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EFFECT OF MORIN ON LIPIDPEROXIDES AND ANTIOXIDANTS IN STREPTOZOTOCIN-INDUCED DIABETIC RATS

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ABSTRACT

The present study investigated the antilipoperoixdative and antioxidant effect of morin in normal and streptozotocin-induced diabetic Wistar rats. Diabetes as induced in rats by an intraperitoneal injection of streptozotocin. Morin was orally administered to normal and diabetic rats for a period of 45 days. In diabetic rats, thiobarbituric acid reactive substances and lipid hydroperoxides were significantly increased, whereas enzymic antioxidants like superoxide dismutase, catalase, glutathione peroxidase and non-enzymic antioxidants (glutathione, vitamin C and vitamin E) were decreased significantly in diabetic rats. Oral administration of morin to diabetic rats significantly decreased the levels of thiobarbituric acid reactive substances and lipid hydroperoxides and increased the levels/activities of enzymatic and non-enzymatic antioxidants. Treatment of normal rats with morin did not significantly alter any of the parameters studied. Thus, morin exhibits free radical scavenging and antioxidant properties in streptozotocin-induced diabetic rats.

KEY WORDS: Morin, Streptozotocin, Lipidperoxides, Antioxidants, Diabetes, Free Rdaicals.

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INTRODUCTION

Diabetes mellitus is an endocrine disorder, characterized by altered glucose homeostasis leading to derangements in the carbohydrate, protein and lipid metabolism, resulting from partial or complete deficiency of insulin synthesis or due to peripheral resistance to insulin action[1]. The prevalence of diabetes is strongly associated with a sedentary lifestyle, high calorie nutrition and obesity. Elevated blood glucose level is a common result of uncontrolled diabetes, if untreated, can damage the organs like heart, eyes, kidneys and nerves, mainly through deteriorating blood vessels supplying the organs.

Streptozotocin (STZ) is often used to induce diabetes mellitus in experimental animals through its toxic effects on pancreatic β-cells. STZ-induced diabetes mellitus is associated with the generation of reactive oxygen species causing oxidative damage[2]. The effects of STZ on glucose as well as insulin homeostasis reflect the toxin-induced abnormalities in β̃-cell function. STZ is selectively accumulated in pancreatic beta cells via the low-affinity GLUT2 glucose transporter in the plasma membrane. The greater toxicity of STZ compared with N-methyl-N-nitrosourea in cells that express GLUT2, even though both substances alkylate DNA to a similar extent[3]. STZ-administration also damages other organs expressing this transporter, particularly kidney and liver.

Under physiological conditions, a wide range of antioxidant defences protects against the adverse effects of free radical production *in vivo*[4]. ROS are generated during cell aerobic respiration. Under normal physiological conditions, the redox state is tightly controlled by antioxidants. However, increased production of ROS can overwhelm the antioxidant defenses, leading to an imbalance and imposing oxidative stress on the physiological systems. The oxidative damage caused by ROS on lipids, proteins and nucleic acids may trigger various chronic disease[5]. During the last 20 years, flavonoids have gained much attention due to their beneficial health potential and to a large part due to their antioxidant activity. Because of their antioxidant character, resulting from different conjugation and varying number of hydroxyl groups, flavonoids and phenolic acids are able to act as reducing agents, hydrogen of electron-donating species and as ROS scavengers[6]. Flavonoids represent the most common and widely distributed group of plant phenolics and are abundant in foods. Much interest has grown in the role and usage of natural antioxidants as a means to prevent oxidative damage in diabetes with high oxidative stress.

Morin (2',3,4',5,7-pentahydroxyflavone), (Fig. 1) a pigment found in yellow Brazil wood[7], is predominantly present as glycosides and distributed in fruit e.g. mulberry and herbs[8]. Morin has been reported to prevent coronary artery diseases[9], inhibit tumor proliferation[10] and protect human erythrocytes, ventricular myocytes, and saphenous vein endothelial cells[11], prevent LDL-oxidation[7], as well as scavenge free radicals[12,13]. It was reported that morin also act as an antioxidant that protects various human cells, like myocytes, endothelial cells, hepatocytes and erythrocytes, against oxidative damages[14]. Phenolic phytochemicals due to their phenolic ring and hydroxyl substituents can function as effective antioxidants due to their ability to quench free radicals. It is therefore believed that dietary phenolic antioxidants can scavenge harmful free radicals and thus inhibit their oxidative reactions with vital biological molecules and prevent development of many pathophysiological conditions. The present study was designed to evaluate the role of morin on lipid peroxidation and antioxidant status in the diabetic rat plasma, liver, and kidney.

MATERIALS AND METHODS

Drugs and Chemicals

Streptozotocin was purchased from Sigma Chemical Co., St. Louis, MO, USA. Carboxy methyl cellulose (CMC) sodium salt, butylated hydroxyl toluene, nitroblue tetrazolium, phenazine methosulphate and glutathione were obtained from S.D. Fine Chemicals, Mumbai, India. Morin was purchased from Hi-media Laboratories Pvt, Ltd, Mumbai. Blood glucose and insulin kits were purchased from Agappe diagnostics, Kerala, India. All other chemicals used in the study were of analytical grade.

Animals

Male albino Wistar rats (150-200g) obtained from the Venkateswara Enterprises, Bangalore were used in this study. The animals were housed in polypropylene cages (47x34x18 cm) lined with husk. It was renewed every 24 hour. The animals were fed on a standard pellet diet (Sri Durga Seeds and Foods, Bangalore, India) and water ad libitum . The standard pellet diet comprised 21% protein, 5% lipids, 4% crude fibre, 8% ash, 1% calcium, 0.6% phosphorus, 3.4% glucose, 2% vitamin and 55% nitrogen free extract (carbohydrates). It provides metabolisable energy of 3, 600 kcal. The experimental animals were maintained in a controlled environment (12:12 h light/dark cycle) and temperature (30 $\pm$ 2°C). All the experiments were carried out according to the guidelines of the committee for the purpose of control and supervision of experiments on Animals (CPCSEA), New Delhi, India and approved by the Animal Ethical Committee of Vinayaka Missions University.

Induction of Experimental Diabetes

Streptozotocin was freshly dissolved in citrate buffer (0.01 M, pH 4.5) and overnight fasted rats were intraperitoneally injected with STZ (50 mg/kg).

Experimental Design

In this experiment a total of 24 rats divided in to 4 groups of 6 rats each. Morin was dissolved in carboxy methyl cellulose (CMC) at doses of 50 mg/kg and 100 mg/kg respectively given to rats orally for a period of 45 days[15].

Group 1: Normal control rats
Group 2: Normal rats + Morin 100 mg/kg
Group 3: STZ induced Diabetic rats (50 mg/kg)
Group 4: Diabetic rats + Morin 100 mg/kg

After 45 days of treatment period the fasted rats were sacrificed by cervical decapitation and the blood was collected using potassium oxalate and sodium fluoride as anticoagulant for plasma separation. The liver and kidney were weighted and 10% tissue homogenate was prepared with 0.025 M, Tris–Hcl buffer pH 7.5. After centrifugation at 2,000 rpm for 10 min, the clear supernatant was used for the analysis of various biochemical parameters.

Biochemical Analysis

Plasma thiobarbituric acid reactive substances (TBARS) were estimated by the method of Yagi (1987)[16]. TBARS were quantitated by their reactivity with thiobarbituric acid (TBA) in acidic conditions to generate a pink coloured chromophore, which was read at 530 nm. TBARS in the heart was estimated by the method of Fraga et al. (1988)[17]. In this method, malondialdehyde and other TBARS

were measured by their reactivity with TBA in acidic conditions to generate a pink coloured chromophore, which was read at 535 nm. Estimation of plasma and cardiac tissue lipid hydroperoxides (HP) was done by the method of Jiang et al. (1992)[18]. In this method, oxidation of ferrous ion (Fe^{2+}) under acidic conditions in the presence of xylenol orange led to the formation of a chromophore, which was read at 560 nm. Superoxide dismutase (SOD) activity in the myocardium was assayed by the method of Kakkar et al. (1984)[19]. Superoxide radicals react with nitroblue tetrazolium in the presence of reduced nicotinamide adenine dinucleotide and produce formazon blue. SOD removes the superoxide radicals and inhibits the formation of formazon blue. The intensity of the colour is inversely proportional to the activity of the enzyme and read at 560 nm. The activity of catalase in myocardium was assayed by the method of Sinha (1972)[20]. In this method, dichromate in acetic acid is converted to perchromic acid and then to chromic acetate when heated in the presence of hydrogen peroxide. The chromic acetate formed was measured at 620 nm. Estimation of GSH in plasma and the heart tissue was done by the method of Ellman (1959)[21]. This method is based on the development of yellow colour, when dithionitro benzoic acid is added to compounds containing sulfhydryl groups. The colour developed was read at 412 nm. GPx activity was assayed by the method of Rotruck et al. (1973)[22]. A known amount of enzyme preparation was allowed to react with hydrogen peroxide and GSH for a specified time period. The GSH content remaining after the reaction was measured by Ellman's reaction. The activity of GST was assayed in the cardiac tissue following the increase in the absorbance at 340 nm using 1-chloro-2,4-dinitro benzene as substrate by the method of Habig and Jakoby (1981)[23].

Vitamin C in plasma and the heart tissue was estimated by the method of Omaye et al. (1979)[24]. The ascorbic acid is converted into dehydroascorbic acid in the presence of thiourea, a mild reducing agent and then coupled with 2,4-dinitrophenyl hydrazine (DNPH). The coupled DNPH is converted into a red coloured complex when treated with sulphuric acid, which was read at 530 nm. The levels of Vitamin E in plasma and the concentration in cardiac tissue were estimated by the method of Baker et al. (1980)[25]. This method involves the reduction of ferric ion to ferrous ion by α–tocopherol and the formation of red coloured complex with 2,2-dipyridyl. The absorbance of the chromophore was measured at 520 nm. Protein in the enzyme extract was determined by the method of Lowry et al. (1951)[26]. The CO–NH group (peptide bond) present in the protein molecule reacts with copper sulphate in alkaline medium to give a blue colour, which was read at 620 nm.

Statistical Analysis

Statistical analysis was done by one-way analysis of variance (ANOVA) followed by Duncan's multiple range test (DMRT). Using SPSS software package, version 9.05 p values <0.05 were considered as significant.

RESULTS

Tables 1 and 2 depict the effect of morin on the levels of thiobarbituric acid reactive substances (TBARS) and hydroperoxides (HP) in plasma and tissues (liver and kidney) of normal and STZ-induced diabetic rats. Diabetic control rats showed a significant increase in the levels of TBARS and HP in plasma and tissues (liver and kidney). Rats treated with morin significantly decreased the levels of TBARS and HP in plasma and tissues in STZ-induced diabetic rats. The effect of morin on the activities of superoxide dismutase (SOD), catalase, glutathione peroxidase (GPx) and glutathione S-transferase (GST) in liver and kidney of normal and STZ-induced diabetic rats are revealed in Tables 3 and 4. Diabetic control rats showed significant decrease in the activities of theses antioxidant enzymes in liver and kidney. Morin treated diabetic rats

significantly increased the activities of SOD, catalase, GPx and GST in liver and kidney in STZ-induced diabetic rats. The effect of Morin on the levels of reduced glutathione (GSH), vitamin C and E in plasma, liver and kidney in normal and STZ-induced diabetic rats are shown in Tables 5, 6 and 7. Rats induced with STZ, showed significant decrease in the levels of GSH, vitamin C and vitamin E in plasma, liver and kidney. Morin treated rats significantly increased the levels of GSH, vitamin C and vitamin E plasma, liver and kidney levels in STZ-induced diabetic rats. In all the parameters studied, oral administration of Morin (100 mg/kg) to normal rats for a period of 45 days showed minor effects but none was statistically significant.

Table 1

Effect of morin on the levels of thiobarbituric acid reactive substances (TBARS) in plasma and tissues (liver and kidney) in normal and streptozotocin (STZ)-induced diabetic rats.

Groups	Plasma TBARS (nmol/ml)	TBARS (mM/100g tissue)	
		Liver	Kidney
Normal control rats	2.56 ± 0.10[a]	0.87 ± 0.05[a]	1.57 ± 0.12[a]
Normal + Morin 100 mg/kg	2.54 ± 0.09[a]	0.87 ± 0.05[a]	2.51 ± 0.12[b]
Diabetic control rats (50 mg/kg)	4.86 ± 0.21[b]	2.72 ± 0.23[b]	4.17 ± 0.22[b]
Diabetic + Morin 100 mg/kg	2.70 ± 0.17[c]	1.12 ± 0.09[c]	1.98 ± 0.15[c]

Each value is mean ± S.D. for six rats in each group.
Values not sharing a common superscript (a-c) differ significantly with each other (P<0.05, DMRT).

Table 2

Effect of morin on the levels of lipid hydroperoxide (HP) in plasma and tissues in normal and streptozotocin (STZ)- induced diabetic rats.

Groups	Plasma Hydroperoxides (mM/dL)	Lipid hydroperoxide (mM/100g tissue)	
		Liver	Kidney
Normal control rats	6.51 ± 0.41[a]	69.4 ± 5.8[a]	62.7 ± 4.1[a]
Normal + Morin 100 mg/kg	6.70 ± 0.48[a]	69.5 ± 5.8[a]	61.4 ± 5.7[a]
Diabetic control rats (50 mg/kg)	14.5 ± 1.02[b]	132.4 ± 9.5[b]	127.6 ± 10.0[b]
Diabetic + Morin 100 mg/kg	8.1 ± 0.77[c]	81.4 ± 5.7[c]	73.4 ± 5.4[c]

Each value is mean ± S.D. for six rats in each group.
Values not sharing a common superscript (a-c) differ significantly with each other (P<0.05, DMRT).

Table 3

Effect of morin on the activities of superoxide dismutase (SOD) and catalase in liver and kidney in normal and streptozotocin (STZ)-induced diabetic rats.

Groups	SOD (Units[a] / mg protein)		Catalase (Units[b] / mg protein)	
	Liver	Kidney	Liver	Kidney
Normal control rats	9.02 ± 0.6[a]	15.4 ± 0.8[a]	107.8 ± 6.1[a]	50.4 ± 4.2[a]
Normal + Morin 100 mg/kg	9.05 ± 0.5[a]	15.7 ± 0.4[a]	107.4 ± 7.4[a]	50.2 ± 3.9[a]
Diabetic control rats (50 mg/kg)	3.82 ± 0.2[b]	8.1 ± 0.7[b]	55.1 ± 3.5[b]	31.8 ± 1.8[b]
Diabetic + Morin 100 mg/kg	7.96 ± 0.6[c]	13.8 ± 0.7[c]	95.2 ± 7.5[c]	45.3 ± 3.7[c]

U[a] – Enzyme concentration required to inhibit the chromogen produced by 50% in one minute.
U[b] – μmol of hydrogen peroxide consumed per minute.
Each value is mean ± S.D. for six rats in each group. Values not sharing a common superscript (a-c) differ significantly with each other (P<0.05, DMRT).

Table 4

Effect of morin on the activities of glutathione peroxidase (GPx) and glutathione-S-transferase (GST) in liver and kidney in normal and streptozotocin (STZ)-induced diabetic rats.

Groups	GPx (Units[a] /min/mg protein)		GST (Units [b]/min/mg protein)	
	Liver	Kidney	Liver	Kidney
Normal control rats	10.2 ± 0.42[a]	12.8 ± 0.72[a]	68.4 ± 4.7[a]	32.8 ± 2.8[a]
Normal + Morin 100 mg/kg	10.5 ± 0.54[a]	12.5 ± 0.63[a]	68.7 ± 6.2[a]	33.1 ± 2.3[a]
Diabetic control rats (50 mg/kg)	5.2 ± 0.31[b]	4.82 ± 0.30[b]	45.4 ± 3.2[b]	20.4 ± 1.8[b]
Diabetic + Morin 100 mg/kg	9.1 ± 0.47[c]	10.92 ± 0.75[c]	62.6 ± 4.1[c]	28.6 ± 2.1[c]

U^a - μg glutathione consumed. U^b - nmoles of CDNB conjugated.
Each value is mean ± S.D. for six rats in each group.
Values not sharing a common superscript (a-c) differ significantly with each other (P<0.05, DMRT).

Table 5

Effect of morin on the levels of reduced glutathione (GSH) in plasma, liver and kidney in normal and streptozotocin (STZ)-induced diabetic rats.

Groups	Plasma GSH (mg/dL)	GSH (mg/100g tissue)	
		Liver	Kidney
Normal control rats	22.2 ± 1.8[a]	50.3 ± 3.6[a]	32.4 ± 2.4[a]
Normal + Morin 100 mg/kg	22.8 ± 1.5[a]	50.4 ± 3.6[a]	31.2 ± 2.0[a]
Diabetic control rats (50 mg/kg)	15.6 ± 1.0[b]	23.8 ± 1.7[b]	18.7 ± 1.2[b]
Diabetic + Morin 100 mg/kg	20.1 ± 1.5[c]	45.5 ± 3.0[c]	27.8 ± 2.2[c]

Each value is mean ± S.D. for six rats in each group.
Values not sharing a common superscript (a-c) differ significantly with each other (P<0.05, DMRT).

Table 6

Effect of morin on the levels of vitamin C in plasma, liver and kidney in normal and streptozotocin (STZ)-induced diabetic rats.

Groups	Vitamin C		
	Plasma(mg/dL)	Liver (μmol/mg tissue)	Kidney (μmol/mg tissue)
Normal control rats	0.98 ± 0.004[a]	1.55 ± 0.05[a]	1.39 ± 0.03[a]
Normal + Morin 100 mg/kg	1.05 ± 0.005[a]	1.54 ± 0.04[a]	1.42 ± 0.05[a]
Diabetic control rats (50 mg/kg)	0.39 ± 0.003[b]	0.83 ± 0.06[b]	0.62 ± 0.03[b]
Diabetic + Morin 100 mg/kg	0.85 ± 0.005[c]	1.39 ± 0.04[c]	1.23 ± 0.05[c]

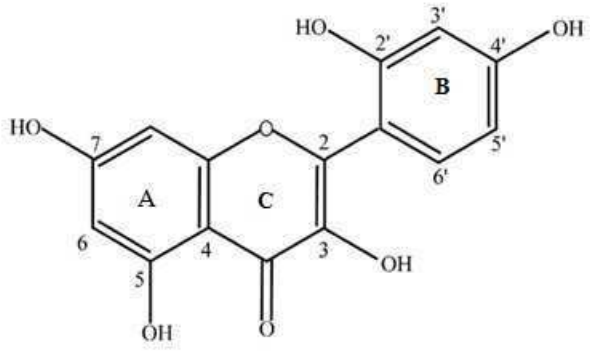
Each value is mean ± S.D. for six rats in each group.
Values not sharing a common superscript (a-c) differ significantly with each other (P<0.05, DMRT).

Table 7
Effect of morin on the levels of vitamin E in plasma, liver and kidney in normal and streptozotocin (STZ)-induced diabetic rats.

Groups	Vitamin E		
	Plasma(mg/dL)	Liver (μmol/mg tissue)	Kidney (μmol/mg tissue)
Normal control rats	0.060 ± 0.007^{a}	0.82 ± 0.04^{a}	0.71 ± 0.05^{a}
Normal + Morin 100 mg/kg	0.062 ± 0.008^{a}	0.83 ± 0.03^{a}	0.73 ± 0.04^{a}
Diabetic control rats (50 mg/kg)	0.028 ± 0.005^{b}	0.39 ± 0.03^{b}	0.30 ± 0.02^{b}
Diabetic + Morin 100 mg/kg	0.054 ± 0.006^{c}	0.70 ± 0.06^{c}	0.62 ± 0.05^{c}

Each value is mean ± S.D. for six rats in each group.
Values not sharing a common superscript (a-c) differ significantly with each other (P<0.05, DMRT).

Figure 1
Structure of Morin



DISCUSSION

Streptozotocin-induced diabetes provides a relevant example of endogenous chronic oxidative stress due to the resulting hyperglycemia[27]. An increase in the lipid peroxidative products such as TBARS and HP were observed in serum, liver and kidney of STZ-induced diabetic rats in this study. Diabetic rats' exhibit high oxidative stress due to extended and chronic hyperglycemia thereby depletes the antioxidative system and thus promotes the free radicals generation[28]. Hypoinsulinaemia occurs during diabetes increases the activity of fatty acyl coenzyme A oxidase, which initiates β-oxidation of fatty acids, resulting in lipid peroxidation. Treatment with Morin to diabetic rats significantly decreased the concentration of lipid peroxidative products such as TBARS and HP in serum, liver and kidney. This could be attributed to diminish in hyperglycemia and the antioxidant effect of Morin . It has been already reported that, administration of flavonoids to rats' significantly decreased the levels of lipoperoxidative products in STZ-induced diabetic conditions.

Antioxidants are chemical compounds that bind to free radicals and thus prevent them from damaging normal healthy cells. Antioxidants can be divided into enzymatic and non-enzymatic subtypes. Several

antioxidant enzymes are produced by the body, with the three major classes being catalase, the glutathione peroxidases (GPx), and superoxide dismutases (SOD). Non-enzymatic antioxidants include the innate compound glutathione (GSH) and antioxidant vitamins obtained through the diet, such as α-tocopherol (vitamin E), ascorbic acid (vitamin C), and ceruloplasmin[29]. SOD converts the superoxide anion radicals produced in the body to hydrogen peroxide, thereby reducing the likelihood of superoxide anion interacting with nitric oxide to form reactive peroxynitrite. Catalase catalyzes the conversion of hydrogen peroxide within the cell to harmless products, thereby curtailing the quantity of cellular destruction inflicted by lipid peroxidation byproducts. Diminished activities of SOD and catalase in diabetic tissues might be linked to increased oxidative stress in diabetes accompanied by hyperglycemia[3].

Oxidative stress is the imbalance between production and removal of ROS. Increased oxidative stress, which contributes substantially to the pathogenesis of diabetic complications, is the consequences of either enhanced ROS production or attenuated ROS scavenging capacity. Several reports have shown the alterations in the anti-oxidant enzymes during diabetic condition[30]. GSH is involved in the maintenance of the normal cell structure and function, probably through its redox and detoxification reactions[31]. The decreased concentration of GSH in liver and kidney could be due to NADPH depletion or GSH consumption in the removal of peroxides. Decreased GSH levels might be due to increased utilization in protecting 'SH' containing proteins from lipid peroxides. The unavailability of GSH may decrease the activities of GPx and GST in oxidative stress conditions.

Administration of Morin to diabetic rats increased the activities of SOD, CAT and GSH and may help to control free radical, as Morin offered protection to cells against oxidative stress by scavenging free radicals generated during diabetic condition. The increased activities of anti-oxidant enzymes may act as an added compensation machinery to preserve the cell integrity and defense against free radical damage. Flavonoids play an important role in regulating the antioxidative capacity by increasing SOD, catalase and GPx activities by up regulating their mRNA expression in oxidative stress conditions[32]. Elevation of glucose concentration reduces the activity of GPx, leading to an accumulation of H_2O_2. Hydrogen peroxide catabolism leads to the formation of the superoxide anion. GPx and GRD are found in the cytoplasm, mitochondria, and nucleus. GPx metabolizes the conversion of hydrogen peroxide to water using reduced glutathione as a hydrogen donor. Glutathione disulfide is recycled back to glutathione by GRD using the cofactor called NADPH, which is generated by glucose 6- phosphate dehydrogenase. GPx serve to detoxify peroxides by reacting them with GSH. Diminished GPx activity in diabetic tissues might be due to low GSH content, since GSH is a substrate and cofactor of these enzymes. Vitamins A, C, and E are diet-derived and detoxify free radicals directly. α-tocopherol is reconstituted, when ascorbic acid recycles the tocopherol radical; dihydroascorbic acid, which is generated, is recycled by glutathione. Vitamin E, a component of the total peroxyl radical-trapping antioxidant system, reacts directly with peroxyl and superoxide radicals and singlet oxygen and protects membranes from lipid peroxidation.

Vitamin C acts as a co-antioxidant by regenerating the vitamin A, E and GSH from radicals[33]. Vitamin E is a fat soluble vitamin; regeneration of vitamin E requires ascorbic acid, an aqueous phase antioxidant, which requires GSH[34]. A decreased level of vitamin C and E in liver, kidney and serum of diabetic rats reported in the present study could be due to its increased utilization and deactivation of ROS. Oral administration of Morin improved the level of vitamin C and E levels in serum, liver and kidney of STZ-induced diabetic rats. This could be due to free scavenging and antioxidant properties of

Morin. Structure-activity of flavonoids on inhibition of lipid peroxidation explained their mechanism of action being based on their structure. The presence of the hydroxyl group at C-3 position of the skeletons of Morin has been shown to be responsible for the potent inhibitory action on lipid peroxidation[35-38]. When the double bond between the carbons 2 and 3 of the C ring is hydrogenated, antiperoxidative potential decreases[40,41]. The carbonyl group is essential for the antiperoxidant activity[36,40]. The number of hydroxyl groups in the rings A and B of flavonoids has been shown to be important in the protection against free radicals. It has been shown that the more hydroxyl groups are substituted in the B-ring. The hydroxyl groups at the C-5 and C-7 positions of the A-ring and C-4' of the B-ring and C-3 of the C-ring seem to contribute to the antioxidant action[41]. The flavonoids that have hydroxyl groups at C-2' position, such as Morin, have shown antiperoxidative properties[40]. The hydroxyl groups at the C-3 and C-5 of the flavonoid skeleton, like in quercetin and Morin, can form chelators for iron ions. The ability of flavonoids to kidnap metallic ions contributes to their antiperoxidatives properties, preventing the formation of free radicals[35,37]. These structural components present in Morin, could be responsible for its antilipoperoxidative, antioxidative and metal chelating properties. All these properties may responsible for the elevation of both enzymatic and non-enzymatic antioxidants in STZ-induced diabetic rats. Hence, administration of Morin to diabetic rats posses free radical scavenging and antioxidant properties.

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