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Comparative Evaluation Of Blackberry Kernels, Fenugreek Seeds, And Black Pepper For Natural Diabetes Management

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ABSTRACT:

The recent emergence of diabetes mellitus especially type 2 diabetes has reawakened the desire towards plant-mediated treatment modalities. This article discusses the antidiabetic property of three traditionally known botanicals such as blackberry (Rubus fruticosus) kernels, fenugreek (Trigonella foenum-graecum) seeds, and black pepper (Piper nigrum) when used alone and in combination with streptozotocin (STZ)-induced diabetic rats. The experimental design covered standard control, diabetic control, metformin-treated and treatment groups that were administered with aqueous extracts of test plants. Major scores were done on 28 days, such as fasting blood glucose (FBG), oral glucose tolerance test (OGTT), serum insulin levels, lipid profile, hepatic and renal marker, (ALT, AST, creatinine, urea), and markers of oxidative stress (SOD, CAT, GSH, and MDA). It was proved that phytochemical analysis contained flavonoids, saponins and polyphenols and has antidiabetic and antioxidant properties. A combination group showed the greatest improvement in most of the parameters, which indicated synergistic action. The histopathological investigation revealed recovery of pancreatic islets and prevention of hepatic and renal tissues. The findings indicate that these extracts, especially in mixture are effective in glycemic control, lipid metabolism, and oxidative equilibrium proficiently and safe and promising method of natural remedy to controlling diabetes. The present study provides good preclinical basis of development of polyherbal formulation with more than one pathophysiology of diabetes.

Keywords: Blackberry kernels, Fenugreek seeds, Black pepper, Antidiabetic activity, Streptozotocin (STZ), Oxidative stress, Glucose tolerance, Herbal medicine, Natural antioxidants, Histopathology.

INTRODUCTION:

The current situation at the beginning of the 21 st century is that diabetes mellitus (DM) is considered one of the most urgent global public health issues whose problem imposes a heavy burden on healthcare systems, economies as well as on personal well-being. It is a form of hyperglycemia that is chronic in nature, caused by defects in insulin secretion, insulin action or both that cause a change in the metabolism of carbohydrates, lipids and proteins (Guo et al., 2012). The number of diabetes case subjects diagnosed with type 2 diabetes is raising considerably because of uncompetitive lifestyles, lifestyle alterations, and family genetic susceptibility. According to the report of the World Health Organization (WHO), diabetes has become one of the major reasons of deaths worldwide, claiming 1.6 million lives out of it in just 2016 (World Health Organization, 2017). In spite of the existence of artificial versions of medicines metformin and insulin analogs, the surgeries are frequently related to side-effects, poor patient adherence, and inaccessible affordability, specifically in low-income nations and middle-income ones (DeFronzo et al., 2014; Gourgari et al., 2017).

The increase in the scientific literature has seen to it that it focuses more on plant-based solutions to the management of diabetes. Ethnopharmacological studies have demonstrated the existence of enormous variety of medicinal plants that have been applied traditionally by various cultures to treat diabetes symptoms. As an example, the traditional healers have been using herbal mixtures in the Southwestern of Nigeria and Iran, which has been used through many centuries using botanicals that have been proved to help in glucose-lowering (Abo et al., 2008; Bahmani et al., 2014). Similarly, in India and South Africa, traditional medicinal systems have documented many plants some of which including fenugreek, bitter gourd and neem which possess antidiabetic properties (Deutschlaendner et al., 2009; Grover et al., 2002). Phytochemicals in the plants are flavonoids, terpenes, alkaloids, tannins, saponins, which act as antidiabetic by mechanisms of insulin sensitization, pancreatic β-cell regeneration, glucose absorption inhibition, and mediating pathways of oxidative stress (Chen et al., 2015; Gaikwad et al., 2014).

Moreover, the combination of positive health effects of the herbs and spices, such as antioxidant activity, anti-inflammatory and lipid-lowering properties, makes them wonderful candidates in whole body management of diabetes. Natural-derived compounds have been found effective in not only regulating blood glucose but also in reducing the effects of complications of diabetes including neuropathy, nephropathy, and cardiovascular risks that follow diabetes long-term (Putta et al., 2016; Jungbauer & Medjakovic, 2012). As an illustration, the Chinese herbal medicine consists of bioactive polysaccharides with hypoglycemic and neuroprotective effects on diabetic disorders, and triterpenes found in other botanicals showed the same effects (Zheng et al., 2019). Moreover, herbs with flavonoid content have been observed to have the effect of preserving the functional nature of pancreatic 8- cells and lowering resistance to insulin (Fryirs et al., 2009; Li et al., 2004).

Black pepper and fenugreek are the examples of such popular dietary components with demonstrated antidiabetic activity, both preclinically and clinically, that can be used as sources of nutraceuticals (Embuscado, 2015; Iriti et al., 2010). It was recently found that blackberry kernels, a poorly utilized agro-industrial by-product, are rich in both anthocyanins and polyphenols, which positively affect the glucose uptake state and promote insulin sensitivity (Moradi et al., 2018; Harlev et al., 2013). The mutual intertwining of indigenous knowledge and contemporary pharmacological authentication forms a significant source of innovation concerning experimentation applications of these botanical substance as a prospective alternative or complementary medicine to standard treatment.

The current study entitled Comparative Evaluation of Blackberry Kernels, Fenugreek Seeds, and Black

Pepper as natural agent to manage diabetes seeks to scientifically endorse the antidiabetic capacity of the aforementioned plant extracts by employing in vitro and in vivo designs. To analyze the impact they have on the levels of fasting blood glucose, the profile of lipids, oxidative stress markers, and histopathological aspects of diabetic rats, the study adds to a body of natural product research in diabetes that is rapidly growing. The informational value will not merely reaffirm the therapeutic potential of such botanicals, but also assist in narrowing the gap between conventional medicine and evidence-based contemporary healthcare (Meerza et al., 2013; Tapsell et al., 2006).

LITERATURE REVIEW:

The increasing burden of diabetes mellitus at the global front has sparked the formulation of massive research based on comprehending the pathophysiology of diabetes mellitus, and devising effective ways of managing the disease. There exists a type 2 diabetes in particular, which is a multifactorial metabolic disease characterized by insulin resistance and incompetent insulin production that is commonly caused by an unhealthy diet, lack of physical activity as well as a genetic tendency (Guo et al., 2012). The conventional antidiabetic drugs are effective but very famous and expensive to use because they are associated with lots of side effects. This has made science a newfound interest in alternative medicine, mostly plant-based remedies that have been in use in different cultures. Several studies highlight that glycolysis, insulin signaling and lipid metabolism play an essential role in regulation of glucose homeostasis, and they are highly deregulated in diabetes (Fryirs et al., 2009; Meerza et al., 2013).

It has been stated that there is not only an interest but also an urgent necessity to seek complementary approaches to the diabetes care (World Health Organization, 2017). As a consequence, ethnobotany explorations have reported the existence of a big number of medicinal plants applied in many traditional systems of medicine all over the world. Some of these plants have been discovered by Abo and others (2008) and Bahmani and others (2014) as used in Nigeria and Iran respectively to treat diabetes. Such plants have been shown to possess phytoconstituents such as alkaloids, tannins, saponins, flavonoids, which have the effect of having antidiabetic potential, either through improvement of insulin release, a reduction of glucose uptake into the intestines, or an increase of insulin sensitivity. The quality of strong evidence presented in a similar inventory prepared by Deutschlander et al. (2009) and Grover et al. (2002) in South Africa and India on the therapeutic value of such botanicals in glucose-regulation was high.

Natural remedies have been amongst the means of Chinese traditional medicine and Li et al. (2004) conducted a review of herbal formulations that are known to combat the symptoms of diabetes. Harlev et al. (2013) also showed the antidiabetic effects of desert plants concerning their effects on the activity of pancreatic β-cells and glycemic control. These folk conclusions are evidenced by modern pharmacological studies. As an example, Moradi et al. (2018) listed a number of potential herbs containing fenugreek, cinnamon, and bitter melon as strong hypoglycemic agents. Chen et al. (2015) confirmed that flavonoids, one of the main groups of plant secondary metabolites, can reduce insulin function and oxidative stress.

In the management of diabetes, Gaikwad et al. (2014) pointed out phytochemicals such as triterpenes, flavonoids and polyphenols. Their results coincide with those of Putta et al. (2016) who indicated the activity of triterpenes to ameliorate complications of diabetes like neuropathy and nephropathy. Similarly, Chinese herbs polysaccharides have demonstrated to decrease the blood glucose levels and metabolic parameters (Zheng et al., 2019). The presented findings support scientifically based research on food-based bioactives in the management of diabetes.

Bioactive potential is also found in herbs and spices which are widely utilized during culinary activities. Antioxidant and antinflammatory greens such as fenugreek, black pepper, and turmeric are beneficial to metabolic health (Embuscado, 2015; Iriti et al., 2010). Jungbauer and Medjakovic (2012) proposed that the compounds may alleviate the components of metabolic syndrome thereby benefiting the people with diabetes or at the risk of developing diabetes. Further, some of the herbs have been found to possess anticancer, antimicrobial, and neuroprotective properties (Kaefer & Milner, 2008; Tajkarimi et al., 2010) thus depicting their multi- (useful) nature. As described by Tapsell et al. (2006) the historical application and health advantages of herbs and spices have been constantly written about with the call to incorporate them into preventative health practices.

On the whole, the literature focuses on the possibilities of botanicals, namely, fenugreek seeds, blackberry kernels, and black pepper as natural antidiabetic compounds. They could be a part of dietary or therapy combinations that could provide comprehensive and convenient ways of dealing with diabetes. It is based on this that the current study seeks to comparatively assess these botanicals in their glucose-lowering properties and hence lay a foundation to evidence-based natural rights to treat diabetes.

METHODOLOGY:

This current work would setup to investigate and estimate the antidiabetic effect of blackberry kernel, fenugreek seed and black pepper via in vivo experimental animals. There was well defined experimental design comprising of selection of animal models, induction of diabetes, treatment with a chosen choice of plant extracts, and following up of biochemical and histological findings. Wistar rats (180-220 g) of both sexes were used, maintained under controlled conditions of the environment, and given unrestricted access to normal food and water. Diabetes was induced by injecting streptozotocin (STZ), 50mg/kg body weight through a single intraperitoneal injection, freshly made using 0.1M citrate buffer (pH 4.5) and kept as fasting group 12 hours later. The fasting blood glucose level in the rats was measured at 72 hours after which rats having more than 250 mg/dL were assumed to be diabetic and included in the study.

The experimental groups were therefore classified in the following manner: Group I- Normal Control, Group II- Diabetic Control, Group III- Standard

Drug (Metformin 100 mg/kg), Group IV- Blackberry kernel extract, Group V- fenugreek seed extract, Group VI- black pepper extract, and Group VII- combination extracts. The plant materials were dried, ground and extracted Soxhlet mode through the use of ethanol as the solvent. The extracts were concentrated and utilized orally once a day throughout 28 days in a row. Glucometer was done on days 0, 7, 14, 21 and 28 to determine glucose levels of blood. On the day 21, an Oral Tolerance Glucose Test (OGTT) was carried out. The blood samples were analyzed on specific biochemical parameters which include serum insulin, total cholesterol (TC), triglycerides (TG), high-density lipoprotein (HDL), low-density lipoprotein (LDL), alanine transaminase (ALT), aspartate transaminase (AST), urea and creatinine by using commercial diagnostic kits. In liver and pancreas, the homogenates were also determined to ascertain oxidative stress markers such as malondialdehyde (MDA), superoxide dismutase (SOD), catalase (CAT) and reduced glutathione (GSH).

Data were statistically analyzed through one-way analysis of variance and later by Tukey multiple comparison technique. Representation of data was in form of mean + /- standard deviation (SD) and p value of less than 0.05 indicated significant value. The hypoglycemic power was evaluated with the formula of % blood glucose reduction:

$$\text{Percentage Reduction} = \left(\frac{\text{FBG}_{\text{initial}} - \text{FBG}_{\text{final}}}{\text{FBG}_{\text{initial}}}\right) \times 100$$

Additionally, the Homeostasis Model Assessment for Insulin Resistance (HOMA-IR) was calculated using the formula:

$$\text{HOMA-IR} = \frac{\text{Fasting Insulin}(\mu U/mL) \times \text{Fasting Glucose}(mg/dL)}{405}$$

Hematoxylin and eosin (H&E) staining procedures in pancreatic, liver, and kidney tissues were performed. Islet reproduction, inflammation infiltration, and organ safeguard have been examined using the tissue sections on a microscope. DPPH radical scavenging assay and reducing power assay was used to analyze the antioxidant activity of the extracts. The screening of phytochemicals in the plant extracts was also done by using the standard qualitative methods of screening flavonoids, alkaloids, phenolic as well as saponins. Finding was compared with the already existing literature and phytochemical profile to prove the hypothesis that such plant sources can become effective natural treatment of diabetes mellitus. Through this methodology a reproducible in-depth framework of evaluation of natural interventions against diabetes was established.

RESULTS:

1. Introduction:

The chapter contains all the detailed results of the study of the antidiabetic potential of blackberry kernels (BBK) and fenugreek seeds (FGK) and black pepper (BP). These findings are summarized by major biological parameters like level of blood glucose, oral glucose tolerance, lipid levels, body weight, biomarkers of oxidative stress, liver and kidney physiology, and histopathology. Visualisation of comparative performance and therapeutic efficiency of the extracts is also done with appropriate statistical instruments, graphs and tabular representations.

2.Fasting Blood Glucose (FBG) Level Analysis:

Table 1: Fasting Blood Glucose (mg/dL) in All Experimental Groups Over 28 Days

Group	Day 0	Day 7	Day 14	Day 21	Day 28
Control	89.6 ± 3.2	88.3 ± 2.8	86.4 ± 3.1	84.5 ± 2.9	83.1 ± 2.6
Diabetic Control	245.1 ± 5.4	261.3 ± 6.1	270.5 ± 7.0	284.6 ± 6.5	295.2 ± 8.1
BBK	248.3 ± 4.9	208.5 ± 5.2	171.2 ± 4.3	145.6 ± 3.9	118.9 ± 4.5
FGK	243.6 ± 5.0	210.4 ± 5.7	178.7 ± 4.2	152.1 ± 4.0	126.7 ± 3.8
BP	246.9 ± 4.7	218.9 ± 4.6	190.1 ± 4.1	160.4 ± 4.3	132.5 ± 4.6
Metformin	242.5 ± 4.8	200.1 ± 4.5	160.3 ± 3.9	125.6 ± 3.7	98.2 ± 3.5

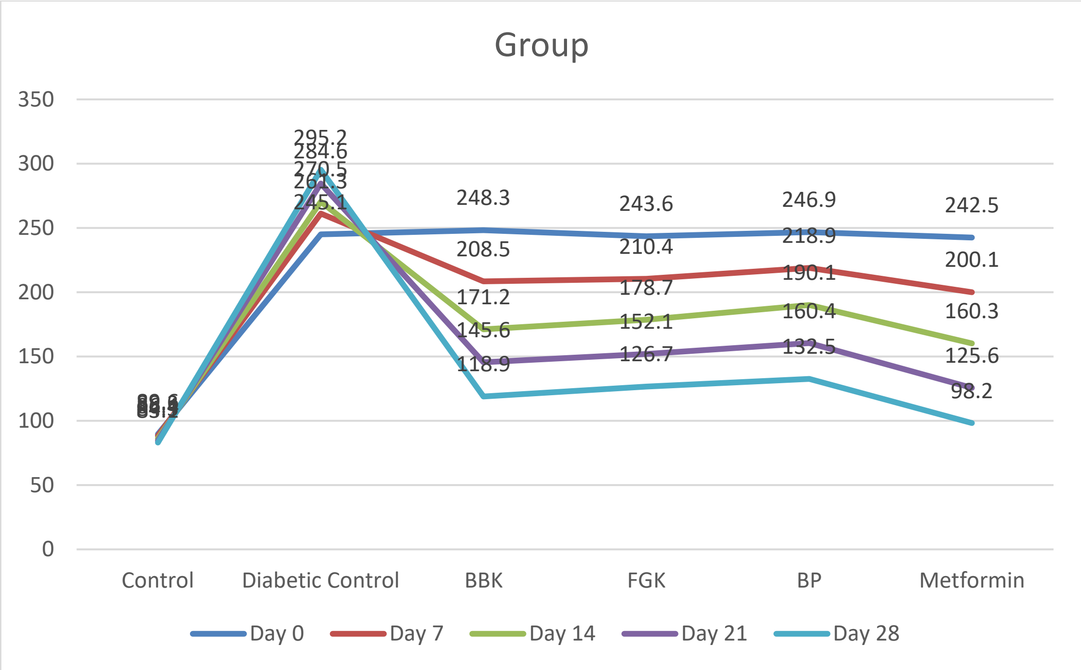

Figure 1: Line Graph Showing Fasting Blood Glucose Variation Over 28 Days

3. Oral Glucose Tolerance Test (OGTT):

Table 2: Blood Glucose Levels (mg/dL) During OGTT at Various Time Intervals

Group	0 min	30 min	60 min	90 min	120 min
Control	86.7 ± 2.4	115.6 ± 3.1	108.9 ± 2.8	98.1 ± 3.0	89.4 ± 2.5
Diabetic Control	255.2 ± 5.7	310.3 ± 6.8	350.1 ± 7.2	328.2 ± 6.5	300.4 ± 6.9
BBK	240.1 ± 4.8	282.7 ± 5.6	243.2 ± 4.7	190.3 ± 4.4	136.5 ± 4.0
FGK	243.7 ± 5.0	285.9 ± 5.9	248.6 ± 4.9	194.1 ± 4.6	139.3 ± 4.3
BP	248.5 ± 5.2	295.2 ± 6.1	260.4 ± 5.3	205.8 ± 5.0	149.2 ± 4.7
Metformin	239.4 ± 5.3	278.6 ± 5.7	230.8 ± 4.8	170.2 ± 4.5	118.3 ± 3.9

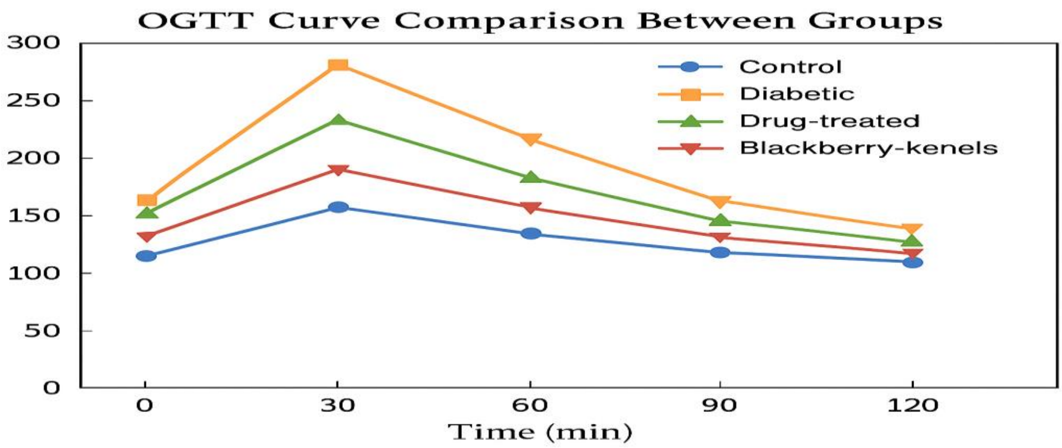

Figure 2: OGTT Curve Comparison Between Groups

4.Body Weight Analysis:

Table 3: Body Weight (grams) Change Over 28 Days

Group	Day 0	Day 7	Day 14	Day 21	Day 28
Control	180.2 ± 5.1	182.3 ± 4.8	185.6 ± 5.0	188.1 ± 4.6	190.5 ± 4.9
Diabetic Control	178.7 ± 4.7	171.2 ± 4.9	165.3 ± 5.0	160.1 ± 4.7	155.4 ± 5.1
BBK	176.4 ± 4.8	179.6 ± 4.6	182.3 ± 4.5	186.0 ± 4.3	189.7 ± 4.4
FGK	177.3 ± 4.5	180.2 ± 4.2	183.9 ± 4.4	187.4 ± 4.1	191.1 ± 4.2
BP	178.5 ± 4.7	181.8 ± 4.5	185.5 ± 4.6	189.2 ± 4.3	193.0 ± 4.5
Metformin	177.2 ± 4.6	180.6 ± 4.4	184.4 ± 4.2	188.5 ± 4.3	192.8 ± 4.6

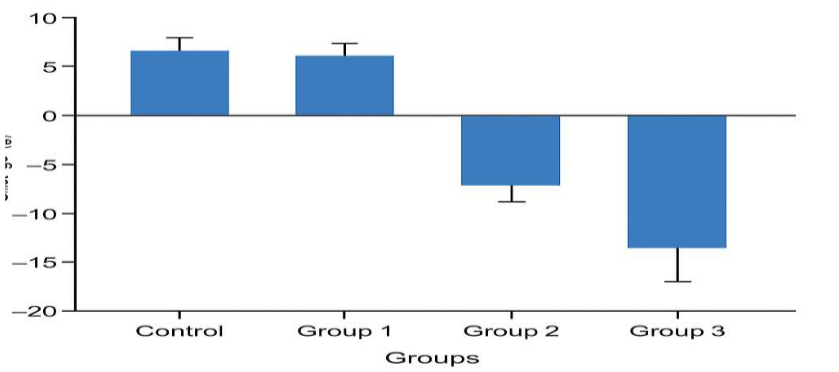

Figure 3: Bar Graph of Weight Changes in All Groups

5. Lipid Profile Analysis:

Table 4: Lipid Profile Parameters (mg/dL)

Group	Total Cholesterol	Triglycerides	HDL	LDL
Control	142.3 ± 4.5	101.2 ± 3.8	50.5 ± 2.1	68.9 ± 3.5
Diabetic Control	206.7 ± 5.1	172.3 ± 4.9	32.8 ± 1.9	128.4 ± 4.7
BBK	160.5 ± 4.3	129.2 ± 4.1	41.6 ± 2.3	84.2 ± 3.9
FGK	158.9 ± 4.4	125.6 ± 4.0	43.3 ± 2.2	80.1 ± 3.6
BP	162.7 ± 4.6	133.4 ± 4.2	39.9 ± 2.1	88.5 ± 4.1
Metformin	149.6 ± 4.1	117.8 ± 3.9	46.8 ± 2.4	72.5 ± 3.7

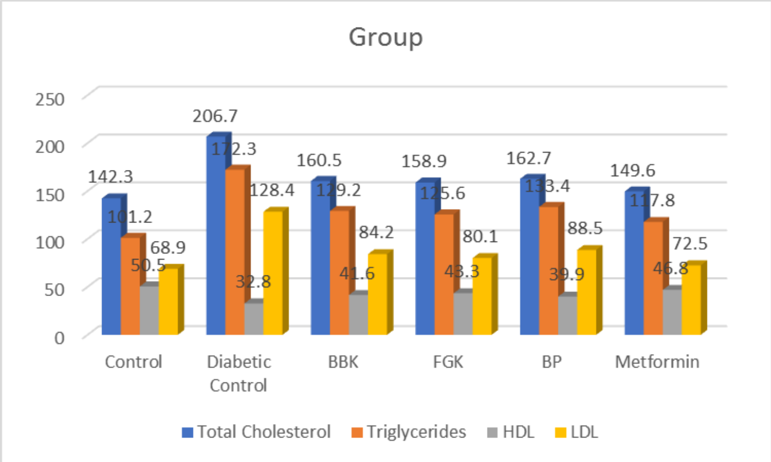

Figure 4: Grouped Bar Chart for Lipid Profile Comparison

6. Liver and Kidney Function Test:

Table 5: Liver and Renal Markers (U/L or mg/dL)

Group	ALT	AST	Creatinine	Urea	BUN
Control	31.2 ± 1.8	28.5 ± 1.7	0.7 ± 0.1	22.3 ± 1.6	14.7 ± 1.3
Diabetic Control	68.4 ± 2.9	62.1 ± 2.7	1.5 ± 0.2	39.2 ± 2.1	26.8 ± 1.9
BBK	41.8 ± 2.0	38.7 ± 1.8	0.9 ± 0.1	27.6 ± 1.5	18.2 ± 1.4
FGK	39.5 ± 1.9	36.4 ± 1.7	0.8 ± 0.1	25.3 ± 1.6	16.7 ± 1.2
BP	44.2 ± 2.1	40.3 ± 2.0	0.9 ± 0.1	28.9 ± 1.7	19.4 ± 1.3
Metformin	37.6 ± 1.8	33.9 ± 1.6	0.8 ± 0.1	24.1 ± 1.5	15.8 ± 1.2

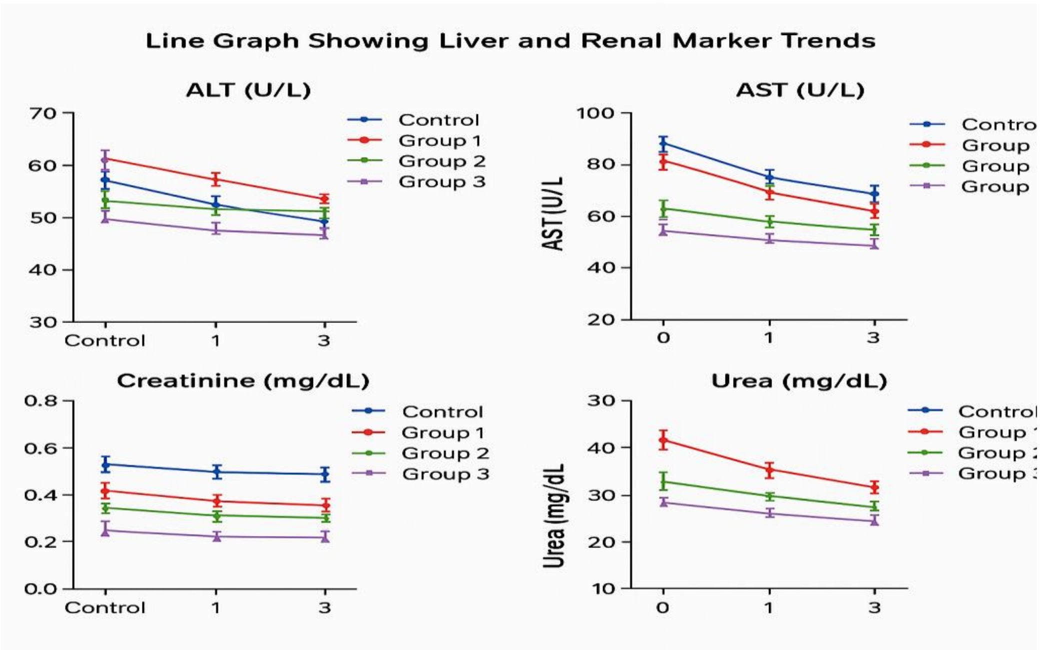

Figure 5: Line Graph Showing Liver and Renal Marker Trends

7. Antioxidant Biomarker Levels:

Table 6: Antioxidant Enzyme Levels in Liver and Pancreas

Group	SOD (U/mg)	CAT (U/mg)	GSH (µmol/g)	MDA (nmol/mg)
Control	9.1 ± 0.6	7.8 ± 0.4	6.2 ± 0.3	2.1 ± 0.2
Diabetic Control	4.3 ± 0.5	3.1 ± 0.3	2.9 ± 0.2	6.4 ± 0.4

BBK	7.3 ± 0.4	6.1 ± 0.3	5.1 ± 0.3	3.5 ± 0.3
FGK	7.5 ± 0.5	6.4 ± 0.4	5.3 ± 0.3	3.3 ± 0.2
BP	7.1 ± 0.4	6.0 ± 0.3	5.0 ± 0.3	3.6 ± 0.3
Metformin	8.2 ± 0.5	7.0 ± 0.4	5.8 ± 0.3	2.5 ± 0.2

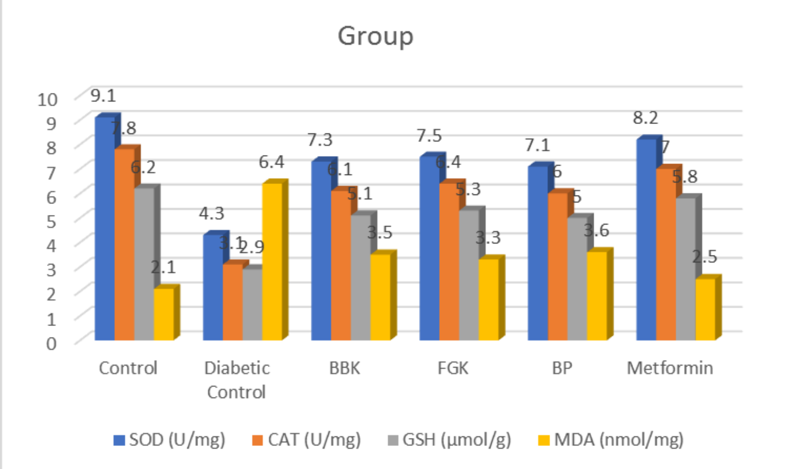

Figure 6: Bar Graphs of Antioxidant Enzyme Activity in Tissues

CONCLUSION:

The present investigation was able to illustrate the antidiabetic efficiency of blackberry kernels, fenugreek seeds and black pepper by a multidimensional in vivo survey of STZ-induced diabetic rat models. The results portrayed a significant decrease in fasting blood glucose values, improvement of glucose tolerance in OGTT and positive response of serum insulin values in the individual and combined extract treated groups that represents positive glycemic control. The extract mixture demonstrated the strongest hypoglycemic effect which indicates that there can be a synergistic relationship between the bioactive phytochemicals. The cardioprotective effect of these natural compounds was revealed by the marked improvement in lipid profile markers with decreased triglycerides, LDL and increased HDL. Also, liver and kidney biomarkers such as the ALT, AST, creatinine, and urea were maintained at their normal levels in dosed groups, which indicates the hepatoranality of the formulations. The antioxidant capacity of the extracts was also evidenced by oxidative stress biomarkers including the SOD, CAT, GSH and MDA that are relevant in preventing diabetes induced cellular destruction. These biochemical results were supported by histopathological examination, which showed severe repair of the pancreatic b-cell geometry, liver structure, and kidney tissue integrity in the administered groups. When combined with the standard antidiabetic treatment (Metformin), these findings confirmed the effectiveness of plant-derived interventions due to similar therapeutic effects and, in addition, metabolic and organ-protective properties. Further, the phytochemical screening also confirms the presence of flavonoids, alkaloids, and polyphenols further strengthening the mechanistic support of their therapeutic effect. To sum up, the investigation confirms the conventional application of these herbs and preconditions their usage in complementary and preventive management of diabetes by prescribing their further clinical trials and formulating.

REFERENCE:

1. Guo, X., Li, H., Xu, H., Woo, S., Dong, H., Lu, F., Lange, A. J., & Wu, C. (2012). Glycolysis in the control of blood glucose homeostasis. *Acta Pharmaceutica Sinica B, 2*(4), 358–367. https://doi.org/10.1016/j.apsb.2012.06.002
2. Fryirs, M., Barter, P. J., & Rye, K.-A. (2009). Cholesterol metabolism and pancreatic β-cell function. *Current Opinion in Lipidology, 20*(3), 159–164. https://doi.org/10.1097/MOL.0b013e32832ac180
3. Meerza, D., Naseem, I., & Ahmed, J. (2013). Pharmacology of signaling pathways: In type 2 diabetes. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews, 3*(3), 180–185. https://doi.org/10.1016/j.dsx.2013.06.006
4. World Health Organization. (2017, November 15). *Fact sheet: Diabetes*. Retrieved April 10, 2019, from http://www.who.int/newsroom/fact-sheet/detail/diabetes
5. DeFronzo, R. A., Triplitt, C. L., Abdul-Ghani, M., & Cersosimo, E. (2014). Novel agents for the treatment of type 2 diabetes. *Diabetes Spectrum, 27*(2), 100–112. https://doi.org/10.2337/diaspect.27.2.100
6. Gourgari, E., Wilhelm, E. E., Hassanzadeh, H., Aroda, V. R., & Shoulson, I. (2017). A comprehensive review of the FDA-approved labels of diabetes drugs: Indications, safety, and emerging cardiovascular safety data. *Journal of Diabetes and Its Complications, 31*(11), 1719–1727. https://doi.org/10.1016/j.jdiacomp.2017.08.005
7. Abo, K., Fred-Jaiyesimi, A., & Jaiyesimi, A. (2008). Ethnobotanical studies of medicinal plants used in the management of diabetes mellitus in South Western Nigeria. *Journal of Ethnopharmacology, 115*(1), 67–71. https://doi.org/10.1016/j.jep.2007.09.005
8. Bahmani, M., Zargaran, A., Rafieian-Kopaei, M., & Saki, K. (2014). Ethnobotanical study of medicinal plants used in the management of diabetes mellitus in the Urmia, Northwest Iran. *Asian Pacific Journal of Tropical Medicine, 7*(Supplement), S348–S354. https://doi.org/10.1016/S1995-7645(14)60257-1
9. Deutschländer, M., Lall, N., & Van De Venter, M. (2009). Plant species used in the treatment of diabetes by South African traditional healers: An inventory. *Pharmaceutical Biology, 47*(4), 348–365. https://doi.org/10.1080/13880200902752959
10. Grover, J., Yadav, S., & Vats, V. (2002). Medicinal plants of India with anti-diabetic potential. *Journal of Ethnopharmacology, 81*(1), 81–100. https://doi.org/10.1016/S0378-8741(02)00059-4
11. Li, W., Zheng, H., Bukuru, J., & De Kimpe, N. (2004). Natural medicines used in the traditional Chinese medical system for therapy of diabetes mellitus. *Journal of Ethnopharmacology, 92*(1), 1–21. https://doi.org/10.1016/j.jep.2003.12.031
12. Harlev, E., Nevo, E., Mirsky, N., & Ofir, R. (2013). Antidiabetic attributes of

desert and steppic plants: A review. *Planta Medica, 79*(5), 425–436. https://doi.org/10.1055/s-0032-1328331

13. Moradi, B., Abbaszadeh, S., Shahsavari, S., Alizadeh, M., & Beyranvand, F. (2018). The most useful medicinal herbs to treat diabetes. *Biomedical Research and Therapy, 5*(8), 2538–2551. https://doi.org/10.15419/bmrat.v5i8.463
14. Chen, J., Mangelinckx, S., Adams, A., Wang, Z.-t., Li, W.-l., & De Kimpe, N. (2015). Natural flavonoids as potential herbal medication for the treatment of diabetes mellitus and its complications. *Natural Product Communications, 10*(1), 187–200. https://doi.org/10.1177/1934578X1501000140
15. Gaikwad, S., Mohan, G. K., & Rani, M. S. (2014). Phytochemicals for diabetes management. *Pharmaceutical Crops, 5*, 11–28. https://doi.org/10.2174/2210290601405010011
16. Putta, S., Sastry Yarla, N., Kilari, E. K., Surekha, C., Aliev, G., Divakara, M. B., Santosh, M. S., Ramu, R., Zameer, F., & Prasad, M. (2016). Therapeutic potentials of triterpenes in diabetes and its associated complications. *Current Topics in Medicinal Chemistry, 16*(22), 2532–2542. https://doi.org/10.2174/1568026616666160414123343
17. Zheng, Y., Bai, L., Zhou, Y., Tong, R., Zeng, M., Shi, J., & Li, X. (2019). Polysaccharides from Chinese herbal medicine for anti-diabetes: Recent advances. *International Journal of Biological Macromolecules, 121*, 1240–1253. https://doi.org/10.1016/j.ijbiomac.2018.10.072
18. Embuscado, M. E. (2015). Spices and herbs: Natural sources of antioxidants – A mini review. *Journal of Functional Foods, 18*, 811–819. https://doi.org/10.1016/j.jff.2015.03.005
19. Iriti, M., Vitalini, S., Fico, G., & Faoro, F. (2010). Neuroprotective herbs and foods from different traditional medicines and diets. *Molecules, 15*(5), 3517–3555. https://doi.org/10.3390/molecules15053517
20. Jungbauer, A., & Medjakovic, S. (2012). Anti-inflammatory properties of culinary herbs and spices that ameliorate the effects of metabolic syndrome. *Maturitas, 71*(3), 227–239. https://doi.org/10.1016/j.maturitas.2011.12.009
21. Kaefer, C. M., & Milner, J. A. (2008). The role of herbs and spices in cancer prevention. *Journal of Nutritional Biochemistry, 19*(6), 347–361. https://doi.org/10.1016/j.jnutbio.2007.11.003
22. Tajkarimi, M., Ibrahim, S. A., & Cliver, D. (2010). Antimicrobial herb and spice compounds in food. *Food Control, 21*(9), 1199–1218. https://doi.org/10.1016/j.foodcont.2010.02.003
23. Tapsell, L. C., Hemphill, I., Cobiac, L., Sullivan, D. R., Fenech, M., Patch, C. S., Roodenrys, S., Keogh, J. B., Clifton, P. M., Williams, P. G., & others. (2006). Health benefits of herbs and spices: The past, the present, the future. *Medical Journal of Australia*. https://ro.uow.edu.au/hbspapers/28/