Effect of Nutrition with Turmeric, Curcumin and Tetrahydrocurcumin on Diabetic Rats

El-Bana*, M. E.; Abd El-Galeel, M. A. and Badiaa** A. Bessar.**
* Food Tech. Res. Institute, Agric. Res. Center, Giza, Egypt.
** Food Sci. and Tech. Dept., Fac. of Agric., Kafrelsheihk Univ. Egypt.

Abstract

This investigation was carried out to study the hypoglycemic and antihyperlipidemic effects of turmeric, curcumin (the most active component of turmeric) and tetrahydrocurcumin (one of the active metabolites of curcumin) on streptozotocin induced diabetic rats. Chemical composition of turmeric was determined. Turmeric, curcumin and tetrahydrocurcumin (THC) at levels of 50 and 100 mg/kg body weight were orally administered to diabetic rats for six weeks. Blood glucose, plasma insulin, body weight gain and food efficiency ratio (FER) of rats were determined. Also, total cholesterol, high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C), triglycerides and phospholipids content were determined in the serum and liver of the rats. As well as the activities of serum aspartate transaminase (AST) and alanine transaminase (ALT) were determined. The results indicated that turmeric, curcumin and THC led to a significant reduction in blood glucose but a significant increase in both body weight gain, food efficiency ratio and plasma insulin occured of diabetic rats. In addition, total cholesterol, LDL-C, triglycerides and phospholipids in plasma decreased while HDL-C increased after administration of turmeric, curcumin and THC. These ingredients also caused a significant reduction in liver lipids (cholesterol, triglycerides and phospholipids) and suggesting its antihyperlipidemic effect. The activities of hepatic markers were significantly elevated in diabetic rats as compared to control rats. THC appeared to have a better protective effect on studied parameters followed by curcumin. The higher level (100mg/kg body wt) of those substrates have a more effect.

Introduction

Turmeric is the rhizome of (*Curcuma longa L.*), belonging to the family: *Zingiberaceae*. It is a perennial herb widely cultivated in tropical regions of Asia and central America. Turmeric has been used as a coloring and flavoring agents and spice in many foods (Kermanshahi and Riasi, 2006). The use of turmeric became more popular when it was found to act as

atherapeutic agent for various illnesses. In the Ayurvedic system of medicine, turmeric is used as a tonic and blood purifier (Joe *et al.*, 2004). Turmeric has been used in coughs, fever, liver and urinary diseases, wounds, inflammatory troubles of the joints, eczema, parasitic skin diseases and cold (Kapoor, 1990). The rhizome has also been recommended for anemia, hypolipidemic, anticancer and hypoglycemic (Bakhru, 1997).

Curcumin (diferuloylmethane) is the substance that gives the spice turmeric, which is extensively used in Indian as a component of curry powder, its yellow color. It is believed that curcumin is a potent antioxidant and anti-inflammatory agent. Practitioners of traditional Indian medicine believe that curcumin powder is beneficial against many diseases, including biliary disorders, anorexia, coughs, diabetes, hepatic disorders, rheumatism, sinusitis, cancer and Alzheimer's disease (Aggarwal *et al.*, 2003). Curcumin has been shown to reduce hyperlipidemia (Babu and Srinivasan, 1997) and reduce the cross-linking of collagen in a streptozotocin (STZ) treated diabetic animal model (Sajithlal *et al.*, 1998). Curcumin has been shown to lower blood glucose levels in type 2 diabetic KK-AY mice (Nishiyama *et al.*, 2005). The use of curcumin is recommended for the prevention of advanced glycated products accumulation, and the associated complications of diabetes (Sajithlal *et al.*, 1998).

Tetrahydrocurcumin (THC) is one of the major metabolites of curcumin with potential bioactivity. This metabolite was identified in intestinal and hepatic cytosol from humans and rats (Naito *et al.*, 2002). Recently, attention has focused on THC as one of the major metabolites of curcumin, because it appears to exert greater antioxidant activity both in vitro and vivo systems (Okada *et al.*, 2001 and Pari and Murugan 2004). Sugiyama *et al.*, (1996) demonstrated that THC exhibit similar physiological and pharmacological properties as the active form of curcumin in vivo. Naito *et al.*, (2002) showed clear involvement of THC in biochemical and molecular actions at the cellular level in ameliorating oxidative stress in cholesterol-fed rabbitsSeveral studies in experimental animals indicated that THC prevent cancer (Lin and Lin-Shiau 2001), as well as a protective agent against inflammation (Nakamura 1998, Hong *et al.*, 2004), atherosclerotic lesions (Naito *et al.*, 2002) and antidiabetic (Pari and Murugan 2005).

Changes in the concentrations of lipids including cholesterol, triglycerides are complications frequently observed with diabetes mellitus and certainly contribute to development of vascular disease (Murugan and Pari, 2006). Liver is an insulin-dependent tissue that plays a pivotal role in glucose and lipid homeostasis and is severely affected during diabetes. Liver participates in the uptake, oxidation, and metabolic conversion of free fatty

acids, as well as the synthesis of cholesterol , phospholipids and triglycerides. Decreased glycolysis, impeded glycogenesis, and increased gluconeogenesis are some of the changes of glucose metabolism in diabetic liver. There are many compositional abnormalities of lipoproteins: very low density lipoprotein (VLDL), low density lipoprotein (LDL), and high density lipoprotein (HDL) have been found in diabetic patients. These alterations may be relevant in explaining, at least in part, the increased predisposition of diabetes to atherosclerosis (Murugan and Pari, 2007).

There is an increasing demand by patients to use the natural products with antidiabetic activity, because insulin and oral hypoglycaemic drugs are having undesirable side effects. The plants with antidiabetic activities provide useful sources for the development of drugs in the treatment of diabetes mellitus (Kameswara Rao and Appa Rao, 2001). The present work was carried out to study the effect of nutrition with turmeric, curcumin and tetrahydrocurcumin on blood glucose and lipids of serum and liver in streptozotocin induced diabetic rats.

Materials and Methods

1- Materials

1.1- Drugs and chemicals:

Turmeric (*Curcuma longa L.*) powder was obtained from the local perfumer market at Kafr El-Sheikh, Egypt. Curcumin, tetrahydrocurcumin and other chemicals and bio-chemicals (analytical grade) were purchased from Sigma Chemical Co.(St. Louis, Mo, USA).

1.2- Animals:

Adult male albino rats of the waister strain weighing 120-130 gms were obtained from experimental house of Veterinary Medicine Faculty – Cairo University – Egypt.

2- Methods

2.1- Chemical analysis:

Moisture, crude protein, ether extract, ash and essential oils were determined according to A.O.A.C. (1990). Total carbohydrates content was calculated by difference.

2.2- Expermentai animals:

Animals were housed individually in stainless steel cages and maintained at 24 ± 2^{0}C and 12 hr light : dark cycle. Rats were fed on basal diet

and water ad libitum. Basal diet containing casein 21%, cane sugar 10%, corn starch 54%, corn oil 10%, vitamin mixture 1% and salt mixture 4% as reported by Babu and Srinivasan, (1997).

2.3- Induction of rats:

Experimental rats were induced by a single intraperitoneal injection of streptozotocin to animals fasted overnight at a dose of 60 mg/kg body weight (1ml fresh solution in 0.1M citrate buffer, pH 4.5) and control rats were injected with the citrate buffer alone. The rats had free access to basal diet and water (Babu and Srinivasan 1997). After one week, diabetic rats with blood glucose concentration more than 200 mg/dl were selected for the study. The normal blood glucose level of rats ranged from 50 to135 mg/dl (Arun and Nalini, 2002)

2.4- Experimental Design:

Forty eight male albino rats were divided randomly into eight groups of six rats each (n = 6) after the induction of streptozotocin diabetes according to the following scheme:

Group1: normal control (untreated rats).
Group2: diabetic control rats.
Group3: Diabetic rats given turmeric 50mg/kg body weight in aqueous suspension daily using intragastric tube for six weeks.
Group4: Diabetic rats given turmeric 100mg/kg body weight in aqueous suspension daily using intragastric tube for six weeks
Group5: Diabetic rats given curcumin 50mg/kg body weight in aqueous suspension daily using intragastric tube for six weeks
Group6: Diabetic rats given curcumin 100mg/kg body weight in aqueous suspension daily using intragastric tube for six weeks
Group7: Diabetic rats given tetrahydrocurcumin 50mg/kg body weight in aqueous suspension daily using intragastric tube for six weeks
Group8: Diabetic rats given tetrahydrocurcumin 100mg/kg body weight in aqueous suspension daily using intragastric tube for six weeks.

2.5- Blood sampling:

Blood samples were taken from the previously mentioned groups at the end of the experiment. The blood samples were collected after 12 hours fasting from vein plexus eye into dry clean centrifuge tubes and left to cold. The blood was centrifuged for 10 min at 300 rpm to separate the serum, which was carefully aspirated and transferred into clean quite plastic tubes and kept at frozen condition at -18 $\pm 2^0$C until biochemical analysis (El-Khamissy. 2005).

2.6- Collection of organs:

All rats were scarified and the abdomen was offend and the organs were separated by carefully dissection then cleaned from the adhesive matter and washed with running water after that weighted and kept in the freezer at -18 $\pm$ 2^{0}C until biochemical analysis.

2.7- Body weight gain and food efficiency ratio:

All rats were weighed weekly so as food intake. At the end of the experiment, body weight gain and food efficiency ratio (as gm of weight gain /gm of food intake) were calculated for each group of rats.

2.8- Biochemical analysis:

2.8.1- Determination of blood glucose:

Blood glucose was measured according to the method described by Alles *et al.*, (1999) using blood glucose meter (free style TM).

2.8.2- Determination of plasma insulin:

Plasma insulin was assayed by ELISA using a Boehringer-Mannheim kit with an ES 300 Boehringer analyzer (Mannheim, Germany). As outlined by Murugan and Pari (2007).

2.8.3- Determination of serum enzymatic activity:

The activities of aspartate transaminase (AST) and alanine transaminase (ALT) of serum were determined according to the methods described by Murugan and Pari (2007) on fully automated chemistry analyzer Roche/Hitachi-912 (Roche Diagnostics, Mannheim, Germany) using Roche Diagnostics GmbH kits. The values were expressed as *Iu/L* serum.

2.8.4- Determination of serum lipids:

Triglycerides, total cholesterol and high density lipoprotein cholesterol (HDL-C) levels were measured by enzymic-colorimetric procedures using commercial available kits. Triglycerides were carried out according to the method of Fossati and Prancipe (1982). Total cholesterol (TC) and HDL-C were carried out according to the methods of Richmond (1973). Low-density lipoprotein cholesterol (LDL-C) was calculated as the difference between total and HD-C according to the method of Freiedwald *et al.*, (1972). Phospholipids content was estimated by the method of Zilversmit and Davis (1950).

2.8.5- Determination of liver lipids:

Liver lipids were determined according to Kim and Shin (1998). Liver and fecal samples were extracted with solvents before subjecting to the aforementioned analysis according to Folch *et al.*, (1957).

2.9- Statistical analysis:

Most of the received data were analyzed statistically using the analysis of variance and the means were further tested using the least significant difference test (LSD) as outlined by Steel and Torrie (1980).

Results and Discussion

Chemical composition of turmeric rhizome powder:

Chemical composition of turmeric rhizome powder presented in Table (1). It is clear from the presented results that, turmeric contains 7.2 % protein, 5.6% ether extract and 3.47 ash. The essential oil was 5.75% that obtained by steam distillation. These results were approximately in agreement with those of Chattopadhyay *et al.,* (2004) who found that turmeric contains 6.3% protein, 5.19% fat and 3.5% ash content.

Table 1: Chemical composition of turmeric (on dry weight basis)

Component	Moisture content	Crude protein	Ether extract	Ash	Total carbohydrates	Essential oils
%	13.0	7.2	5.6	3.47	83.73	5.75

The values are means of three determinations.

Effect of turmeric, curcumin and THC on nutritional parameters of rats:

Data in Table (2) indicate that the mean values of initial body weights of all groups at the start of the experiment, were approximately the same and ranged from 129.89 to 133.11gms. At the end of experiment (6 weeks), the final weight of the control diabetic rats (G2) was lower than that of the normal control (G1). Diabetic rats fed on turmeric, curcumin and THC (G3-G8) had greater final body weight, body weight gain, food intake and food efficiency ratio (FER) than those of diabetic control rats (G2). These results may be due to the improvement in their health resulting the effects of lowering the blood glucose and helped the rats to overcome the impaired body functions and recovered their appetite to food and gain in weight (Gaber, 1998). These results are in agreement with those reported by Babu and Srinivasan (1995) who found that using of turmeric and curcumin at levels of 20 and 40mg/kg body weight with diabetic rats led to increase of food intake, body weight gain and FER compared with the diabetic control one.

Table 2: Effect of turmeric, curcumin and THC on nutritional parameters of diabetic rats.

Dietary groups	Initial weight (gm)	Final weight (gm)	Body weight gain (gm)	Food intake (gm)	FER
G1	130.87 a	183.01 f	52,14 g	289.53 c	0.18 cde
G2	132.36 a	142.47 a	10.11 a	206.63 a	0.050a
G3	131.68 a	167.62 b	35.26 b	223.38 ab	0.158 bc
G4	131.36 a	169.32 bc	37.96 bc	238.83 b	0.159 bc
G5	129.89 a	170.30 bcd	40.50 cd	226.49 ab	0.18 bcd
G6	133.11 a	176.41 def	43.30 de	219.20 a	0.198 e
G7	130.06 a	175.01 cde	44.95 ef	241.61 b	0.186 de
G8	131.23 a	179.24 ef	48.01 f	285.75 c	0.17 bcd

Each value is an average of six determinations. Values followed by the same letter in column are not significantly different at P<0.05.
G1-G8: as mentioned in materials and methods section.

Effect of turmeric, curcumin and THC on organs of rats:

The results presented in Table (3) revealed that all treatments showed significant changes in the weight of liver, kidney and spleen of all experimental rats. It could be noticed that the liver and kideny weights of rats fed with turmeric, curcumin and THC were somewhat lower than that of control rats. On the other hand, the spleen weights of rats fed with turmeric, curcumin and THC specially at higher levels (100 mg/kg body weight) were higher than that of control rats. Generally, the changes in the organs of rats as result of nutrition with turmeric, curcumin and THC were in the normal state.

Table 3: Effect of turmeric, curcumin and THC on organs weight of studied rats.

Groups	Liver weight (gm)	Kidneys weight (gm)	Spleen weight (gm)
G1	6.0 e	1.53 cd	0.49 a
G2	5.1 a	1.24 a	0.52 b
G3	5.3 b	1.52 cd	0.49 a
G4	5.5 c	1.47 bc	0.55 bc
G5	5.4 bc	1.49 c	0.53 b
G6	5.5 c	1.52 cd	0.59 d
G7	5.4 bc	1.45 bc	0.60 de
G8	5.7 d	1.42 b	0.62 e

Each value is an average of six determinations. Values followed by the same letter in column are not significantly different at P<0.05.
G1-G8: as mentioned in materials and methods section.

Glucose tolerance test (GTT) for normal and diabetic rats:

Results in Table (4) shows that the blood glucose levels of normal and, diabetic controls and diabetic treated rats subjected to glucose tolerance test after 6 weeks. Concerning the diabetic control rats, the increase beak of blood glucose level was observed after 1 hr and slightly decreased at the next period of experiment

Table 4: The blood glucose levels of experimental groups of rats after oral administration of glucose (2gm/kg body weight).

Groups	Blood glucose (mg/dl)				
	0 hr (fasting)	0.5 hr	1 hr	1.5 hr	2 hr
G1	79.5 a	143.6 b	160.2 b	128.7 b	87.4 a
G2	295.4 d	311.8 d	359.7 g	336.5 f	319.3 d
G3	102.5 c	149.6 c	193.4 e	161.7 e	112.6 c
G4	85.0 b	142.3 b	210.0 f	102.5 a	97.5 b
G5	83.0 ab	147.3 bc	188.7 e	145.9 d	95.3 b
G6	82.3 ab	144.7 bc	168.0 c	132.9 bc	93.8 b
G7	81.6 ab	146.1 bc	176.8 d	137.4 c	92.1 b
G8	80.9 a	112.2 a	119.5 a	100.0 a	90.3 b

Each value is an average of six determinations. Values followed by the same letter in column are not significantly different at $P<0.05$.
(G1-G8) as mentioned in materials and methods section.

For the rats treated with turmeric, curcumin and THC, the blood glucose increased after 1 hr and significantly decreased at the next hour.The decreasing rate of blood glucose concentration of treated rats was nearly similar to control rats (group 1). The differences between the blood glucose of treated rats and the control rats after 2 hrs were no significant especially in case of rats treated with curcumin and THC. The glucose tolerance effect was more pronounced after a 2 hr interval.

Effect of turmeric, curcumin and THC on blood glucose and plasma insulin of experimental rats:

Table (5) illustrated the mean blood glucose and plasma insulin levels of normal control and diabetic rats groups through the experimental period. There was a significant elevation in blood glucose level, whereas plasma insulin level decreased significantly in streptozotocin diabetic rats compared to normal rats. Administration of turmeric, curcumin and tetrahydrocurcumin tended to bring blood glucose and plasma insulin towards normal levels. Apparent, tetrahydrocurcumin had highly effect on blood glucose and plasma insulin levels than the curcumin and turmeric. In addition, administration with

the higher level (100mg/kg body wt.) of turmeric, curcumin and THC led to more reduction of blood glucose. The obtained data concerned with blood glucose levels indicated that the effect of THC was more prominent when compared with curcumin. These results are in a harmony with those reported by Pari and Murugan, (2005) who found that the diabetic control rats showed a significant increase in blood glucose with a significant decrease in plasma insulin levels but oral administration of THC to diabetic rats reversed significantly the above biochemical changes. They also (2007) found that curcumin and THC decreases the blood glucose in streptozotocin diabetic rats. The possible mechanism by which THC mediates its antidiabetic action may be by potentialities of pancreatic secretion of insulin from existing beta-cell or due to enhanced transport of blood glucose to peripheral tissue. It is evidenced by the significant increase in the level of insulin by THC in diabetic rats.

Table 5: Effect of turmeric, curcumin and THC on blood glucose and plasma insulin of experimental rats.

Groups	Blood glucose (mg/dl)		Plasma insulin (*uU/l*)
	Initial	Final (6 wk)	
G1	94.45 a	97.19 a	16.6 h
G2	358.0 e	363.37 g	3.98 a
G3	339.73 bc	170.41 f	5.31 b
G4	348.56 d	156.21 e	6.73 c
G5	345.31 cd	146.23 d	8.17 d
G6	336.18 b	134.38 c	9.21 e
G7	348.47 d	129.45 c	10.31 f
G8	359.27 e	114.08 b	12.69 g

Each value is an average of six determinations. Values followed by the same letter in column are not significantly different at $P<0.05$.
(G1-G8) as mentioned in materials and methods section.

Effect of turmeric, curcumin and THC on serum lipids in rats:

Although the relationship between lipids abnormalities and diabetes is complex, there is usually a specific lipid abnormality found in diabetes (Rosalyn and Bauman, 1983). Also, hypertriglyceridemia, hypercholesrolemia and reduced HDL-C levels were commonly seen in diabetes. The abnormal high level of lipids in diabetes is mainly due to the increase in the mobilization of free fatty acids from the peripheral depots, since the insulin inhibits the hormone sensitive lipase but glucagons, catecholamines and other hormones enhance lipolysis. The marked hyperlipidemia that characterizes the diabetic state may therefore be regarded as a consequence of the fat depots (Al-Shamaony *et al.*, 1994).

According to the results given in Table (6), it could be concluded that treated diabetic rats had a significantly lower serum total cholesterol, low density lipoprotein cholesterol, triglycerides and phospholipids but they had a significantly higher serum high density lipoprotein cholesterol compared to diabetic control rats. Murugan and Pari (2006) studied the effect of curcumin and THC on diabetic rats and found similar results. The ratio of TC/HDL-C was significantly higher in case of diabetic control rats than that of other groups. These results may be due to the treatment of diabetic rats with streptozotocin helped to increase of TC/HDL-C ratio. The increasing of triglycerides in streptozotocin diabetes rats that observed in this study may be due to lack of insulin, which normally activates the enzyme lipoprotein lipase. (Baur 1995) stated that the TC/HDL-C ratio should be ranged between 4 and 6 and when it increased above 6 is high risk on heart. The TC/HDL-C ratio is important as an indicator of the coronary artery disease. Hypertriglycermia is one of the risk factors in coronary artery disease and diabetes mellitus is always associated with raised triglycerides.

Table 6: Effect of turmeric, curcumin and THC on serum lipids (mg/dl) in rats.

Groups	TC	HDL -c	LDL – c	TC/HDL - c ratio	Tri-glycerides	Phospho -lipids
G1	88.8 a	51.6 c	37.2 a	1.72	114.7 c	37.8 a
G2	232.0 h	30.2 a	201.8 d	7.69	242.0 h	55.9 g
G3	163.0 g	69.9 h	93.2 c	2.33	145.9 g	52.1 f
G4	145.3 f	66.4 g	79.0 bc	2.19	127.2 f	48.7 e
G5	133.8 e	60.0 e	73.8 b	2.23	119.9 e	42.4 d
G6	129.0 d	63.8 f	65.2 b	2.02	114.8 d	39.7 c
G7	116.6 c	52.5 d	64.1 b	2.22	112.4 b	39.0 b
G8	110.1 b	43.9 b	66.2 b	2.51	105.9 a	38.1 a

Each value is an average of six determinations. Values followed by the same letter in column are not significantly different at $P<0.05$.
(G1-G8) as mentioned in materials and methods section. TC = Total cholesterol, HDL-c = High density lipoprotein cholesterol, LDL-c = Low density lipoprotein cholesterol.

Effect of turmeric, curcumin and THC on liver lipids in rats:

The results in Table (7) shows that cholesterol, triglycerides and phospholipids levels decreased significantly in diabetic rats treated with turmeric, curcumin and THC compared with untreated diabetic rats. The rats treated with level of 100 mg/kg body wt. of all studied substrates was more effective than those treated with the level of 50 mg/kg. Also, the feeding with THC had highly effective compared with turmeric and curcumin. The

obtained results are in agreement with those reported by Murugan and Pari (2006) who found that THC significantly reduces the levels of serum and tissue lipids and lipid peroxidation marker. From the same Table, it could be observed that high levels of cholesterol, triglycerides and phospholipids were obtained in liver of streptozotocin diabetic control rats (G2). Cholesterol is a powerful risk factor for many coronary heart diseases. The degree of hypercholesterolaemia is directly proportional to the severity of diabetes (Zavaroni *et al.*, 1989). Increasing of liver cholesterol level in diabetic rats may be due to increase cholesterogenesis. Increasing levels of cholesterol in liver and kidney are due to decrease level of HDL-C. This in turn results in decreased removal of cholesterol from extrahepatic tissues by the HDL-C (Prince *et al.*, 1998).

Table 7: Effect of turmeric, curcumin and THC on liver lipids (mg/100gm tissue) of rats.

Groups	Cholesterol	Triglycerides	Phospholipids
G1	326 a	344 a	1.66 a
G2	518 h	850 g	3.15 f
G3	483 g	750 f	2.83 e
G4	470 f	710 e	2.65 e
G5	457 e	692 e	2.37 d
G6	445 d	588 d	2.20 cd
G7	415 c	544 c	1.99 bc
G8	401 b	427 b	1.85 ab

Each value is an average of six determinations. Values followed by the same letter in column are not significantly different at P<0.05.
(G1-G8) as mentioned in materials and methods section.

Effect of turmeric, curcumin and THC on serum aspertate transaminase and alanine transaminase in rats:

Elevated activities of serum transaminase enzymes are a common sing of hepatic dysfunction, and are more frequently observed among people with diabetes than in the general population. Furthermore, diabetic complications such as limited joint mobility, retinopathy and neuropathy are associated with liver enzyme activities, independent of alcohol consumption, body mass index and metabolic control of diabetes (Brownlee, 2001). Table (8) represents the effect of turmeric, curcumin and THC on changes in the activities of serum aspertate transaminase and alanine transaminase. The activities of hepatic markers were significantly elevated in diabetic rats compared with control rats. The treatment of diabetic rats by turmeric, curcumin and THC reversed the above changes in a significant manner compared with untreated diabetic

rats. The effect of THC was more than those of turmeric and curcumin. Several investigators reported increase in aspertate and alanine transaminase in the liver and serum of streptozotocin diabetic rats (Brownlee, 2001). The changes in levels of serum enzymes are directly related to the changes in metabolism of its involved enzymes. Murugan and Pari (2007) suggested that liver and kidney functions are highly altered in diabetic state. Treatment with THC and curcumin reversed these changes in diabetic rats, which indicates that these substrates protect the hepatic and renal function in the diabetic condition.

Table 8: effect of turmeric, curcumin and THC on serum aspetate transaminase and alanine transaminase of studied rats.

Groups	Aspertate transaminase (*IU*)	Alanine transaminase (*IU*)
G1	74.61 a	27.73 a
G2	121.02 h	64.54 h
G3	103.15 g	59.13 f
G4	98.33 f	51.27 e
G5	96.75 e	45.47 d
G6	94.18 d	40.08 c
G7	87.23 c	36.93 b
G8	83.53 b	34.22 b

Each value is an average of six determinations. Values followed by the same letter in column are not significantly different at $P<0.05$.
(G1-G8) as mentioned in materials and methods section.

Conclusion

From the aforementioned data, it could be concluded that:
Turmeric, curcumin and tetrahydrocurcumin significantly reduced the levels of blood glucose and lipids of both serum and liver, beside a significant increase in the plasma insulin of diabetic rats occurred. Moreover, they also had a positive effect on the activities of serum enzymes. Tetrahydrocurcumin had the highest effect on the previously mentioned parameters followed by curcumin. In addition, normalizing effects of turmeric, curcumin and tetrahydrocurcumin on hepatocellular damage and suppression of gluconogenesis.

References

Aggarwal, B.; Kumar, A. and Bharti, A. (2003). Anticancer potential of curcumin: Preclinical and clinical studies. Anticancer Res. 23:363-398.

Alles, S.M.; Ross, M.N.; Bakx, C.J.; Lisdonk, E.; Zock, L.P. and Hautvast, G. A.J. (1999). Consumption of fructooligosaccharides have favorably affect blood glucose and serum lipid concentrations in patients with type 2 diabetes. Am J. Clin. Nutr. 69(1): 64-69.

Al-Shamaony, L., Al-Khazraji, S. M., and Twaij, H. A. (1994). Hypoglycaemic effect of Artemisia herba alba II. Effect of a valuable extract on some blood parameters in diabetic animals. J. Ethnopharmacol, 43: 167-171.

A.O.A.C. (1990). Association of Official Agricultural Chemists. Official Methods of Analysis. 15th Ed., Washington D.C., U.S.A.

Arun, N. and Nalini, N. (2002). Efficiency of turmeric on blood sugar and polyol pathwayin diabetic albino rats. Plant Foods for Human Nutrition, 57: 41-52.

Babu, P. and Srinivasan K. (1995). Influence of dietary curcumin and cholesterol on the progressin of experimentally induced diabetes in albino rat. Molecular and Cellular Biochem. 152: 13-21.

Babu, P. and Srinivasan K. (1997). Hypolipidemic action of curcumin, the active princible of turmeric *Curcuma longa* in streptozotocin induced diabetic rats. Mol. Cell Biochem. 166: 169-175.

Bakhru, H.K., (1997). Herb that heal: Natural remedies for good health. Orient paperwork, New Delhi, pp:164-166.

Baur, F. j. (1995). Nutritional aspects of oils and fats. In: Food Oils and Fats, Technology, Utilization and Nutrition. Laswon, H. (ed.) Chapman & Hall, New York. pp. 203-280.

Brownlee, M. (2001). Biochemistry and molecular cell biology diabetic complications. Nature, 414: 813-820.

Chattopadhyay, I.; Biswas, K.; Banyopadhyay, U. and Banerjee, K. (2004). Turmeric and curcumin: biological actions and medicinal applications. Current Sci., 87 (1).

El-Khamissy, A. (2005). Studies on biological effects of some diabetes foods. Ph.D. Thesis, Fac. of specific Education, Home Economics, Tanta Univ.

Folch, J.; Lees, M. and Sloane-Stanley, G.H. (1957). A simple method for isolation and purification of total lipids from animal tissue. J. Biol. Chem., 226: 497-509.

Fossati, P. and Prancipe, L. (1982). Triglycerides determination after enzymatic hydrolysis. Clin. Chem., 28: 2077.

Freiedwald, W. T.; Levy, R. I. and Fredrickson, D. S. (1972). Estimation of the concentration of low density lipoprotein separation by three different methods. Clin. Chem., 18:499-502.

Gaber, F. A. (1998). Biochemical Studies of Some Wild Plants. Ph.D. Thesis, Fac. of Agric. Caio Univ.

Hong, J.; Bose, M.; JU, J.; Ryu hm, J.; Chenm, X.; Sang, S.; Lee, M. J. and Yang, C. S. (2004). Modulation of arachidonic acid metabolism by curcumin and relatedB-diketone derivatives: effects on cytosolic phosphlipase A92), cyclooxygenases and 5-lipoxygenase. Carcinogenesis. 25, 1671-1679.

Joe, B.; Vaijaykumar, M. and Lokesh, B. R. (2004). Biological properties of curcumin-cellular and molecular mechanisms of action. Critical Reviews in Food Science and Nutrition, 44: 97-111.

Kameswara Rao, B. and Appa Rao, C. H. (2001). Hypoglycemic and antihyperglycemic activity of alternifolium (Wt.) Walp. Seed exteacts in normal and diabetic rats. PHytomed. 8, 88-93.

Kapoor, L. D. (1990). Handbook of ayurvedic medical plants. CRC Press, Boca Raton, pp: 149-150.

Kermanshahi, H. and Riasi, A. (2006). Effect of turmeric rhizome powder (Curcuma longa) and soluble NSP degrading enzyme on some blood parameters of laying hens. International J. of Poultry Sci. 5 (5) 494-498.

Kim, M. and Shin, H.K. (1998). The water-soluble extract of chicory influences serum and liver lipid concentrations, cercal short-chain fatty acid concentrations and fecal lipid extraction in rats. J. Nutr. 128(1): 1731-1736.

Lin, JK. and Lin-Shiau SY. (2001) Mechanisms of cancer chemoprevention by curcumin. Pro. Natl. Sc. Counc. Repub. China. 25:59-66.

Murugan, P. and Pari, L. (2006). Effect of tetrahydrocurcumin on lipid peroxidation and lipids in streptoyotocin-Nicotinamide-induced diabetic rats. Basic and clinical Pharmacology and Toxicology, 99: 122-127.

Murugan, P. and Pari, L. (2007). Influence of tetrahydrocurcumin on hepatic and renal functional markers and protein levels in experimental type 2 diabetic rats. Basic and Clinical Pharmacol. and Toxicol., 101: 241-245.

Naito, M.;Wu, X.; Normura, H.; Kodama, M.; Kato, Y.and Osaswa, T. (2002). The protective effect of tetrahydrocurcumin on oxidative stress in cholesterol-fed rabbits. J. Atheroscler. Thromb. 9: 243-250.

Nakamura, Y. (1998). Inhibitory effect and tetrahydrocurcuminoids on the tumor promoter induced reactive oxygen species generation in leucocyte, in vitro and in vivo. Jap. J. Cancer Res. 89, 361-370.

Nishiyama, T.; Mae, T.; Kishida, H.; Tsukagawa, M. and Kuroda, M. (2005). Curcuminoids and sesquiterpenoids in turmeric (Curcuma longa L) suooress and increase in blood glucose level in type 2 diabetic KK-Ay mice. J. Agric. Food Chem. 53:959-963.

Okada, K.; Wangpoengtrakul, C.; Tanaka, T.; Toyokuni, S.; Uchida, K. and Osawa, T. (2001). Curcumin and especially tetrahydrocurcumin ameliorate oxidative stress-induced renal injury in mice. J. Nutr. 31: 2090-2095.

Pari, L. and Murugan, P. (2005). Effect of tetrahydrocurcumin on blood glucose, plasma insulin and hepatic key enzymes in streptozotocin induced diabetic rats. J. Basic. Clin. Physiol. Pharmacol. 16:257-274.

Prince, P. S.M.; Menon, V. P. and Gunasekaran, G. (1998). Hypolipidemic action of Tinospora cordifolia roots in alloxan diabetic rats. J. Ethnopharmacol. 64:53-57.

Richmond, N. (1973). Calorimetric method of determination of total cholesterol and high density lipoprotein cholesterol. Clin. Chem. 19:1350-1356.

Rosalyn, Y. and Bauman, W. A. (1983). Plasma insulin in heaith and disease, In: diabetes mellitus theory and practice, M. Ellenbery and H. Rifkin ed., (New York: Excerpta Medica: 119-150).

Sajithlal, G.; Chthra, P. and Chandrakasan, G. (1998). Effect of curcumin on the advanced glycation and cross-liking of collagen in diabetic rats. Biochem. Pharmacol. 56:1607-1614.

Steel, R. G. and Torrie, J. H. (1980). Principles and procedures of statistics. 2nd ed., pp.120. McGraw-Hill, New York, USA.

Sugiyama, Y.; Kawakishi, S. and Osawa, T. (1996). Involvement of beta diketone moiety in the antioxidant mechanism of tetrahydrocurcuminoids. Biochem. Pharmacol. 52:519-525.

Zavaroni, I.; Bonara, E. and Pagilora, M. (1989). Risk factors for coronary artery disease in healthy persons with hyperinsulinemia and normal glucose tolerance. New Eng. J. Med. 320:702-705.

Zilversmit, BB. And Davis, AK. (1950). Micro determination of plasma phospholipids by TCA precipitation. J. Lab. Clin. Med. 35:155-160.

الملخص العربي

تأثير التغذية مع الكركم و الكركومين والتتراهيدروكوركومين علي مرضي السكر

***محمد السيد البنا- **محمد عوض عبدالجليل- **بديعة عبدالرحمن بيصار**

*معهد تكنولوجيا الأغذية- مركز البحوث الزراعية- الجيزة- مصر
**قسم علوم و تكنولوجيا الأغذية- كلية الزراعة- جامعة كفرالشيخ- مصر

تهدف هذه الدراسة إلي بحث تأثير الكركم وأحد أهم مكوناته وهو الكوركومين

وكذلك أحد نواتج التمثيل الغذائي للكوركومين (التتراهيدروكوركومين) علي الفئران التي تم حقنها بمادة Streptozotocin المحدثة للإصابة بمرض السكر.

أجريت هذه التجربة لمدة ٦ اسابيع بإعطاء الفئران مستويين من هذه المواد ٥٠، ١٠٠ ملجم/كجم من وزن الجسم عن طريق الفم باستخدام سرنجة بها مخلوط هذه المواد مع الماء. في نهاية التجربة تم تقدير تأثير هذه المواد علي الفئران المصابة من خلال القياسات الأتية:

١- الزيادة في الوزن وكفاءة التمثيل الغذائي وكذلك وزن الأعضاء (الكبد والكلي والطحال).
٢- مستوي الجلوكوز في الدم وكذلك تم تقدير أنسولين البلازما.
٣- تقدير الليبيدات في الكبد والسيرم.
٤- تقدير نشاط أنزيمات اسبرتات ترانس امينيز وألانين ترانس امينيز في سيرم الدم.

النتائج المتحصل عليها كانت كالأتي:

١- المواد المختبرة لها تأثيرمعنوي علي زيادة وزن الفئران وزيادة الإستفادة من الغذاء.
٢- لهذه المواد تأثير واضح في تقليل مستوي الجلوكوز في الدم وزيادة الأنسولين.
٣- كما أظهرت النتائج تأثير واضح لهذه المواد في خفض الليبيدات مثل الكوليسترول والكوليسترول ليبوبروتين منخفض الكثافة الجليسريدات الثلاثية والفوسفوليبيدات سواءا في الكبد او في الدم.
٤- تأثير المواد المختبرة كان واضحا في تقليل نشاط بعض انزيمات السيرم مثل اسبرتات ترانس امينيز و الانين ترانس امينيز مما يوضح أن لها تأثير في حماية وظائف الكبد والكلي.
٥- مادة التتراهيدروكوركومين كان لها تاثير أحسن علي كل الخواص المدروسة يليها الكوركومين. كما أن المستوي الأعلي للمواد المختبرة (١٠٠ ملجم/كجم من وزن الفأر) كان له تأثير أحسن من المستوي الأقل (٥٠ ملجم/كجم من وزن الفأر).

بناءا علي النتائج المتحصل عليها توصي الدراسة باستخدام هذه المواد مع بعض أغذية مرضي السكر.