Pak. j. life soc. Sci. (2016), 14(2): 115-122 E-ISSN: 2221-7630;P-ISSN: 1727-4915

Pakistan Journal of Life and Social Sciences
www.pjlss.edu.pk

RESEARCH ARTICLE

Exploring The Nutritional Characteristics of Different Parts of Fig in Relation to Hypoglycemic Potential

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ARTICLE INFO

Received: Jul 11, 2016
Accepted: Aug 12, 2016
Online: Aug 20, 2016

Keywords
Antioxidants
Ficus carica
Functional Foods
Hyperglycemia
Nutraceuticals
Phytochemicals

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ABSTRACT

The current research study was designed to characterize leaf, peel and pulp of locally grown black variety of common fig (*Ficus carica*) followed by exploring its hypoglycemic potential through animal modeling. For the purpose, raw materials (fig, fruit and leaves) were procured from Abbotabad (Khyber Pakhtunkha, Pakistan) and nutritional profiling was carried out through their respective methods. In addition, antioxidants rich fractions were extracted using different solvents i.e. aqueous, methanol and ethanol. In the last, 56 days efficacy study was conducted in rats to assess the hypoglycemic potential of different parts of fig. Results showed that fig components are good sources of fiber, protein and minerals. Regarding extraction efficiency, aqueous extract exhibited the highest recovery (8.17%) followed by methanolic (7.65%) and ethanolic (7.30%) fractions, respectively. Additionally, Total phenolics, anthocyanins and flavonoids were estimated through HPLC and were found in descending order in leaf, peel and pulp, correspondingly. The highest amount of cyanidine-3-rutinoside (C3R) was recorded in aqueous extract of fruit peel, while leaf showed higher ferric reducing antioxidant power (FRAP) and 1,1-Diphenyl-2-picryl-hydrazyl (DPPH) inhibition potential in comparison of peel & pulp. The leaf extract of fig was effective in reducing the blood glucose level as compared to other treatments in both trials from 98±4.25 to 90.90±4.38 and 100±4.13 to 93.46±4.29 mg/dL, respectively. The results might be due to reduced cell damage that improved the insulin concentrations (Trial I) in experimental group i.e. 7.12, 5.23 & 3.56% by feeding leaf, peel and pulp extract, respectively, and similar trends were observed in trial II. Conclusively, fig leaf should be included in dietary regimens in addition to fig fruit due to health promoting potential that can combat lifestyle related disorders.

INTRODUCTION

Plants are important component of human diet furnishing nutrients for normal metabolism but also offering bioactive chemical components to improve their health (Ansari et al., 2016). They contain array of bioactive components including phytochemicals, pharmaceutics, antioxidants and phytosterols. Accordingly, plant extracts are extensively used in the food, pharmaceutical and cosmetics industries (Wang and Weller, 2006). The phenolic compounds are secondary metabolites of plants origin and are widely distributed in various fruits and vegetables. They are considered as most important among numerous bioactive compounds present in nature (Butt and Sultan, 2013). There are thousands of plants rich in these bioactive components and amongst common fig hold an important position. Since ancient times, it is an integral part of Mediterranean diets providing owing to its perceived health claims. Moreover, fig is one of only five fruit plants cited in the Holy Quran along with olives, grapes, pomegranate and dates (Solomon et al., 2006; Sheikh, 2016).

Ficus carica is used in fresh, dried, concentrate and paste form or as an ingredient in various preparations and contains appreciable amounts of phytochemicals, antioxidants minerals, vitamins and dietary fiber. It has been reported previously that dried figs contain higher amounts of calcium, potassium, and dietary fiber than other fruits of same family (Vinson et al., 2005; Veberic et al., 2008). In 2014, Fig production was 459 tons from 162 hectares in Pakistan. Brown Turkey and Black Mission are two eminent fig varieties being nurtured in Pakistan. Currently, it is being utilized in various food products including jams and jellies. Fig fruit has also been utilized as an ingredient in baked products (cakes, bread and pies), puddings filling and garnishing purposes (Sher et al., 2016).

The medicinal properties of fig fruit have been known for centuries and people still use it as a traditional medication. The anthocyanins possess the ability to modulate the hyperglycemia due to their ability to delay digestion of dietary carbohydrate leading to hypoglycemic response (Adisakwattana et al., 2011). The phenolics of figs bind themselves with lipoproteins in plasma and provide them protection against subsequent oxidation. The consumption of dried figs significantly upsurges the antioxidant capacity of human plasma. The total antioxidant capacity of the fresh figs is linked with the amounts of polyphenols and anthocyanins (Yang et al., 2009). As mentioned earlier, anthocyanins potentially retard the activities of intestinal glucosidases and α-amylase activities resulting in delay of carbohydrate digestion. The suppression of postprandial hyperglycemia subsequently delays the progression of micro- and macro-vascular complications. Additionally, decoctions of leaves of figs are effective in ameliorating post-prandial hyperglycemia. Reduction in hyperglycemia and hypercholesterolemia has been confirmed by treatment of aqueous decoction of fig leaves (Khan et al., 2011). The extract induced a significant hypoglycemic effect after either oral or intraperitoneal administration. The population suffering from diabetes mellitus is increasing each year and demands the attention of the researchers. The raised blood glucose level is a major ailment of present era that might be well addressed through dietary interventions. Common fig fruit and its leaves can be effectively used to mitigate this disease. Thus, the current study has been designed to explore nutritional aspects of different parts of figs with special reference to its hyperglycemic perspectives.

MATERIALS AND METHODS

The present research was conducted in Analytical Laboratory of Department of Food Science and Animal Room of Physiology Department, Government College University, Faisalabad, Pakistan was used for repeated efficacy trials. Local black colored variety (Mission) of fig was selected for the current study. Mission variety is abundantly found in hilly areas of Pakistan especially of District Abbottabad, Khyber PukhtoonKha. The fruit & leaves of Fig were procured in July-August fruit season and transported to Faisalabad. The raw materials were washed to clean the samples from impurities and later different parts of the plant and fruit were separated i.e. leaves, pulp and peel. HPLC & analytical grade reagents, standards and enzyme kits were procured from Sigma-Aldrich, Deutsche Gesellschaft für Klinische Chemie and Merck (Merck, Darmstadt, Germany). Sprague Dawley rats procured from National Institute of Health (NIH) were used in efficacy trials.

Proximate analysis

The fig leaves, peels and pulps were analyzed for the chemical composition i.e. moisture, crude protein, fat, fiber, total ash content. The moisture content was determined by following guide lines of AACC (2000), Method No. 44-01. The crude protein was determined by automatic Kjeltech System (Kjeltec, K12, 804849101, Behr Labor Technik, Gmbh-Germany) following the Method No. 46-13 as described in AACC (2000). Similarly, fig fruit and leaf samples were analyzed for fat contents using Soxhlet Apparatus (Tecator Soxtec System, HT 1043, FOSS, Denmark). For the purpose, n-hexane was used as solvent in fat extraction following the Method No. 30-10 (AACC 2000). Fiber contents of figs were measured using fat free samples according to AACC (2000), Method No. 32-10. The Muffle Furnace (MF-1/02, PCSIR, Pakistan) was used to determine the ash content by direct ignition of Fig fruit peel, pulp and leaf samples as per protocol of AACC (2000), Method No. 08-01. Lastly, equation based method was used to assess the nitrogen free extract (NFE) following the method from AACC (2000).

Extraction of fig components

The extracts were prepared by following the method of Ismail and Hong (2002). Firstly, fruit peel and leaves were washed with tap water to remove adhering dust and residue. Afterward, 25 gram of chopped fig leaves, peel, and pulp samples were homogenized in 500mL distilled water at room temperature. Mixture was shaken by orbital shaker at 200 rpm for 2 hours. Then mixtures were filtered and concentrated through Rotary Evaporator (Rotavapor R-210, BUCHI, Germany). The resultant extracts were stored at 4°C until further analysis. Following the same protocol, aqueous methanolic & ethanolic extracts were also prepared.

Total phenolic contents (TPC)

Total polyphenols (TP) in fig leaf, peel and pulp samples were estimated through Folin-Ciocalteu method (Singleton et al., 1999).

Total flavonoids (TF)
Total flavonoids were estimated using the method of Ordonez et al. (2006). Total flavonoid contents were calculated as catechin equivalent (mg/100g) using the equation obtained from the calibration curve.

Total anthocyanins (TA)
Total anthocyanins contents were analyzed, according to the pH differential method.

Determination of cyanidine-3-rutinoside (C3R)
High Pressure Liquid Chromatography (HPLC) quantification of fig anthocyanins was carried out by using HPLC (S-200, Perkin-Elmer, USA). The dry residue was dissolved in 0.1% (v/v) methanolic HCl and chromatographed by RP-HPLC to find out concentration of cyanidine-3-rutinoside (C3R) in samples. Separation was achieved on reverse phase C18 column adjusted at 35°C (Solomon et al., 2006).

Efficacy studies
Efficacy trials were conducted on experimental rats, to evaluate the antidiabetic potential of Fig leaf, peel & pulp extracts. For the purpose, 80 male Sprague Dawley rats were procured and housed in the Animal Room of Department of Physiology, Government College University, Faisalabad, Pakistan. In Study I, rats were fed on normal diet whereas in study II, high glucose diets were being supplied to induce hyperglycemia. In both studies, rats were divided into four groups based on diet plan and ten rats were included in each group. Accordingly, four types of diets i.e. control, leaf extract, peel extract and pulp extracts were given to the respective groups. At the termination of study (56^{th} day), the overnight fasted rats were decapitated and blood samples were collected in anticlotting tubes. Furthermore, the serum was centrifuged by Centrifugal Machine (Rotrofix 32-A Heltich, Germany) for 5 min @ 5000 rpm. The collected samples were preserved by Rendox Toerauta (RX-Monza Republic of Ireland). The trial was repeated to confirm claims as mentioned above.

Hypoglycemic perspectives
GOD-PAP based kit method (Sigma-Aldrich, Tokyo, Japan) was used to estimate the glucose concentration mentioned in Katz et al. (2000) methods, while, insulin level was assessed by using the protocol of Ahn et al. (2011).

Liver functioning tests
Liver functioning tests including aspartate transferase (AST), alkaline phosphatase (ALP) and alanine transferase (ALT) were measured by (DNPH) through Sigma Aldrich (Tokyo, Japan), whereas ALP assessment was carried out using Deutsche Gesellschaft für Klinische Chemie kit.

Kidney functioning tests
The serum samples were analyzed for urea by GLDH-method, while, creatinine by Jaffe-procedure via commercial kits (Sigma Aldrich, Tokyo, Japan) to evaluate the kidney functioning (Jacobs et al., 1996; Thomas, 1998).

Statistical analysis
The data obtained was statistically analyzed keeping in mind the basic principles of completely randomized design (CRD) using Statistical Package (Statistix 8.1). Analysis of Variance (ANOVA) was applied to determine the significant variations in variable as a function of plant materials or experimental diets. Later, the means were compared using Duncan Multiple Range Test (DMR) using procedures outlined by Steel et al. (1997).

RESULTS AND DISCUSSION

Nutritional composition
The nutritional composition of the three parts of fig "leaf, peel and pulp" is depicted in Table 1. Results revealed that pulp possessed the highest moisture contents (84.24±1.00%) followed by peel & leaf which have 74.56±0.57% and 66.45±1.07%, respectively. Moreover, the lowest ash contents (0.71±0.08) were observed in pulp, while leaf exhibited the highest (4.73±0.32%). Mean values for protein contents were 4.88±0.08, 2.95±0.10 and 1.1±0.05%, respectively, for leaf, peel and pulp. Furthermore, the fat contents were observed as 0.96±0.09, 0.38±0.06 and 0.2±0.01% for leaf, peel and pulp, respectively. The fig leaves contains the highest amounts of fiber (4.62±0.09%), however, the lowest fiber contents were recorded in pulp i.e. 2.1±0.10%.

The results regarding chemical composition of present research work are in accordance with the work of Ghazi et al. (2012) who compared small and big fig leaves for nutritional evaluation and explicated that slight higher concentrations of moisture, fat, protein and ash were observed in big fig leaves as compared to small leaves. In addition, Khan et al. (2011) evaluated the moisture content, ash and volatiles of dry fruit (fig) indigenous to Pakistan that ranged from 12.89 to 17.50, 1.39-2.31 and 79.81–82.25%, respectively. Likewise, the fig fruit contained 82.20, 0.65, 1.00, 1.70, 1.55 and 12.90% moisture content, ash, protein, fat, fiber and carbohydrates correspondingly. Later, Mahmoud et al. (2013) reported the chemical composition of fresh and dried fig and pointed out that fresh fig fruit contains 79.0, 0.85, 0.34, 2.74, 0.75 and 4.31% of moisture, protein, fat, fiber, ash and carbohydrates, respectively.

Phenolic composition
Results in Table 2 showed the total phenolics content (mg catechin & gm/100 gm fig) followed by the antioxidant properties for the three parts of fig including leaf, peel and pulp. Mean values revealed that TPC of different Fig parts were in the order of 0.25±0.02, 0.19±0.01 and 0.04±0.01g/100 gm for leaf, peel and pulp, respectively. Maximum flavonoids were

Table 1: Chemical composition of different parts of fig (%)

	Moisture	Ash	Protein	Fat	Fiber	NFE
Leaf	66.45±1.07^{c}	4.73±0.32^{a}	4.88±0.08^{a}	0.96±0.09^{a}	4.62±0.09^{a}	17.8±0.51 ^{ns}
Peel	74.56±0.57^{b}	1.78±0.15^{b}	2.95±0.10^{b}	0.38±0.06^{b}	3.09±0.11^{b}	18.00±1.08 ^{ns}
Pulp	84.24±1.00^{a}	0.71±0.08^{c}	1.1±0.05^{c}	0.2±0.01^{c}	2.1±0.10^{c}	19.6±0.90 ^{ns}

Values with different superscripts in a column differ significantly from each other (P<0.05); ns=non-significant

Table 2: Phenolic composition & Antioxidant properties of fig parts

	TPC[1] (g/100 g)	Flavonoids (mg catechin/ 100 g)	Anthocyanins (g/100 g)	C3R[2] (g/100 g FW)	FRAP (µ mol/L)	DPPH (% inhibition)
Leaf	0.25±0.02^{a}	95.62±5.2^{a}	0.14±0.03^{a}	0.14±0.03^{a}	414±19.6^{a}	59.55±4.6^{a}
Peel	0.19±0.01^{b}	38.90±2.9^{b}	0.10±0.02^{b}	0.09±0.02^{b}	380.44±16.8^{b}	49.44±3.8^{b}
Pulp	0.04±0.01^{c}	4.49±0.25^{c}	0.03±0.01^{c}	0.03±0.01^{c}	330±13.75^{c}	27.33±2.2^{c}

Values with different superscripts in a column differ significantly from each other (P<0.05); TPC = Total polyphenol contents; C3R (Cyanidine-3-rutinoside)

identified in leaf (95.62±5.2 mg catechin/100 gm) whereas, minimum contents were found in pulp (4.49±0.25 mg catechin/100 gm). C3R was main anthocyanin in all fig parts. Leaf was major contributor of this compound (0.14±0.03 gm/100 gm), while pulp contributed C3R least in quantity (0.03±0.01g/100gm).

The current data are in mild agreement with the research work of Yang et al. (2009), they determined 12.25 mg/gm GAE phenolics in fig fruit. Total polyphenolics of skin part belonging to black fig variety (Mission) were 463.0±44.3 mg GAE/100gm whereas, its pulp contained 100.6±8.6 mg GAE/100gm (Solomon et al., 2006). Moreover, Viuda-Martos et al. (2015) elaborated that fig peel of Collar variety contained 5.76±0.13 mg GAE/gm while pulp contained 1.92±0.7 mg GAE/gm of sample. Furthermore, Vallejo et al. (2012) elucidated that TPC ranged from 19.1 to 140.2 mg/100gm in peel of different fig varieties, while values in pulp were in the range of 0.05 to 11.3 mg/100gm.

Total flavonoids of Mission fig were estimated as 45.6±3.7 and 5.7±0.5 mg catechin/100 gm respectively, in skin and pulp of fruits by Solomon et al. (2006). Viuda-Martos et al. (2015) also determined total flavonoids as rutin equivalent (RE) in peel and pulp of fig powder coproduct and revealed 19.12±0.04 & 9.24±0.22 mg RE/gm TF contents respectively. TF contents were reported as 2.5±0.05 mg catechin equivalent/gm of sample by Buci-koji et al. (2011). Del Caro and Piga (2008) probed flavonoids in peel of Italian fig varieties as 1451.08 & 697.42 mg/Kg fresh weight but pulp was missing this valuable content.

Duenas et al. (2008) described anthocyanin content of fig skin and pulp of different fig varieties in the range of 31.79±0.08 to 96.81±6.91 and 1.52±0.40 to 14.62±1.10 µg/gm fresh weight, respectively. Previously, 27.3±2.3 & 1.3 mg C3G/100gm total anthocyanins were determined in skin and pulp of black fig variety mission by Solomon et al. (2006) and Caliskan and Polat (2011). Total anthocyanins were recorded as 929.27 and 17.60 mg/Kg fresh weight of Italian fig fruit Del Caro and Piga (2008). Kamiloglu and Capaninoglu (2013) determined two major anthocyanins in fig fruit namely Cyanidin-3-rutinoside and cyanidin-3- glucoside.

Duenas et al. (2008) probed 10.16±1.21 µg/gm fresh weight of Cyanidin-3-rutinoside in pulp of Collar fig as compared peel (15.42±0.53 µg/gm). Veberic et al. (2008) also claimed that rutin was present in highest concentrations among all phenolics found in fig fruit. Solomon et al. (2006) revealed that 95% of total anthocyanin was Cyanidin-3- Rutinoside (C3R).

Ferric Reducing Antioxidant Power (FRAP)

The maximum FRAP value was observed in leaf samples as 414±19.6 µmol/L and minimum in pulp (330±13.75 µmol/L). Similarly, a declining trend in DPPH values was found among leaf, peel and pulp samples in the order of 59.55±4.6, 49.44±3.8 and 27.33±2.2%, respectively.

Aqueous extract of fig leaves has less ferric reducing power (16.66±4.40 mmol Fe^{++}/100 gm as compared to methanolic extract (131.39±13.96 mmol Fe^{++}/100 gm), described by Ghazi et al. (2012). Viuda-Martos et al. (2015) also revealed 2.15±0.01 and 1.70±0.06 TEAC, ferric reducing power respectively for 50 mg/ml of peel and pulp fig extracts.

DPPH of aqueous extract of fig fruit was recorded 9.50 and 92.60% at 0.1 mg/ml and 4 mg/ml concentrations (Yang et al. 2009). Peel and pulp of collar fig has DPPH 65.57±0.65 and 14.74±0.53% respectively at 50 mg/ml concentration (Viuda-Martos et al. 2015). Hydroalcoholic crude extract of Omani fig tree leaves showed more than 90% radical scavenging activity (DPPH) at different concentrations.

Blood glucose

The feeding of different parts of fig results in pronounced hypoglycemic effect. Means regarding blood glucose (Table 3) showed maximum value 84±3.95 mg/dL in D_0 substantially reduced to 81.47±3.98, 82.08±3.81and 82.98±3.69 mg/dL in D_1, D_2 and D_3, respectively in trial I of normal study. A similar trend was observed in trial-II, D_0 exhibited the

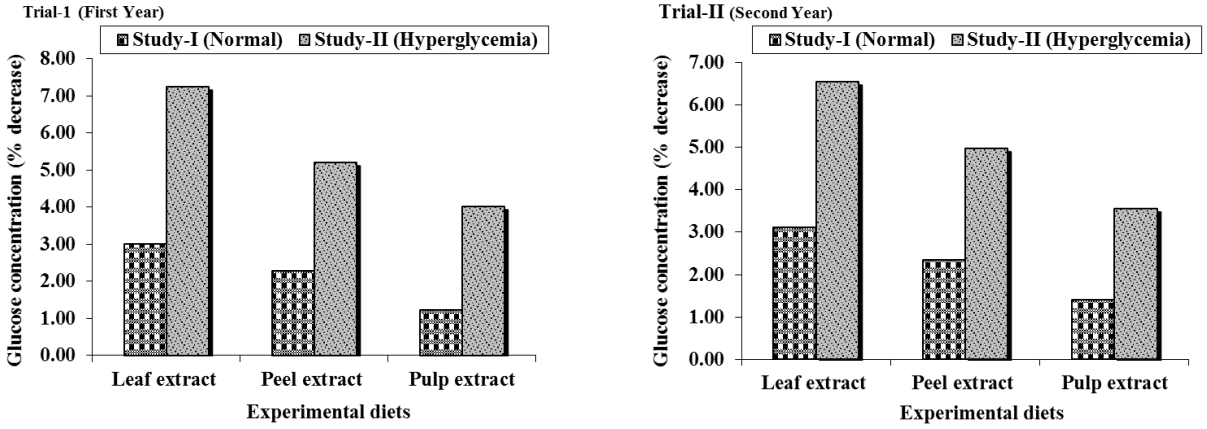

Fig. 1: Percent decrease in blood glucose level in normal and hyperglycemic rats

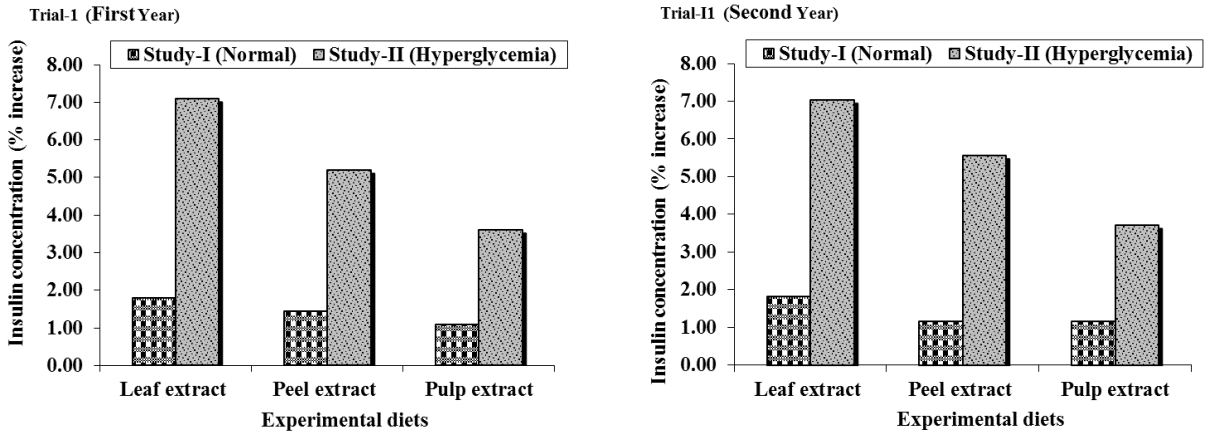

Fig. 2: Percent increase (%) in blood insulin concentrations in normal and hyperglycemic rats

Table 3: Effect of experimental diets on blood glucose level

	Groups	D_0	D_1	D_2	D_3
Study-I (Normal)					
	Trial I	84±3.95 [a]	81.47±3.98 [b]	82.08±3.81 [b]	82.98±3.69 [b]
	Trial II	86±4.06 [a]	83.32±3.87 [b]	83.98±3.72 [b]	84.79±3.55 [b]
Study-II (Hyperglycemic)					
	Trial I	149±7.24 [a]	130.81±7.10 [c]	135.38±6.83 [bc]	141.21±6.70 [b]
	Trial II	145±7.15 [a]	127.61±6.98 [c]	132.59±6.76 [bc]	138.46±6.56 [b]

D_0 = Control diet; D_1= Leaf extract supplemented diet; D_2 = Peel extract supplemented diet; D_3 = Pulp extract supplemented diet.

Table 4: Effect of experimental diets on blood insulin level

	Groups	D_0	D_1	D_2	D_3
Study-I (Normal rats)					
	Trial I	5.56±0.24	5.66±0.32	5.64±0.23	5.62±0.33
	Trial II	6.01±0.30	6.12±0.28	6.08±0.27	6.08±0.26
Study-II (Hyperglycemic rats)					
	Trial I	7.89±0.29 [c]	8.37±0.25 [a]	8.36±0.24 [b]	8.07±0.19 [b]
	Trial II	8.12±0.23 [c]	8.56±0.22 [a]	8.57±0.20 [b]	8.28±0.16 [b]

D_0 = Control diet; D_1= Leaf extract supplemented diet; D_2 = Peel extract supplemented diet; D_3 = Pulp extract supplemented diet

highest glucose 86±4.06, while the lowest (83.32±3.87 mg/dL) was recorded in was in experimental group fed on leaf extract. Maximum glucose reduction was observed in D_1 from 149±7.24 to 130.81±7.10 mg/dL trailed by 149±7.24to 135.38±6.83(D_2) and 149±7.24 to 141.21±6.70 mg/dL by D_3 , respectively during trial I. Glucose concentration was recorded as 145±7.15, 127.61±6.98, 132.59±6.76, 138.46±6.56 mg/dL for D_0, D_1, D_2 and D_3 respectively. It is obvious from Fig. 1, that the treatment D_1 decreased glucose by 12.21 &

11.99% followed by D_2 9.14 & 8.56% and D_3 5.23 & 4.51% in trial I and II of hyperglycemic study, respectively.

Fig fruit and leaves showed good glycemic response by lowering blood glucose level. Blood glucose level was observed as 177.07±0.99 and 131.27±2.90 by using 20% fig fruit and 8% fig leaves supplementation respectively in diets as compared to control 228.32±3.27 mg/dL (El-Shobaki et al., 2010). Glycemic level was significantly reduced in streptozotocin induced diabetic rats by intraperitoneal administration of fig leaf extract. Capillary glucose was determined as 245.8±14.2 mg/dL and 166.7±23.6 mg/dL in orally administered doses of commercial tea decoction & fig leaf decoction for one month in insulin dependent diabetes patients (Serraclara et al., 1998). Fig fruit phenolics help in uptake of glucose in the body resulting in hypoglycemic action. The phenols of figs enrich lipoproteins in plasma and shield them from subsequent oxidation. The ingesting of dried figs significantly enhances the antioxidant capacity of human plasma. Anthocyanins potentially inhibit intestinal α glucosidases and α-amylase activities, resulting in delay of carbohydrate digestion to absorbable monosaccharide (Yang et al., 2009).

Insulin

Means concerning insulin (Table 4) showed that the D_0 exhibited the lowest insulin level 5.56±0.24 IU/L that was progressively enhanced to 5.62±0.33, 5.64±0.23 and 5.66±0.32 IU/L in groups fed on D_3, D_2 and D_1 diets, respectively, in trial I of normal study. Trial II also produced same results as 6.01±0.30, 6.08±0.26, 6.08±0.27 and 6.12±0.28 IU/L for D_0, D_3, D_2 and D_1, respectively. Maximum insulin level (10.72±0.51 IU/L) was recorded in group feeding on fig leaf extract followed by fig peel extract group (10.53±0.6 IU/L), while the least concentrations of insulin (10.01±0.56 IU/L) were recorded in control during trial I. In second trial, results were obtained in the same order as 10.25±0.53, 10.97±0.48, 10.82±0.54 and 10.63±0.45 IU/L for D_0, D_1, D_2 and D_3 diets.

It is evident from the Figure 2 that the feeding of fig leaf and fruit enriched diets caused elevation in serum insulin as compared to the control. In this context, the consumption of leaf extract (D_1) exhibited maximum increase as 7.12 and 6.99% followed by fig peel extract (D_2) 5.23 and 5.55% and pulp extract (D_3) 3.56 and 3.67% in both trials, respectively. Insulin level was enhanced in rats feeding on high fat diet supplemented with 50 and 100 mg/kg extract of fig as compared to normal group (Maha et al., 2013). Serraclara et al. (1998) studied the effect of fig leaf decoction in insulin dependent diabetes patients. Insulin dose was reduced 15.5% on daily basis compared to baseline value when oral fig leaf decoction was used. El-Shobaki et al. (2010) explicated the effect of fig fruit and leaves on hyperglycemia of Alloxan diabetic rats. Supplementation levels were (5, 10 & 20%) for fruit and 2, 4 & 6% for fig leaves in basal diets.

Conclusion

Conclusively, fig leaf & fruit supplementation in diet has been proved beneficial to cope with various metabolic disorders due to their strong nutritional potential as well as its antioxidant activity. For curtailing hyperglycemia, leaf extract addition provides maximum reduction as compared to peel extract and pulp extract. Nevertheless, fig leaf alleviates the glucose and insulin abnormalities more efficiently than the rest. Furthermore, fig leaf should be introduced in diet based therapies to curtail different physiological malfunctioning in vulnerable groups in addition to fruit peel and pulp.

Authors' contributions

All the authors contributed equally in this manuscript.

REFERENCES

AACC, 2000. Approved Methods of the American Association of Cereal Chemists. American Association of Cereal Chemists, St. Paul, MN.

Adisakwattana S, S Yibchok-Anun, P Charoenlertkul and N Wongsasiripa, 2011. Cyanidin-3-rutinoside alleviates postprandial hyperglycemia and its synergism with acarbose by inhibition of intestinal. ALPHA.-glucosidase. Journal of Clinical Biochemistry and Nutrition, 49: 36-41.

Ahn J, W Choi, S Kim and T Ha, 2011. Anti-diabetic effect of watermelon (Citrullus vulgaris Schrad) on streptozotocin-induced diabetic mice. Food Science and Biotechnology, 20: 251-254.

Ansari JA, AR Khan, MK Ahmad, N Fatima, N Rastogi, MF Khan, HJ Khan and AA Mahdi, 2016. Phytochemicals, antioxidant and antiproliferative studies of some medicinal plants from Indian sub-continent. British Journal of Pharmaceutical Research, 11: 1-11.

Buci -koji A, M Planini , SK Tomas, S Joki , I Muji, M Bili and D Veli, 2011. Effect of Extraction Conditions on the Extractability of Phenolic Compounds from Lyophilised Fig Fruits (*Ficus Carica* L.). Polish Journal of Food and Nutrition Sciences. 61: 195–199.

Butt MS and MT Sultan, 2011. Selected functional foods for potential in diseases treatment and their regulatory issues. International Journal of Food Properties, 16: 397–415.

Caliskan O and AA Polat, 2011. Phytochemical and antioxidant properties of selected fig (Ficus carica L.) accessions from the eastern Mediterranean region of Turkey. Scientia Horticulturae, 128: 473–478.

Del Caro A and A Piga, 2008. Polyphenol composition of peel and pulp of two Italian fresh fig fruits cultivars (Ficus carica L.). European Food Research and Technology, 226: 715

Duenas M, JJ Pérez-Alonso, C Santos-Buelga and T Escribano-Bailón, 2008. Anthocyanin composition in fig (*Ficus carica* L.). Journal of Food Composition and Analysis, 21: 107-115.

El-Shobaki F, A El-Bahay, R Esmail, A El-Megeid and N Esmail, 2010. Effect of figs fruit (*Ficus carica* L.) and its leaves on hyperglycemia in alloxan diabetic rats. World Journal of Dairy in Food Science, 5: 47-57.

Ghazi F, A Rahmat, Z Yassin, NS Ramli and NA Buslima, 2012. Determination of total polyphenols and nutritional composition of two different types of *Ficus carica* leaves cultivated in Saudi Arabia. Pakistan Journal of Nutrition, 11: 1061.

Ismail A and TS Hong, 2002. Antioxidant activity of selected commercial seaweeds. Malaysian Journal of Nutrition, 8: 167-177.

Jacobs DS, WR DeMott, HJ Grady, RT Horvat, DW Huestis and BL Kasten, 1996. Laboratory test handbook, 4th ed. Lexi-comp Inc., Hudson (Cleveland).

Katz A, SS Nambi, K Mather, DA Baron, Follmann, G Sullivan and MJ Quon, 2000. Quantitative insulin sensitivity check index: a simple, accurate method for assessing insulin sensitivity in humans. Journal of Clinical Endocrinology and Metabolism, 85: 2402-2410.

Kamiloglu S and E Capanoglu, 2013. Investigating the in vitro bioaccessibility of polyphenols in fresh and sun-dried figs (*Ficus carica* L.). International Journal of Food Science and Technology, 48: 1365-2621.

Khan KY, MA Khan, M Ahmad, I Hussain, P Mazari, H Fazal, B Ali and IB Zaima, 2011. Hypoglycemic potential of genus Ficus L.: a review of ten years of plant based medicine used to cure diabetes (2000–2010). Journal of Applied Pharmaceutical Science, 1: 223-227.

Kim DO, SW Jeong and CY Lee, 2003. Antioxidant capacity of phenolic phytochemicals from various cultivars of plums. Food Chemistry, 81: 321-326.

Maha H, AZ Mahmoud, IH Badawy, A Yehya, Abdel-Hady and GM Badawi, 2013. Hypocholesterolemic effect of antioxidant containing fruits in rats fed on high-cholesterol and fat diet. Journal of Applied Pharmaceutical Science, 9: 4233-4244.

Mahamoud A, B Roche and J Homer, 2013. Modeling the social determinants of health and simulating short-term and long-term intervention impacts for the city of Toronto, Canada. Social Science and Medicine 93: 247–255.

Ordonez A, J Gomez and M Vattuone, 2006. Antioxidant activities of Sechium edule (Jacq.) Swartz extracts. Food Chemistry, 97: 452-458.

Serraclara A, F Hawkins, C Perez, E Domínguez, JE Campillo and MD Torres, 1998. Hypoglycemic action of an oral fig-leaf decoction in type-I diabetic patients. Diabetes Research and Clinical Practice, 39: 19-22.

Sheikh BY, 2016. The role of prophetic medicine in the management of diabetes mellitus: A review of literature. Journal of Taibah University Medical Sciences, 11: 339–352.

Sher H, RW Bussmann, R Hart and HJ de Boer. 2016. Traditional use of medicinal plants among Kalasha, Ismaeli and Sunni groups in Chitral District, Khyber Pakhtunkhwa province, Pakistan. Journal of Ethnopharmacology, 188: 57-69.

Singleton VL, R Orthofer and RM Lamuela-Raventos, 1999. Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. Methods Enzymology, 299: 152-178.

Solomon A, S Golubowicz, Z Yablowicz, S Grossman, M Bergman, HE Gottlieb, A Altman, Z Kerem and MA Flaishman, 2006. Antioxidant activities and anthocyanin content of fresh fruits of common fig (*Ficus carica* L.). Journal of Agricultural and Food Chemistry, 54: 7717-7723.

Steel RG, JH Torri and DJH Dickey, 1997. Principles and procedures of statistics a biometrical approach. WCB/McGraw-Hill, USA.

Thomas L. 1998. Clinical laboratory diagnostics. 1st edition. Frankfurt: TH-Books Verlagsgesellschaft, Germany, pp. 241-247.

Vallejo F, J Marín and FA Tomás-Barberán, 2012. Phenolic compound content of fresh and dried figs (*Ficus carica* L.). Food Chemistry, 130: 485-492.

Veberic R, M Colaric and F Stampar, 2008. Phenolic acids and flavonoids of fig fruit (*Ficus carica* L.) in the northern Mediterranean region. Food Chemistry, 106: 153-157.

Vinson JA, L Zubik, P Bose, N Samman and J Proch, 2005. Dried fruits: excellent in vitro and in vivo antioxidants. Journal of the American College of Nutrition, 24: 44-50.

Viuda-Martos M, X Barber, JA Pérez-Álvarez and J Fernández-López, 2015. Assessment of chemical, physico-chemical, techno-functional and antioxidant properties of fig (*Ficus carica*

L.) powder co-products. Industrial Crops and Products, 69: 472-479.

Wang L, and CL Weller, 2006. Recent advances in extraction of nutraceuticals from plants. Trends in Food Sciene Technology, 17: 300-312.

Yang XM, W Yu, ZP Ou, WM Liu and XL Ji, 2009. Antioxidant and immunity activity of water extract and crude polysaccharide from *Ficus carica* L. fruit. Plant Foods for Human Nutrition, 64: 167-173.