different parts of purslane plant has been recommended for treatment of diabetes.[2] Several studies have shown that purslane extracts have hypoglycemic and hypolipidemic effects in animals.[3-11] To verify the biological effect of purslane on hyperglycemia, this study focuses on the effect of supplementation of dehydrated purslane spice powder on the blood glucose levels, change of the lipid components among diabetic human subjects.

METHODS

Study design

About 60 individuals who were hyperglycemic, between 40 and 60 years of age and had previously recorded blood sugar level FBS and PBS was in the range of 120-140 mg/dl, 200-250 mg/dl (and who underwent a recent blood sugar (cholesterol) screening at, family practice clinics for diabetic screenings in the BHEL General Hospital, Ramachandrapuram, Hyderabad were selected. Subjects were further evaluated using two additional complete blood sugar (fasting lipid profiles that included Total-C, LDL-C, HDL-C and triglycerides. Those whose total cholesterol for age and sex as outlined by lipid research clinics 1980 based on the mean of the baseline measurements were invited to participate in the study. The resulting sample (n=60) was grouped for this analysis into a test/experimental group and control group. Subjects who gave written informed consent for this study, which was approved by the committee for the use of human subjects, were selected.

Subjects were supplemented with 15 gm per day spice powder which was made by incorporating dehydrated purslane leaves for a period of three months. Biochemical parameters like FBS, PBS, HbA1C, lipid profile, i.e., total cholesterol, LDL-C, triglycerides, HDL, VLDL were assessed. The kidney functioning capacity was assessed by measuring the levels of serum creatinine, urea and uric acid.[12-19] Liver function test were assessed by serum bilirubin, alkaline phosphatase, alkaline amino transferase (SGPT/ALAT) using standard kits with help of Roche/Hitachi 904/911 automatic enzyme analyzer.[20-22] Baseline information, their medical history and 24-hour dietary recall was elicited from the subjects through a pretested schedule.

Selection criteria

The subjects who consented were included on the criteria that they were screened previously and were recorded with FBS.PBS was in the range of 120-140 mg/dl, 200-250 mg/dl total cholesterol (total-C) values between the 50th and 95th percentile for age and sex, as outlined by the lipid research clinics (1980) were included.

Period of study

Duration the study period was 9 months first 3 months from September 2017 to November 2017 a base line study was conducted, between December 2017 and February 2018 supplementation of the developed product was given and between March 2018 and may 2018 a follow up study was taken up

Ethical approval

A written consent was obtained from the subjects for their willingness to participate in the study for the said period. The covariance of the variables under study was measured to statistical analysis of the results was measured and compared.

RESULTS

The general information such as mean age, BMI, social status and medical history of the selected subjects (control and experimental) has been displayed in Tables 1 and 2.

Table 1: General information of the selected hyperglycemic human subjects.

Parameter	Control	Experimental
Number of subjects	30	30
Sex		
Males	17 (56.66%)	19 (63.66%)
Females	13 (43.33%)	11 (36.66%)
Mean age (years)	54.1±5.64	55.22±5.551
Mean height (cm)	154.2±7.06	155.60±6.63
Mean weight (kg)	67.02±7.44	68.04±8.32
Mean BMI (weight/height)	28.12±2.78	28.33±5.63
Categories of BMI		
Normal weight	3 (10%)	6 (20%)
Over weight	20 (66.6%)	20 (66.66%)
Obese	7 (23.4%)	4 (13.33%)
Social status		
Middle income	17 (56.66%)	15 (50%)
Upper middle income	8 (26.66%)	9 (30%)
Higher income	5 (16.66%)	6 (20%)

24-hour dietary recall of the subject's food intake

The 24-hour dietary method was used to assess the average daily intake of cereals, pulses, green leafy vegetables, other vegetables, milk and milk products, oils and fats, meat and meat products. Daily nutrient intake of cereals, pulses, oils and fats and meat and meat products was higher than RDA values in both control and experimental groups as seen in Table 3. The intake of all

the nutrients was higher in control group than the experimental group. The intake of leafy vegetables was less than fifty percent, other vegetables was fifty percent of the RDA values. Amount of milk and milk products consumed was around seventy percent of the RDA.

Table 2: Medical history of the selected patients.

Parameters	Control	Experimental
Mean blood pressure (mm/Hg)		
Systole	140.08±19.75	137.66±15.23
Diastole	83.50±8.53	82.81±7.21
Mean duration of disease	5.3±2.20	4.32±3.0
Oral drugs		
Family history		
Positive history		
Mother	8 (26.66%)	8 (26.66%)
Father	8 (26.66%)	10 (33.33%)
Brother	3 (10%)	1 (3.33%)
Both parents	2 (6.66%)	3 (10%)
Grand parents	2 (6.66%)	2 (6.66%)
Negative history	7 (23.33%)	6 (20%)
Personal habits		
Smoking	6 (20%)	7 (23.33%)
Alcohol	14 (16.66%)	12 (40%)
None	10 (33.33%)	11 (36.66%)

The mean cereal intake was approximately 370 g/day in control and 363.5 gm/day in experimental group. The mean pulse intake was 39.3 gm/day (control) and 38.8 gm/day (experimental) Table 3. The oils and fat consumption were higher than that recommended for healthy normal adults of ICMR at 63.8 gm/day for control and 57.7 gm/day in experimental which was more than the recommended allowance. Milk and milk product intake was lesser and meat and meat products was higher than the RDA in both the groups. Overall, it was observed that the diet was high in fat, low in fibre and was comparable between the control and experimental groups.

Table 3: Mean food intake of hyperglycemic subjects by 24-hour dietary recall method.

Food groups (gm)	Control (n=30)	Experimental (n=30)	RDA
Cereals	370±59.9	363.5±41.4	250
Pulses	39.3±19.3	38.8±16.1	20
Green leafy vegetables	40.8±18.6	68.3±36.3	200
Other vegetables	108±54.2	106.6±44.7	200
Milk and milk products	109.1±74.4	104.3±48.21	150
Oils and fats	63.8±38.7	57.7±28.8	20
Meat and meat products	67.47±10.34	66.32±9.65	40

Values are expressed as mean±SD. Source: -RDA- Raghuramulu et al, RDA for diabetic patients.[23]

Plasma glucose was determined every month (fasting and random) for 9 months and compared with control presented in Table 4. Plasma glucose levels were greatly reduced in the subjects supplemented group with purslane spice powder from 122.12 mg/dl to 97.03 mg/dl, percentage reduction range was 19.23 to 35.8 while a marked increase after 4 weeks was observed for subjects when the spice power was weaned off from 120.87 mg/dl to 136.90 mg/dl in the concomitant three months. Throughout the study it was seen that the control subjects were on a mean of 140 mg/dl or higher (range 140.7-149.7 mg/dl). Post prandial blood glucose levels were running on parallel with the fasting glucose decrease and increase on dose dependent strategy of spice powder of purslane and percentage reduction range was 18.79 to 38.77. However, control showed a stagnant increase or decrease in post prandial blood glucose levels as seen in the Table 4.

Table 4: Effect of supplementation on fasting and postprandial blood sugar levels in hyperglycemic patients (n=30).

Period of supplementation in months	Blood glucose levels (mg/dl)		Hb A1C
	Fasting	Post lunch	
Pre supplementation			
1st month	151.27±21.7 (145.23±14.14)	260.07±16.33 (243.63±21.5)	8.7±0.41 (8.5±0.48)
2nd month	143. ±19.58 (144.33±14.6)	243.97±14.1 (243.27±17.42)	
3rd month	151.2±13.38 (149.63±12.27)	253.2±18.58 (253.4±12.24)	
During supplementation			
1st month	122.13±11.69* (144.4±13.8)	205.8±17.96* (242.47±13.11)	6.7±0.32* (8.4±0.32)
2nd month	106.6±13.6* (142.57±11.1)	177.83±19.52* (238.13±15.76)*	
3rd month	97.03±12.42* (140.2±8.76)	155.17±16.26* (234.0±12.83)	
Post supplementation			
1st month	120.87±5.43* (143.73±6.71)	193.6±11.02* (238.93±9.04)	7.8±0.2* (8.5±0.2)
2nd month	129.6±76.36* (144.77±6.20)	221.7±16.44* (239.9±8.9)	
3rd month	136.90±8.19* (149.7±2.9)	233.93±14.94* (245.77±7.71)	

Figures in the parenthesis are control values. *-Significant at 0.05% level ($p<0.05$).

Table 5: Effect of supplementation of purslane spice powder on lipid profile in hyperglycemia patients (n=30).

Period of supplementation in months	Cholesterol levels (mg/dl)	LDL-C levels (mg/dl)	HDL-C levels (mg/dl)	VLDL-C levels (mg/dl)	Triglycerides (mg/dl)
Pre supplementation					
1st month	150.07±18.19 (159.10±20.24)	94.77±4.25 (98.7±5.84)	38.53±3.2 (30.6±3.15)	24.4±3.69 (27.83±2.36)	121.73±18.2 (139.0±11.4)
2nd month	151.8±17.58 (159.33±21.3)	94.2±4.34 (97.7±4.31)	38.87±2.78 (30.45±3.33)	23.97±3.66 (27.66±2.10)	120.33±17.82 (137.7±10.09)
3rd month	151.53±16.16 (159.27±21.31)	93.97±4.13 (97.0±4.34)	39.77±3.19 (31.90±2.62)	24.13±3.6 (27.83±1.56)	120.27±17.58 (139.13±7.98)
During supplementation					
1st month	145.07±14.43* (154.0±20.1)^{ns}	91.53±3.90^{ns} (94.37±4.45)	43.90±2.32* (32.93±2.41)	22.53±3.79* (26.48±1.90)	114.0±18.2^{ns} (132.5±9.38)
2nd month	143.30±13.67* (148.07±27.56)*	90.1±3.9^{ns} (93.73±4.68)	45.67±2.42* (34.34±2.83)	21.93±3.68* (26.10±1.91)	111.13±18.32^{ns} (129.97±9.44)
3rd month	139.90±12.09* (151.77±19.9)^{ns}	89.13±3.53^{ns} (93.0±4.5)	46.13±2.04* (33.93±2.32)	21.60±3.7* (26.0±2.01)	109.23±17.95^{ns} (129.33±9.94)
Post supplementation					
1st month	140.67±11.19* (153.37±19.92)^{ns}	90.03±3.28^{ns} (94.2±4.48)	45.03±2.38* (34.76±2.11)	22.30±3.51* (26.14±1.95)	111.67±17.9^{ns} (130.6±9.37)
2nd month	142.27±12.35* (153.57±19.98)^{ns}	90.93±3.1^{ns} (94.5±4.0)	44.10±2.92* (34.69±1.91)	22.67±3.26* (26.45±1.72)	114.10±16.39^{ns} (131.87±8.41)
3rd month	143.6±10.73* (154.70±19.96)^{ns}	91.40±3.52^{ns} (95.90±4.0)	43.60±2.72* (34.90±2.27)	22.97±3.33* (26.69±1.65)	115.43±16.48^{ns} (133.23±7.67)

Figures in the parenthesis are control values, ns not significant. *-Significant at 0.05% level ($p<0.05$).

Table 6: Effect of *Portulaca oleracea* spice powder supplementation on blood urea, serum creatinine, serum uric acid in hyperglycemic patients.

Period of supplementation in months	Blood urea levels (mg/dl)	Serum creatinine levels (mg/dl)	Serum uric acid levels (mg/dl)
Pre-supplementation			
1st month	36.47±3.47 (36.59±3.83)	0.72±0.11 (0.74±0.14)	4.650.86 (4.54±0.79)
2nd month	36.27±3.53 (36.72±4.23)	0.73±0.10 (0.75±0.16)	4.54±0.79 (4.58±072)
3rd month	36.27±2.85 (36.79±3.80)	0.75±0.10 (0.76±0.11)	4.51±0.80 (4.60±0.73)
During supplementation			
1st month	33.60±2.59* (36.84±3.50)	0.68±0.07^{ns} (0.77±0.07)	4.25±0.79^{ns} (4.61±0.69)
2nd month	33.20±3.40* (36.89±3.59)	0.68±0.08^{ns} (0.78±0.08)	4.18±0.79^{ns} (4.64±0.67)
3rd month	33.33±2.41* (36.92±3.68)	0.69±0.094^{ns} (0.79±0.075)	4.16±0.77^{ns} (4.70±0.68)
Post supplementation			
1st month	34.97±2.15* (37.52±3.05)	0.70±0.078^{ns} (0.81±0.08)	4.24±0.76^{ns} (4.79±0.67)
2nd month	34.57±2.37* (37.97±3.55)	0.69±0.08^{ns} (0.83±0.08)	4.14±0.77^{ns} (4.81±0.60)
3rd month	34.80±2.14* (38.04±3.35)	0.70±0.08^{ns} (0.82±0.92)	4.24±0.77^{ns} (4.83±0.67)

Figures in the parenthesis are control group values, ns not significant; *-Significantat0.05%level ($p<0.05$).

Glycosylated hemoglobin was seen to decrease from 8.7% (first 3 months of pre-supplementation) to 6.7% (the concomitant 3 months period of supplementation) with percentage reduction about 23 percent to further enhancement of 7.8% (last three months where purslane was weaned away) which clearly signals that purslane spice powder had indeed a good antidiabetic effect which were in agreement to many other studies.

The present results showed that the cholesterol and triglyceride levels were elevated in both the experimental group subjects and the control group in the pre-supplementation stage of the first three months total cholesterol ranging from 150.07 to 151.8 mg/l (supplemented subject group) and 159.10-159.33 mg/dl (control group) and triglycerides ranging from 120.27-121.73 mg/dl (supplemented subject group) and 137.7 to 139.13 mg/dl (control group). In the purslane supplemented group the cholesterol levels decreased to 139.90 mg/dl after three months supplementation whereas the triglyceride levels decreased to 109.23 mg/dl was which is statistically significant (Table 5). The decrease

of LDL-C, (from 93.97 pre-supplementation to 89.13 in the last month of supplementation) and VLDL-C (from 24.13 pre-supplementation and 21.60 mg/dl in the last month of supplementation) which was statistically not significant. An increase of HDL-C (from 39.77 in the last month of pre-supplementation to 46.13 in the last month of supplementation) as shown in Table 5 was statistically significant. The post supplementation studies as seen in the Table 5 also proved the fact that purslane added a significant effect on the lipid profile parameters of the hyperglycemic patients.

The effect of supplementation of spice powder of *Portulaca oleracea* hyperglycemic on the renal function parameter like serum urea, serum creatinine and serum uric acid shown in Table 6.

Blood urea levels were higher 36.47±3.47 to 36.27±3.85 mg/dl in pre-supplemented stage and it reduced to33.60±2.59 to 33.22±2.41 mg/dl during the supplemented stage when compared to normal range (5-21 mg/dl). Whereas the serum creatinine speckled in the normal range of 0.6 to 1.1 mg/dl as seen in Table 6. Likewise the serum uric acid levels in both the control group and the supplemented subjects were within the normal range of 2.3 to 8.2 mg/dl as evident in the same Table 6. Supplementation of spice powder of *Portulaca oleracea* (purslane) showed a slight reduction in both the creatinine and uric acid which was nonsignificant.

Individuals with type 2 diabetes have a higher incidence of LFT abnormalities than individuals who do not have diabetes. The most common abnormality is elevated ALT. This elevated ALT was seen to reduce in the supplemented subjects with Portulaca oleracea (purslane) spice powder from 24.30±2.56 U/l to 22.27±2.72 U/l indicating Portulaca oleracea (purslane) has an impact on reducing ALT, however all the subjects both supplemented and control group had a range within the normal levels of 0-37 U/l.

Any diabetic patient found to have a mild chronic elevation of ALT, or elevation of ALT ≤37 units/l for >6 months should have screening for treatable causes of chronic liver disease, particularly hepatitis B, hepatitis C, and hemochromatosis, which are found with increased incidence in type 2 diabetes.

Serum alkaline phosphatase and serum bilirubin levels were concomitantly also on the decline on par with ALT in both supplemented subjects and control group as seen in Table 7 for whom a directed medical history and physical examination do not raise suspicion of other causes of elevated LFTs, such as medications, alcohol, autoimmunity, metabolic etiology, or hereditary etiology, and for those who have no evidence of more serious liver disease, such elevations in bilirubin or prothrombin time or decreases in albumin, further diagnostic workup is probably not required. Routine monitoring of LFTs inpatients with type 2 diabetes should occur at the start of drug therapy and if patients develop symptoms rising concern about hepatic impairment. Beyond that, periodic screening will have to be based on clinical judgment, keeping in mind that elevation of transaminases does not always correlate with histological changes in the liver. Elevation of ALT within three times the upper limit of normal is not a contraindication for starting any oral antidiabetic or lipid-modifying therapy. In contrast, antidiabetic agents have generally been shown to decrease ALT levels as tighter blood glucose levels are achieved.

Table 7: Effect of supplementation of *Portulaca oleracea* (purslane) spice powder on LFT levels in hyperglycemia patients.

Period of supplementation in months	Serum bilirubin levels (mg/dl)	Serum alkaline phosphatase levels (KA units) or (IU/l)	SGPT levels U/l
Pre-supplementation			
1st month	0.773±0.094 (0.776±0.073)	8.5±0.90 (8.28±0.80)	25.07±4.06 (26.07±3.57)
2nd month	0.760±0.085 (0.779±0.080)	8.47±0.93 (8.28±0.50)	24.77±3.83 (23.52±3.15)
3rd month	0.757±0.089 (0.778±0.139)	8.40±0.96 (8.39±0.70)	24.30±3.59 (23.79±2.98)
During supplementation			
1st month	0.717±0.074^{ns} (0.784±0.061)	8.07±0.69^{ns} (8.38±0.52)	22.63±2.63 (24.06±2.43)
2nd month	0.697±0.080^{ns} (0.784±0.063)	8.00±0.69^{ns} (8.41±0.59)	22.47±2.75 (24.49±2.46)
3rd month	0.717±0.064^{ns} (0.784±0.061)	8.20±0.71^{ns} (8.45±0.55)	22.27±2.39 (24.81±2.30)
Post supplementation			
1st month	0.733±0.071^{ns} (0.785±0.063)	8.10±0.71^{ns} (8.48±0.49)	22.67±2.26 (24.86±2.47)
2nd month	0.735±0.070^{ns} (0.792±0.063)	8.17±0.74^{ns} (8.49±0.58)	22.73±2.72 (24.86±2.74)
3rd month	0.736±0.085^{ns} (0.792±0.068)	8.23±0.72^{ns} (8.51±0.67)	22.43±2.54 (25.03±2.24)

Figures in the parenthesis are the apparently normal group values, not significant.

DISCUSSION

A positive family history and personal life style habits of smoking and alcoholism was strongly seen in nearly 70% in this subgroup with only a negation of 20 to 23% which confirmed to the study of Gulla et al.[24]

Although numerous studies have attempted to identify the optimal mix of macronutrients for the diabetic diet, it is unlikely that one such combination of macronutrients exists. The best mix of carbohydrate, protein, and fat appears to vary depending on individual circumstances. For those individuals seeking guidance as to macronutrient distribution in healthy adults, the dietary reference intakes (DRIs) may be helpful (Institute of medicine 2002).[25] It must be clearly recognized that regardless of the macronutrient mix, total caloric intake must be appropriate to weight management goals. Further, individualization of the macronutrient composition will depend on the metabolic status of the patient (e.g., lipid profile).

Other bio actives found in purslane are dopamine, dopa, coumarins, alkaloids and saponins, polyphenols, flavonoids and anthocyanin.[26,27] These compounds may influence glucose metabolism by several mechanisms, such as inhibition of carbohydrate digestion and glucose absorption in the intestine, stimulation of insulin secretion from the pancreatic β-cell, modulation of glucose release from liver, activation of insulin receptors and glucose uptake in the insulin sensitive tissues, and modulation of hepatic glucose output.[28] On the other hand, insulin resistance can be generated by decreased adiponectin secretion.[29] Preliminary phytochemical screening of purslane revealed the presence of flavonoids or bioflavonoids which are natural products capable of modulating insulin resistance and atherogenic index.[28]

Total cholesterol and triglycerides which are in accordance to the studies done by Lee et al, and Kwon and Song who showed that total cholesterol level decreased significantly when supplying 3% purslane powder in the hypercholesterolemic diet in rats and they reported that the reduction of the total cholesterol level of serum is highly associated with the ω-3 fatty acid of purslane.[9,30]

In addition to having high levels of ω-3 fatty acid, purslane also has high levels of γ-linolenic acid, fiber and polyphenols, all of which have been shown to have a reducing effect on serum lipid levels[1,32,33] In particular, the ethanol extract of purslane also demonstrated a lowering effect of total lipid, total cholesterol and triglyceride levels in the serum of hypercholesterolemia rats.[33] Consuming *Portulaca oleracea* (purslane) may benefit diabetics due to the plant's compounds, including alkaloids, omega-3 fatty acids, oxalic acids, flavonoids and cardiac glycosides.[34]

The reduction of LDL-C by the supplementation of 10% purslane powder within the hyper cholesterol diet by Lee et al, was expected to be effective for the prevention of arteriosclerosis and cardiovascular diseases, since an increase of serum LDL-C level is considered to be a stronger risk factor for the occurrence of cardiovascular diseases than the increase of the total cholesterol level.[30] In fact, the reduction of LDL-C is emphasized more for the therapy of hyperlipidemia (NCEP 2002).[35]

Supplementation of spice powder of *Portula caoleracea* (purslane) showed a slight reduction in both the creatinine and uric acid levels indicating the positive impact of the herb/plant which is affirmed by Dkhil et al in the results of kidney function tests in *Portulaca oleracea* (purslane) group, which showed that *Portulaca oleracea* (purslane) administration caused significant increase in uric acid (28.0%) with significant decrease in urea and creatinine (33.2 and 28.0%), respectively, showing the beneficial effect of *Portulaca oleracea* (purslane).

Limitations of the study were the study subjects who were screened for hyperglycemia also suffered other co morbidities and were consuming oral medications. The impact and interference of the oral medications on the supplementation of the spice powder was not taken into consideration.

CONCLUSION

The present study concludes that *Portulaca oleracea* (purslane) is a helpful plant in prevention of development of hyperglycemia and hyperlipidemia, fatty liver, etc. through preventing oxidative stress and chronic inflammation, improvement of carbohydrate and fat metabolism, decreasing triglycerides, LDL, and total cholesterol, regulating the levels of liver enzymes (transaminases). The results of the study indicated that the spice powder was rich in polyunsaturated fatty acids and phytochemicals/phytonutrients had a strong hypoglycemic hypolipidemic, hypotriglyceridemic and hypocholesterolemic effects with a reduction of fasting, post lunch blood glucose levels, glycosylated hemoglobin, plasma total cholesterol, LDL-C levels and an increase in HDL-C levels in hyperglycemic subjects.

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