International Journal of Diabetes Sciences
Online ISSN: 2664-911X, Print ISSN: 2664-9101
Received: 02-11-2018; Accepted: 03-12-2018; Published: 02-01-2019
www.diabeticjournals.net
Volume 1; Issue 1; 2019; Page No. 06-11

Role of a vegetarian diet in the prevention of diabetes

Mousumi Niyogi
Gurupalli South West, Santiniketan, West Bengal, India

Abstract
Diabetes Mellitus is an alarming disease in the present day since there is no remedy for the same.
All it can be done is to seek for prevention and arrest of the illness. Polyphenols are known to act as preventor of the disease.
The objective of the investigation done here is to examine how the dietary phenolic acids and flavonoids could help in this goal. A vegetarian diet proposed earlier indicates that it can successfully prevent diabetes if taken regularly.
Antidiabetic polyphenols have been estimated from the diet concerned by evaluating their presence in each element of the diet and the result is obtained by adding them up. The total amount of antidiabetic polyphenols is found to be approximately equal to the daily intake amount. So the diet can be thought to be an antidiabetic one and it can prevent diabetes.

Keywords: diabetes mellitus, polyphenols, insulin, p-cells, glucose level, antidiabetic phenolic acids and flavonoids

Introduction
Diabetes Mellitus (DM) is a burning problem of the day for human being. It is a metabolic disorder characterized by chronic hyperglycemia with disturbances of carbohydrate, fat and protein metabolism resulting from defects in insulin secretion, insulin action occurring singly or both [1,2&3]
Apart from gestational DM which occurs in women during pregnancy, there are mainly two types of diabetes *viz*. Type 1 which happens when the body fails to produce insulin and the person concerned is insulin dependent i.e. he has to get insulin from outside.
Type 2- This type of diabetes affects the mechanism of using the insulin secreted for lowering the blood sugar.
Actually Type 1 DM is due to an autoimmune disorder caused by autoaggressive T lymphocytes that infiltrate the pancreas and destroy insulin producing beta cells, leading to hypoinsulinemia consequently hyperglycemic condition [4]. Type 2 DM is characterized by altered lipid, glucose metabolism, impaired insulin secretion and increased insulin Resistance i.e. the resistance to insulin- mediated glucose disposal. Type2 DM accounts for about 90% of all diabetes and hence is the major causes of premature illness and death through the increased risk of cardiovascular disease.
While diabetes itself is manageable, its complications can severely affect the daily living some of which could be fatal [5]
Basically diabetes is known as an oxidative stress disorder which occurs due to an imbalance between free radical formation and the ability of the organism's natural antioxidant [6].
Antioxidants inhibit the activity of free radicals through destruction of free radicals, binding to metals that simulate the production of free radicals and inhibition of production of the same as well as acting as scavengers of free radicals.
Phenolic acids have been considered as ideal agents against oxidative stress and its complications [7].
Similarly, flavonoids, a group of hydroxylated phenolic substances have been known to be potent against free Radical scavengers and hence attracted tremendous interest as possible therapeutics against free radical mediated diseases like diabetes mellitus [8&9].
After the success of a vegetarian diet [10] in so many aspects [11,122,13,14,15&16] it is now in order to investigate how the above diet helps an antidiabetic agent to combat diabetes, particularly Type 2 disease by the presence of polyphenols in the diet. If taken from very childhood, the proposed diet can act as preventive agent against diabetes because after all even children are affected by the above disease [17]
The phenolic acids presentin the diet are: Salicylic Acid, Gallic Acid, Ellagic Acid, Caffeic Acid, Chlorogenic Acid, Sinapic Acid, Pcoumaric Acid, Ferulic Acid, Syringic Acid and Protocatechuic Acid.
The list of flavonoid in the diet is a big one which includes:
Quercetin, Kaempferol, Isorhamnetin, Luteolin, Apigenin, Catechin, Isoflavones, Lycopene, Anthrocyanin and Proanthocyanidin.
In this article, attention has been drawn to find the amount of polyphenols available from the proposed diet.
These polyphenols act as antidiabetic agents.

Materials and Methods
The diet in consideration involves variety of foods which contains legume, vegetables, cereal, dairy products fruits and refreshing items.
Estimation of the relevant polyphenols from each element of the diet have been calculated and added up to get the net result of the above. The result so obtained are believed to act as preventive doses and sometimes as medicinal doses against diabetes to arrest the disease.

Results and Discussions
Before presenting the amount of phenolic acids and flavonoids obtained from the proposed diet, it may be relevant to discuss how the above phenolic acids and flavonoids take part to act as antidiabetic agents.
Table-1 below summarises the function of the phenolic acids and flavonoids [18] in relation to diabetes.

Table 1: The polyphenols and their functions towards prevention and arrest of diabetes.

Polyphenols(A)	**Corresponding Antidiabetic Function(B)**
1. Salicylic Acid	Phenolic acids are very much available in vegetables, fruits etc and if taken by human have demonstrated anti-diabetic effects [19]. Salicylic acid, one of the phenolic acids is present in the proposed diet [10] coming from guavas, tomatos, radish and mushrooms. Salicylic acid pharmacokinetic study achieved lower blood concentration of salicylic acid and subsequently incomplete inhibition of thromboxane A2 synthesis as measured with S-TxB2concentrations and increased platelet reactivity in diabetes [20].
Polyphenols(A)	Corresponding antidiabetic Function(B)
2. Gallic Acid	Gallic Acid, an endogenous plant phenol is found in black tea leaves, fruits, soyabean, eggplant etc. It improves beta cell regeneration, insulin secretion, lipid profiles and could be used as a drug to bring about insulin secretagogue and hypolipidermic effects. Production of beta cells of the islets of Longerhan's thus stimulating the release of insulin and alleviating the oxidative stress through its antioxidant nature, Upregulation of PPAR expression and AKt activation. It enables glucose uptake through translocation and activation of glucose transporters (GLUT) 4 in phosphatidyleinasitol-3 Kinase path way. Gallic acid suppresses nuclear factor activity and cytokine release. It also reduces CREB-binding protein/ p-300(CBP/P300 a NF-K beta coactivator), gene expression, acetylation levels and CBP/ P300 histone acetyltransferase activity [1].
Polyphenols(A)	Corresponding Antidiabetic Function(B)
3. Ellagic Acid	It is a natural phenol antioxidant found in cowpea, greenpea, Soybean, spinach, banana etc. Ellagic acid in EO exerts antidiabetic activity through the action on beta cells of pancreas that simulates insulin secretion and decreases glucose intolerance [2]. It reduces oxidative stress and improves histopathology in brain. It prevents lipid deposition and decreases vascular smooth muscle-cell proliferation. It suppresses oxidative stress and inflammation. Ellagic acid is believed to be most efficient in increasing the sexual function of diabetes. It attenuates the inflammatory processes by inhibition of NF-KB pathway [21].
Polyphenols(A)	Corresponding Antidiabetic Function(B)
4. Caffeic Acid	It is present in apple, potato, mushroom, mango, guava etc. Caffeic acid is a good agent to treat diabetic patients. It suppresses the hepatic glucose output by enhancing hepaticglucose utilization and inhibiting glucose over production. It lowers triglyceride. It has anticoagulatory, antioxidative and anti-inflammatory protection for cardiac tissue of diabetis [22]. It inhibits nonenzymatic amino acid glycation in the living body which is associated with aging diabetic complications [23].
Polyphenols(A)	Corresponding Antidiabetic Function (B)
5. Chlorogenic Acid	Chlorogenic acid, which is available from apple, peanut, moringa leaves, banana etc, reduces glycemia and the glycemic index of body, thereby lowering the intestinal absorption of glucose. It regulates glucose and lipid metabolism through the activation of AMPK. The mechanisms of the antinociceptive activity of chlorogenic acid may lower the blood glucose, and improve insulin sensitivity through an adiponectin receptor mediated signaling pathway [24].
6. Sinapic Acid	This acid is present in Red Kidney bean, mushroom, peanut, cowpea, soybean. It improves hyperglycemia through phospholipase C-protein Kinase C signals to enhance the glucose utilization [25].
Polyphenols(A)	Corresponding antidiabetic Function(B)
7. Pcoumaric Acid	The acid is found in apple, beans, potato, tomato mushroom etc. It modulates glucose and lipid metabolism via 5 AMPK activation in L6 skeletal muscle cells. Pcoumaric acid contents by high performance liquid chromatography, antioxidant activity as 1.1 diphenyl- 2picryl- hydrazyl- scavenging and porcine pancreatic amylase inhibitory activity [25]].
8. Ferulic Acid	Easily obtained from whole wheat, rice per boiled, banana, guava, potato, mung bean etc. It decreases blood glucose and glucose-6-phosphatase, phosphoenol pyruvate carboxykinase activities and higher glycogen and insulin. Reduces oxidative stress and inflammation pathway. Further, it decreases the glucose and lipid peroxidation. It exhibits significant protection against vascular endothelial dysfunction in diabetes [26].
Polyphenols(A)	Corresponding antidiabetic Function (B)
	Ferulic acid treatment reduces the GLUT2 expression in diabetics by impairing the interaction between the transcription factors (SREBPIC, HNF1-alpha and HNF3-beta and GLUT2 genepromoter) [27].
9. Syringic Acid	Available from fruits, blackbean, soybean, mungbean, mushroom, kidneybean syringic acid is a potential agent to secrete insulin from existing islet betacells. It exhibits lower HBAc1 and fasting plasma insulin levels and also improves glucose homeostatis in lever [28]].
Polyphenol(A)	Corresponding antidiabetic function (B)
10. Protocatechuic Acid	It is present in lentil, eggplant, peanut, mango, apple, brown rice etc which has tremendous effects in the treatment of diabetes. This acid normalizes hyperglycemia and reverses dyslipidemia associated with diabetes. It improves high density lipoprotein C and low density lipoprotein C levels in diabetes. The acid simulates the insulin signaling path way in human adipocytes increasing GLUT4 translocation and glucose uptake [29].
11. Quercetin	Quercetin is available from redgram, eggplant, pumkin, tomato, spinach, various fruits etc and acts as antidiabetic agent. It improves hyperglycemia and oxidative stress. It downgrades glucose and blood HbA1C. It prevents beta cell death via the mitochondrial pathway and NFKB signaling.
Polyphenol(A)	Corresponding Antidiabetic Function (B)
12. Kaempferol	Available from apple, redspinach, potato etc. It inhibits cellular apoptosis and reduces caspase-3 activity in beta cells. Further it increases antioxidant and decreases lipid peroxidation markers. Enhances beta cell survival, improves CAMP signaling and increases GLUT4, AMPK [30&31].
13. Isorhamnetin	This is a bioactive compound found from some elements like eggplant, tomato, pumkin, banana etc. It helps insulin secretion associated with increased GLUT2 and PPARY [23]. There is evidence that isorhamnetin glycosides possess antidiabetic effect and expression of enzymes regulating lipid metabolism [32].
Polyphenol(A)	Corresponding anti-diabetic Function (B)
14. Luteolin	Luteolin is abundantly available in fruits and vegetables etc. It potentiates insulin action, inhibits NF-KB pathway,

	consequently increases iNOS, elevates antioxidants and increases in uptake of FFAS. It reduces mast cell and macrophase infiltrations and inflammatory cytokine levels [33&34].
15. Apigenin	Apigenin is found in fruits, vegetables, nuts etc. It decreases glucose and increases antioxidant enzymes. It helps in the antioxidant and mitochondrial protection while decreasing apoptosis. It is insulin secreta-gogue [35,36&37].
16. Catechin	Catechins are abundant in green tea. It is also found in black tea, apple, mango, banana etc. Studies suggest [38] that catechins can be used in the treatment for controlling blood sugar and risk factors associated with type 2 diabetes like obesity, dyslipidemia and oxidative stress.
Polyphenols(A)	Corresponding antidiabetic Function(B)
17. Isoflavones	Soybean, kidneybeans, peas and peanut are the sources of isoflavones in the proposed diet [10]] of which soybeans are major contributor to the isoflavones. Soy isoflavones contain 12 different isoform in four chemical forms containing genistein. Over the years various studies show that genistein possesses antidiabetic properties like direct effect on beta cell proliferation, glucose simulated insulin secretion and protection against apoptosis [39]]. The soy isoflavone genistein reverses oxidative and inflammatory state [40]].
Polyphenol(A)	Corresponding antidiabetic Function(B)
18. Lycopene	Lycopene is available from tomato, mango, guava and carrot etc. Diabetes is a chronic metabolic disorder. The most commonly accepted cause of diabetes is the oxidative damage caused by free radicals. It is believed that the oxidative damage and low insulin levels associated with diabetes are improved with application of lycopene. Lycopene can act in the prevention of diabetic disorders like body weight loss, decreased insulin levels and decreased plasma glucose level also [41].
19. Anthocyanin	This flavonoid is available from apples, eggplant and radishes etc. It helps in the protection against the development of type2 diabetes. It is conjectured that a lower risk of type2 diabetes was associated with higher anthocyanin content in the diet [42]].
Polyphenol (A)	Corresponding antidiabetic Function(B)
	Considering the impact of anthocyanin on the regulation of glycemia and reduction of insulin resistance, it appears that the consumption of foods rich in anthocyanins may support the prevention and treatment of type2 diabetes [43].
20. Proanthocyanidin	Proanthocyanidin is available from apple, mango, banana, red kidney bean etc. Diabetes is a chronic metabolic disease where glucose metabolism is impaired due to toxicity on pancreas gland and deficit in insulin level. Its therapy requires the inhibition of excess digestive enzymes and formation of advanced glycation end product (AGE). Proanthocyanidin increases normal insulin content and decreases the apoptotic cells in diabetic pancreatic islet.
Polyphenol (A)	Corresponding antidiabetic functiom (B)
	Endoplasmic reticulum(ER) stress is switched on during diabetic stress. Proanthocyanidin partially improves ER stress. It attenuates oxidative stress through inhibition of lipid peroxidation and reduces the risk of vascular disease in diabetes. It also controls hyperglycemia. Proanthocyanidins may slow the progression of diabetic retinopathy [44]

It may now be interesting to note the amount of the relevant phenolic acids and flavonoids obtainable from the proposed diet. This has been presented in Table-2 below.

Table 2: The amount of polyphenols evaluated from the proposed diet

Polyphenols(a)	Amount of minimum value in mgm/day (b)	Amount of maximum value in mgm/day (c)
1. Salicylic Acid	3.71	4.15
2. Gallic Acid	37.81	40.41
3. Ellagic Acid	13.26	17.45
4. Caffeic Acid	33.38	41.85
5. Chlorogenic Acid	24.78	32.12
6. Sinapic Acid	18.37	21.25
7. Pcoumaric Acid	16.98	22.80
8. Ferulic Acid	29.34	32.07
9. Syringic Acid	12.36	21.45
10. Protocate-chuic Acid	19.54	24.89
11. Quercetin	12	15
12. Kaempferol	12.25	13.22
13. Isorhamnetin	14.74	21.19
14. Luteolin	13.60	24.83
15. Apigenin	8.32	9.32
16. Catechin	7.72	12.07
17. Isoflavones	130.65	178.81
18. Lycopene	10.46	17.50
19. Anthocyanin	54	100
20. Proanthocyanidin	670	715

We are now in a position to calculate the mean values of the polyphenols obtained per day from the proposed diet and compare them with the daily intake amounts.
They are presented in Table-3.

Table 3: The mean values of the polyphenols obtained from the proposed diet per day and the daily intake amount.

Polyphenols(a)	**Mean values of proposed diet in mg/day(b)**	**Mean values of intake amount in mg/day(c)**
1. Salicylic Acid	3.93	10
2. Gallic Acid	39.11	97.2
3. Ellagic Acid	15.355	30
4. Caffeic Acid	37.615	70
5. Chlorogenic Acid	28.45	300
6. Sinapic Acid	19.81	10
7. Pcoumaric Acid	19.89	17.9
8. Ferulic Acid	30.705	250
9. Syringic Acid	16.905	4.82
10. Protocate-chuic Acid	22.215	17
11. Polyphenols (a)	Mean values of proposed diet in mg/day(b)	Mean values of intake amount in mg/day(c)
12. Quercetin	13.5	40
13. Kaempferol	12.735	13.3
14. Isorhamnetin	17.965	20.7
15. Luteolin	19.215	0.20
16. Apigenin	8.82	6.5
17. Catechin	9.895	11.1
18. Isoflavones	154.73	50
19. Lycopene	13.98	21
20. Anthocya-nin	77	64.4
21. Proantho-cyanidin	692.5	189
22. Total:-	1248.325	1223.12

From the above data it is clear that of the antidiabetic polyphenols some like luteolin, isoflavones and proanthocyanidin are higher contributor to the antidiabetic effects from the proposed diet while gallic acid, caffeic acid, chlorogenic acid and ferulic acid take the leading role as obtained from the daily intake amount.

Graphical presentation of the mean values of the polyphenols from the proposed diet and the daily intake amount are shown in Fig-1 and Fig-2.

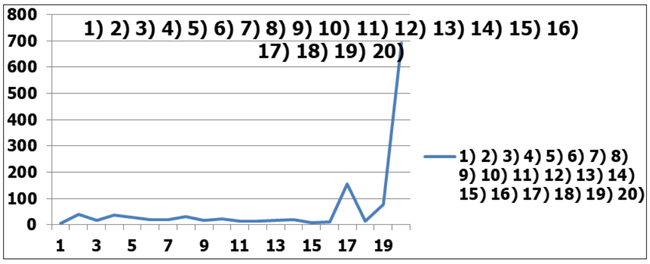

Fig 1: Mean values of the antidiabetic polyphenols per day from the proposed diet

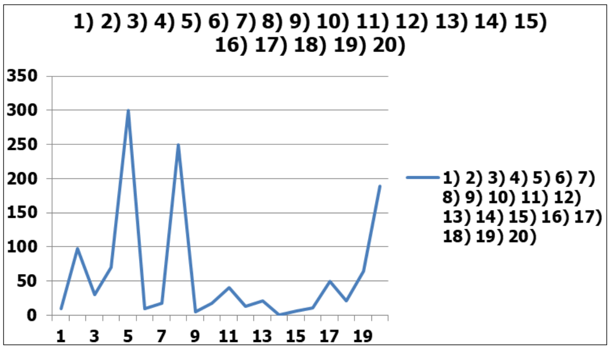

Fig 2: Mean values of the antidiabetic polyphenols intake per day

From the above graphs it is evident that the various elements of the polyphenols in two sets have no correlation between each other. However one interesting point that occurs in the two sets of data is that the total amount of antidiabetic polyphenols in the two cases are almost same.

Thus it can be inferred that they contribute equally to the prevention of diabetes.

However, since the elements of antidiabetic polyphenols in the above two sets contribute differently it may be interesting to study in detail how they act and which set could be more effective in relation to diabetes, and that investigation could be done elsewhere.

Conclusion

Diabetes is a leading problem of the day and the number of diabetic patients are increasing alarmingly day by day.

So, scientists and doctors are engaged to investigate the ways for prevention and remedy of the disease. To get remedy, it may prove fatal due to side complications. Prevention and arrest of the disease could be wise to search for. As there are many polyphenols which act as antidiabetic, attention has been drawn in this article to the availability of the above polyphenols from a proposed diet. It has been shown that the diet in consideration supply phenolic acids and flavonoids in sufficient amount per day to prevent diabetes.

The amount of polyphenols evaluated from the diet differ from the daily intake amount and the amount of various elements from the diet and the daily intake amount have no one-to –one correspondence.

But the net amount of antidiabetic polyphenols from the diet match quite successfully with the daily intake amount.

Hence it may be concluded that the diet presented here could be successful as a preventor of diabetes.

Acknowledgement
The incessant help from Mr. D. Niyogi in preparation of the article is gratefully acknowledged.

References
1. Standards of Medical Care in Diabetes, ADA, Diabetes Care. 2009; 32(Suppl 1):S13-S61.
2. Ramchandran V. Antidiabetic Effects of simple phenolic Acids: A comprehensive Review, Phytother Res. 2016; 30(2):84-99.
3. Ramchandran V, Xu B. Antidiabetic Properties of dietary flavonoids: a cellular mechanism review, Nutrition and Metabolism 12, Art, 2015, 60.
4. Yaufang Fu. High-frequency off target mutagenesis induced by CRISPR- (as nucleases in human cells, Nature Biotechnology. 2013; 31:822-826.
5. Falck S. An overview of diabetes types and treatments, Medical News Today, 2018.
6. Ramchandran V. Antidiabetic effects of simple phenolic Acids, a Comprehensive Review, Phytotherapy Research, 2015, 30(2).
7. Wu M. Sleepless is a Curr. Biol. 2014; 24(6):621-629.
8. Sarian MN. Antioxidant and Antidiabetic effects of flavonoids: A structure –activity relationship based study, Bio Med Research International, 2017.
9. Ramchandran V, Xu B. Antidiabetic properties of dietary flavonoids: A cellular mechanism review. Nutr. Metlab (LOND), 2015.
10. Niyogi M. Well planned Vegetarian diet with MSM, AJFN. 2015; 5(2):30-34.
11. Niyogi M. Estimation of micronutrients in a dietary model, AJFN. 2015; 5(2):49-56.
12. Polyphenols in a vegetarian diet-2016, AJFN, 6(4), 113-116, Health benefits of phytonutrients present in a dietary model, IJFANS. 2017; 6(1):68-79.
13. Antioxidant activity of a vegetarian diet, IJFANS. 2018; 7(2):90-94.
14. Vegetarian diet: A preventive for mental diseases, JFNH. 2018; 1(1):10-15.
15. Antioxidants. Saviours against mental diseases, IJCAR. 2018; 7(9A):15240-15244.
16. Miracles of dietary vitamins and minerals in psychiatric diseases, IJFANS. 2019; 8(3):68-79.
17. What is diabetes? DRI, University of Miami, Miller School of Medicine
18. Lin D. An overview of plant phenolic compounds and their importance in human nutrition and and management of type-2 diabetes, Molecules. 2016; 21(10):1374.
19. Choi HW. Human GAPDH is a target of aspirin's primary metabolite Salicylic acid and its derivatives, PLOS ONE, 2015; 10(11).
20. Fatima N. Ellagic acid in emblica officinalis exerts antidiabetic activity through the action on beta cells of pancreas, Eur. Journal of Nutr. 2017; 56(2):591-601.
21. Ahad A. Ellagic acid an NFKB inhibitor, ameliorates renal function in experimental diabetic nephropathy-Chem Biol. Interact. 2014; 219:64-75.
22. Chao PC. Anti-inflammatory and anticoagulatory activities of caffeic acid and ellagic acid in cardiac tissue of diabetic mice, Nutr. Metlab (Lond), 2009, 6:33.
23. Sasaki K. Effect of natural flavonoids, stilbenes and caffeic acid oligomers on protein glycation, Biomed Rep. 2014; 2:628-632
24. Jim S. Chlorogenic acid improves late diabetes through adiponectin receptor signaling pathways in db/db mice, PLOS one 10, C 0120842, 2015.
25. Cheng YG. Antihyperglycemic action of Sinapic acid in diabetic rats, J Agric. Food chemistry. 2013; 81:12053-12059.
26. Yin Y. Ferulic acid combined with astragalocide iv protects against vascular endothelial dysfunction in diabetic rats, Biosci. Trends. 2014; 8:217-226.
27. Narasimhan A. Ferulic acid regulates hepatic GLUT2 gene expression in high fat and fructose – induced type2 diabetic adult male rat, Eur J Pharmacol. 2015; 761:391-397.
28. Srinivasan S. Antihyperglycemic effect of syringic acid on attenuating the key enzymes of carbohydrate metabolism in experimental diabetic rats a, Biomed Prevent Nutr. 2014; 4:595-602.
29. Scazzochio B. Protocatechuic acid activates key components of insulin signaling pathway mimicring insulin activity, Mol. Nutr. Food Res. 2015; 59:1472-1481.
30. Al khalidy H. small molecule of kaempferol promotes insulin sensitivity and preserved pancreatic beta cell mass in middle aged obese diabetic mice- 2015, J Diabetes Res, 2015, 532984.
31. Zhang Y. Small molecule Kaempferol modulates PDX-1 protein expression and subsequently promotes pancreatic beta cell survival and function via CREB, J Nutr. Biochem. 2013; 24:638-46.
32. Rodriguez-Rodriguez C. The effect of isorhamnetin glycosides extracted from opuntia ficus-indica in a mouse model of diet included obesity, Food Funct. 2015; 6(3):805-15.
33. Xu N. Low-dose diet supplement of a natural flavonoid, luteolin, ameliorates diet induced obesity and insulin resistance in mice, Mol Nutr Food Res. 2014; 58:1258-68.
34. Kwon EY. Luteolin attenuates hepatic steatosis and insulin resistance through the interplay between the liver and adipose tissue in mice with diet induced obesity, Diabetes. 2015; 64:1658-69.
35. Suh KS. Apigenin attenuates 2-deoxy-D-ribose-induced oxidative cell damage in HIT-T15 pancreatic beta cells, Biol Pharm Bull. 2012; 35:121-6, doi: 10, 1248bpb 35,121
36. Cazavolli LH. Mechanism of action of the stimulatory effect of apigenin 6-c- (2''-o-alpha-1-rhamnopyranosy 1) –beta-L- fucopyrano side on 14c-glucose uptake-2009, Chem Biol Interact. 2008; 179:407-12. Doi10, 1016 j cbi, 11, 012 and
37. Yamagata K. Dietary flavonoid apigenin inhibits high glucose and tumor necrosis factor alpha-induced adhesion molecule expression in human endothelial cells, J Nutr Biochem. 2010; 21:116-24. doi: 10, 1016j, jnutbio, 2008, 11:003
38. Alipour M. The effects of catechins on related risk factors with Type-2 diabetes: a review, Progress in Nutrition. 2018; 20(1):12-20.

39. Wang Q. Soy isoflavone: The multipurpose phytochemical (Review), Biomed Rep. 2013; 1(3):697-701.
40. Valsecchi AE. The soy isoflavone genistein reverses oxidative and inflammatory state, neuropathic pain, neurotropic and vasculature deficits in diabetic mouse model, Eur. J Pharmacol. 2011; 650:694-702.
41. Aydin M, Celik S. Effect of lycopene on plasma glucose, insulin levels, oxidative stress and body weights of streptozotocin –induced diabetic rats, Turk. J Med Sciences. 2012; 42(Sup 2):1406-13.
42. Wedick N. Dietary flavonoid intakes and risk of type 2 diabetes in US men and women, Am. J Clin. Nutr. 2012; 95:925-933.
43. Rozanska D. The significance of anthocyanin in the prevention and treatment of Type2 diabetes, Adv Clin Exp Med. 2018; 27(1):135-142.
44. Rauf A. Proanthocyanidins, A comprehensive Review, Biomedicine and Pharmacotherapy, 2019; 116:108999.