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Research Article

STUDY OF ANTIOBESITY ACTIVITY OF POLYHERBAL FORMULATION IN CORRELATION WITH ANTIDIABETIC ACTIVITY

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ABSTRACT

Objective: The objective of this research was to develop a polyherbal formulation using four different herbs using obese diabetic rat's model.

Methods: Rats received high-fat diet and alloxan was injected intraperitoneal to rats for induction of diabetes. In the preventive experiment, diabetic rats received *Momordica charantia* Linn. (200 and 400 mg/kg/day p.o), *Eugenia jambolana* Linn. (200 and 400 mg/kg/day p.o), *Ziziphus mauritiana* (200 and 400 mg/kg/day p.o), *Acacia catechu* (AC) (200 and 400 mg/kg/day p.o), and aqueous extract of all extracts (100 and 200 mg/kg/day p.o). Diabetic rats were also treated with glibenclamide (5 mg/kg p.o.) and orlistat (60 mg/kg/day p.o.) as reference standards.

Results: The results showed that the extract of *M. charantia* Linn., *E. jambolana* Linn., *Z. mauritiana,* and AC significantly ($p<0.05$) inhibited body weight gain, blood glucose, triglyceride, total cholesterol, low-density lipoprotein (LDL), very LDL, high-density lipoprotein cholesterol, serum glutamic pyruvic transaminase, serum glutamic oxaloacetic transaminase, and fasting blood glucose in a dose-dependent manner. Extracts treated rats at doses of 200 and 400 mg/kg improved dyslipidemia in high-fat diet (HFD)-induced obese rats by enhancing their lipid metabolism when compared to the HFD control.

Conclusion: The results obtained in this research work clearly showed that taken together the extract of *M. charantia* Linn., *E. jambolana* Linn., *Z. mauritiana* Lam. AC Willd., and aqueous extract of all extracts has potential as a preventive agent for type 2 diabetes mellitus (and possibly obesity) and deserves clinical trial in the near future.

Keywords: *Momordica charantia* Linn., *Eugenia jambolana* Linn., *Ziziphus mauritiana, Acacia catechu*, Antidiabetic, Antiobesity.

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INTRODUCTION

Diabetes and obesity are chief health crisis and mainly age-related metabolic disorders. Diabetes is the main cause of morbidity and mortality worldwide. Obesity is linked with the progression of diabetes mellitus. High levels of glycerol, fatty acids, enzymes, pro-inflammatory markers, and other obese entities build up insulin resistance in obese persons [1]. Increased intake of high caloric (energy and fat) food promotes body fat storage and greater body weight and adiposity in humans and animals. Over-the-counter remedies based on nutritional supplements are extremely popular, especially with respect to obesity and body composition. Inhibition of the digestion and absorption of dietary fat has been used as targets in obesity treatment.

The prevalence of obesity is rising dramatically among all ages with the changes of lifestyles and dietary fat intake [2]. Obesity represents a serious health problem that increased the risk for many diseases such as cardiovascular diseases, hypertension, and diabetes mellitus [3]. Obesity and insulin resistance are strongly associated with the infiltration of adipose tissue by inflammatory cells [4]. Diabetes mellitus is a chronic and progressive metabolic disease characterized by hyperglycemia due to insulin deficiency, or insulin resistance, or both. Hyperglycemia occurs when the cells become unable to utilize glucose and/or the liver and skeletal muscles cannot store glycogen [5,6]. Drugs such as insulin or oral hypoglycemic agents such as biguanides or sulfonylurea as are used primarily to control symptoms by decreasing concentration of glucose in blood. Secondary aim of such medications is to prevent long-term diabetic complications as described eatrlier by eliminating various risk factors [7]. Insulin resistance, a common accompaniment of obesity, is a major risk factor for diabetes mellitus [8]. Because synthetic chemical drugs prescribed for treating obesity and diabetes had many adverse side effects; therefore, there is a great need to search for complementary alternative medicine, particularly from medicinal plants. India has a rich history of using various potent herbs and herbal components for treating diabetes. Medicinal plant or herb has a variety of metabolites, aliphatic and aromatic compounds have the basic skeleton of organic molecules, which have various functional groups that make their ability to alter the various metabolic pathways make them medicinally important.

Herbal drugs are prescribed widely because of their effectiveness, less side effects, and relatively low cost [9]. *Momordica charantia* Linn., a valuable plant, belongs to the Cucurbitaceae family; it is commonly known as bitter gourd, balsam pear, bitter melon, kugua, or karela [10]. The generic name "Momordica" comes from Latin, meaning "to bite," which refers to its leaf with serrated edges which looks as if it has been bitten [11]. *Eugenia jambolana* Linn. is the member of Myrtaceae family. It is also known in Hindi as jamun, jambo, jambul, jamhool, in English as black plum, purple plum, and black berry, and nerudu in Telugu [12]. *Ziziphus mauritiana*, a member from the family Rhamnaceae with local name Ber, is a fruit tree, which grows in tropical and subtropical regions of the world. It is called as jujube tree or Indian jujube [13]. *Acacia catechu* (L.f.) Willd. or Khair (AC), belonging to the family Mimosaceae, is used in most of the herbal preparations of Ayurveda in India [14,15]. In view of the above facts, the present study was undertaken to determine the antidiabetic and antiobesity effect of *M. charantia* Linn., *E. jambolana* Linn., *Z. mauritiana,* and AC and combination consisting of aqueous extract of all extracts. The effects on diet-induced changes in body weight, plasma glucose, triglyceride (TG), cholesterol and low-density lipoprotein in high-fat diet (HFD), and alloxan-induced rats were evaluated to study the same.

MATERIALS AND METHODS

Authentication of plants

Identification of plant was done by Dr. C.K. Nigwal (Department of Botany), P.G. College of Mandsaur (Madhya Pradesh).

Plant materials

Fresh plant material of *M. charantia* Linn., *E. jambolana* Linn., *Z. mauritiana,* and AC was collected from the local market. Air-dried plant materials were crushed to coarse powder, aqueous extract of *M. charantia* Linn., *E. jambolana* Linn., and *Z. mauritiana* was obtained, and AC was extracted exhaustively in a Soxhlet with ethanol. The extract was concentrated under reduced pressure to yield viscous mass. The aqueous and ethanolic extract was kept in airtight containers in a deep freeze maintained at 4°C until the time of further use.

Chemicals

Normal saline and other graded chemicals: Drug solutions were prepared fresh and doses are expressed in terms of their free bases. Glibenclamide was used as standard drugs for comparison with various extracts. Alloxan monohydrate (Sigma-Aldrich, USA), lipid profile estimation kit (Transasia Bio-Medical Limited, Mumbai, India), and other chemicals and solvent obtained from Qualigens, India, were used.

Instruments

Weighing of animals was done by digital balance, Shimadzu, and blood was collected by hematocrit capillary, Spectrum, India.

Animals

Wistar rats (150–200 g) were group housed (n=6) under a standard 12 h light/dark cycle and controlled conditions of temperature and humidity (25±2°C, 55–65%). Rats received standard rodent chow and water *ad libitum*. Rats were acclimatized to laboratory conditions for 7 days before carrying out the experiments. All the experiments were carried in a noise-free room between 08.00 and 15.00 h. Separate group (n=6) of rats was used for each set of experiments. The animal studies were approved by the Institutional Animal Ethics Committee, constituted for the purpose of control and supervision of experimental animals by Ministry of Environment and Forests, Government of India, New Delhi, India.

Toxicity study

For the acute oral toxicity and lethal dose 50 (LD_{50}) determination, the organization for economic cooperation and development (OECD) guideline 423 was followed. As per OECD guidelines, a step-wise procedure with the use of three animals of a single sex per step was followed. Absence or presence of compound-related mortality of the animal doses at one step will determine the next step, i.e., no further testing needed, dosing of three additional animals with the same dose, and dosing of three additional animals at the next higher or the next lower dose levels.

Experimental model

After 28 days of administration of HFD and on day 29, alloxan was injected intraperitoneal to rats. After 3 days, rats were kept on overnight fasting in polypropylene cages with fasting bottom grills and water *ad libitum*. After 72 h of alloxination, blood glucose level was checked. Approximately 200 µl blood was collected from each animal by retro-orbital sinus in 0.5 ml Eppendorf tubes (Tarsons Products Pvt. Ltd., Kolkata, India) containing 20 µl of 20% sodium fluoride solution. Collected blood was centrifuged at 8000 rpm at temperature of 18–22°C for 10 min by centrifuge machine. 48 animals were weighed, randomized, and divided into eight groups (6 animals each) and were given following treatment for 14 days by oral route [16]:

- Group I - Normal (1% tween 80 solutions).
- Group II - Diabetic rats received only distilled water (negative control).
- Group III - Diabetic rats were treated with glibenclamide (5 mg/kg p.o.) with 1% tween 80 solutions.
- Group IV - Diabetic rats received orlistat (60 mg/kg/day p.o.) suspended in 1% tween 80 solutions.
- Group V - Diabetic rats received aqueous extract of *M. charantiana* Linn. (200 mg/kg/day p.o.) suspended in 1% tween 80 solutions.
- Group VI - Diabetic rats received aqueous extract of *M. charantiana* Linn. (400 mg/kg/day p.o.) suspended in 1% tween 80 solutions.
- Group VII - Diabetic rats received aqueous extract of *E. jambolana* Linn. (200 mg/kg/day p.o.) suspended in 1% tween 80 solutions.
- Group VIII - Diabetic rats received aqueous extract of *E. jambolana* Linn. (400 mg/kg/day p.o.) suspended in 1% tween 80 solutions.
- Group IX - Diabetic rats received aqueous extract of *Z. maurantiana* Lam. (200 mg/kg/day p.o.) suspended in 1% tween 80 solutions.
- Group X - Diabetic rats received aqueous extract of *Z. maurantiana* Lam. (400 mg/kg/day p.o.) suspended in 1% tween 80 solutions.
- Group XI - Diabetic rats received ethanolic extract of AC Willd. (200 mg/kg/day p.o.) suspended in 1% tween 80 solutions.
- Group XII - Diabetic rats received ethanolic extract of AC Willd. (400 mg/kg/day p.o.) suspended in 1% tween 80 solutions.
- Group XII - Diabetic rats received aqueous extract of all extracts (100 mg each extract/kg/day p.o.) suspended in 1% tween 80 solutions.
- Group XIV - Diabetic rats received aqueous extract of all extracts (200 mg each extract/kg/day p.o.) suspended in 1% tween 80 solutions.

Blood sampling and plasma assay

For blood glucose determination, blood was withdrawn by tail snipping technique. For various lipid profile and biochemical parameters estimation, blood was collected from ophthalmic venous plexus by retro-orbital bleeding technique [17]. The blood samples were placed on ice, centrifuged, and the plasma was stored at −20°C until assayed. The blood glucose concentration was determined using the glucose oxidase method [18]. TG, total cholesterol (TC), TG, TC, low-density lipoprotein (LDL), very LDL (VLDL), high-density lipoprotein (HDL) cholesterol, and fasting blood glucose were determined using commercially available kits. Serum glutamic pyruvic transaminase (SGPT) and serum glutamic oxaloacetic transaminase (SGOT) were determined using the method of Reitman and Frankel [19].

Statistical analysis

Variables of interest were entered and all data analyzed using GraphPad Instant 3.06 software version 14 for Windows XP (Microsoft Corporation). All statistical analyses are expressed as mean ± standard error of the mean (SEM). Data were analyzed by one-way ANOVA, where applicable $p<0.05$ was considered statistically significant, compared with vehicle followed by Dunnett's test.

RESULTS AND DISCUSSION

The acute oral toxicity studies and selection of doses were carried out as per guidelines of OECD, draft guidelines 423 received from Committee for the Purpose of Control and Supervision of Experiments on Animals, Ministry of Social Justice and Empowerment, Government of India. Healthy Wistar rats of either sex weighing between 150 and 200 g were used for acute toxicity study to determine LD50 of extract/fractions. The animals were randomly selected, marked to permit individual identification, and kept in their cages for 7 days before dosing to allow for acclimatization to the laboratory condition. In acute toxicity study, no toxic symptoms were observed for polyherbal formulation (PHF) up to dose 2000 mg/kg body weight. All animals behaved normally. No neurological or behavioral effect could be noted. No mortality was found up to 14 days study. PHF was safe up to 2000 mg/kg.

Body weights (g) of the entire animal were measured at onset of study and end of study. Mean body weight change of all the groups is shown in Table 2.

Blood glucose (g) of the entire animals was measured at different times. Mean blood glucose changes of all the groups are shown in Table 2.

In this present study shows initial the animals treated with HFD - alloxan showed marked glucose intolerance which indicated that they developed diabetes. While on the 14th day, PHF showed its hypoglycemic activity compare to negative control with unexplained mechanism.

The increased in blood sugar is accompanied with the increase in TC, TG, LDL, VLDL, and fall of HDL. It is well known that in uncontrolled type 2 diabetes mellitus, there will be an increase in TC, TG, LDL, VLDL, and TG with decrease in HDL, which contributes to the coronary artery disease. From this point of view, it is encouraging that the 14-day treatment of PHF and different extracts associated with reduced the elevated levels of TC, TG, LDL, and VLDL as compared to negative control in diabetic animals. There was increase in HDL also, which indicates that PHF may be beneficial to diabetic individuals with atherosclerosis since superior HDL level is associated with the lowered risk of the development of atherosclerosis in diabetes mellitus.

This antihyperglycemic effect of PHF on the alloxan diabetic rats suggests that its main mechanism may not be due to stimulating insulin release from pancreatic cells but may exert a direct action by promoting glucose utilization by peripheral tissues. We would need much more research work to study the mechanism.

The present study shown that biochemical parameters did not show any of the adverse effect of crude mixed extracts in rats. Liver enzymes such

Table 1: Mean body weight change

Group	Drug	Dose	Body weight (g)	
			Onset of study	End of study
I	Normal	1% tween 80	200.15±8.83	230.18±8.93
II	Control	1% tween 80	230.20±15.62	195.30±8.37
III	Glibenclamide	5 mg/kg p.o.	230.22±12.26	197.40±10.45
IV	Orlistat	60 mg/kg p.o.	232.17±8.09	165.40±6.59
V	*Momordica charantia* Linn.	200 mg/kg p.o.	230.54±6.63	219.17±10.85
VI	*Momordica charantia* Linn.	400 mg/kg p.o.	225.50±6.63	209.17±5.85
VII	*Eugenia jambolana* Linn.	200 mg/kg p.o.	235.80±8.23	220.10±10.37
VIII	*Eugenia jambolana* Linn.	400 mg/kg p.o.	235.70±8.23	207.10±11.07
IX	*Ziziphus maurantiana* Lam.	200 mg/kg p.o.	236.10±6.56	220.63±10.10
X	*Ziziphus maurantiana* Lam.	400 mg/kg p.o.	235.18±7.66	205.93±11.10
XI	AC Willd.	200 mg/kg p.o.	231.40±5.50	220.17±8.07
XII	AC Willd.	400 mg/kg p.o.	236.50±7.50	210.47±9.07
XIII	PHF	100 mg/kg p.o.	235.15±7.00	187.20±7.60
XIV	PHF	200 mg/kg p.o.	230.10±8.00	175.10±6.59

Values are expressed as mean±SEM (n=6). Values are statistically significant at p<0.05 versus negative control group, respectively (one-way ANOVA followed by Dunnett's test). PHF: Polyherbal formulation, SEM: Standard error of the mean, AC: *Acacia catechu*

Table 2: Antidiabetic activity of various extracts on blood glucose level in alloxan-induced diabetic rats for day 14

Group	Drug	Dose	Blood glucose level (mg/dl)						
			0 h	1 h	2 h	3 h	4 h	5 h	6 h
I	Normal	1% tween 80	84.67±22.70	83.67±20.95	87.00±20.40	77.33±20.3	75.00±21.50	79.67±20.23	77.67±20.22
II	Control	1% tween 80	387.40±21.29	414.00±20.66	421.40±20.59	438.00±20.15	447.20±20.36	449.80±20.55	454.60±20.55
III	Glibenclamide	5 mg/kg p.o.	362.80±20.86	310.40±20.12	271.60±21.62	250.80±20.57	230.60±20.55	190.50±22.53	175.5±4.46
IV	Orlistat	60 mg/kg p.o.	368.10±20.50	309.30±5.59	270.40±11.62	269.4±10.5	251.4±12.5	210.17±8.09	186.07±5.45
V	*Momordica charantia* Linn.	200 mg/kg p.o.	369.40±21.44	342.80±25.75	310.20±21.37	281.60±20.54	270.60±22.79	265.00±21.59	240.80±20.62
VI	*Momordica charantia* Linn.	400 mg/kg p.o.	361.40±25.16	332.20±23.61	298.80±22.88	269.20±24.51	257.20±20.55	243.00±21.59	230.80±9.72
VII	*Eugenia jambolana* Linn.	200 mg/kg p.o.	348.60±20.40	330.60±21.28	283.80±21.16	275.40±21.51	241.00±23.66	253.00±23.43	249.80±23.04
VIII	*Eugenia jambolana* Linn.	400 mg/kg p.o.	340.80±25.28	320.80±23.96	295.40±20.01	273.80±21.04	260.60±24.17	245.20±21.52	234.60±20.38
IX	*Ziziphus maurantiana* Lam.	200 mg/kg p.o.	361.20±20.89	339.10±20.30	310.40±20.10	287.60±20.01	280.40±20.64	255.5±13.25	247.00±11.00
X	*Ziziphus maurantiana* Lam.	400 mg/kg p.o.	366.12±10.08	334.11±9.05	305.15±12.00	285.5±14.1	275.10±12.5	245.10±13.0	229.04±10.10
XI	AC Willd.	200 mg/kg p.o.	364.20±20.27	340.14±12.15	309.20±17.10	297.4±14.6	280.10±11.5	259.20±12.0	237.00±12.09
XII	AC Willd.	400 mg/kg p.o.	361.50±10.07	333.10±10.05	300.40±15.00	285.3±15.8	275.10±12.5	249.10±10.0	220.03±10.11
XIII	PHF	100 mg/kg p.o.	364.10±15.17	315.12±10.09	290.40±15.00	279.3±11.6	255.10±12.5	217.60±20.01	195.60±21.03
XIV	PHF	200 mg/kg p.o.	365.60±20.55	310.10±7.59	280.50±11.60	271.4±10.6	249.5±11.5	215.10±9.09	188.20±25.72

Values are expressed as mean±SEM. (n=6). Values are statistically significant at p<0.05 versus negative control group, respectively (one-way ANOVA followed by Dunnett's test). Serum biochemistry was performed on day 14 using automatic serum biochemistry analyzer. PHF: Polyherbal formulation, SEM: Standard error of the mean

Table 3: Effect of various extracts on TC and TG level in alloxan-induced diabetic rats after treatment

Group	Drug	Dose	TC (mg/dl)	TG (mg/dl)
I	Normal	1% tween 80	78.6±2.05	99.16±13.07
II	Control	1% tween 80	66.67±5.95	78.83±7.79
III	Glibenclamide	5 mg/kg p.o.	57.83±2.45	56.50±6.00
IV	Orlistat	60 mg/kg p.o.	53.66±3.06	49.5±5.48
V	*Momordica charantia* Linn.	200 mg/kg p.o.	70.00±1.10	71.33±6.18
VI	*Momordica charantia* Linn.	400 mg/kg p.o.	67.00±2.50	65.02±5.10
VII	*Eugenia jambolana* Linn.	200 mg/kg p.o.	70.00±5.07	80.00±4.11
VIII	*Eugenia jambolana* Linn.	400 mg/kg p.o.	64.01±5.00	76.01±4.60
IX	*Ziziphus maurantiana* Lam.	200 mg/kg p.o.	72.00±8.08	69.99±2.05
X	*Ziziphus maurantiana* Lam.	400 mg/kg p.o.	66.00±7.08	64.20±2.16
XI	AC Willd.	200 mg/kg p.o.	67.00±3.10	70.00±5.16
XII	AC Willd.	400 mg/kg p.o.	61.00±4.10	65.00±4.07
XIII	PHF	100 mg/kg p.o.	59.00±2.45	62.00±2.10
XIV	PHF	200 mg/kg p.o.	57.83±3.50	57.01±3.06

Values are expressed as mean±SEM. (n=6). Values are statistically significant at p<0.05 (one-way ANOVA followed by Dunnett's test). PHF: Polyherbal formulation, SEM: Standard error of the mean, AC: *Acacia catechu,* TG: Triglyceride, TC: Total cholesterol

Table 4: Effect of various extracts on LDL and VLDL in alloxan-induced diabetic rats after treatment

Group	Drug	Dose	LDL (mg/dl)	VLDL (mg/dl)
I	Normal	1% tween 80	17.8±3.60	19.83±2.07
II	Control	1% tween 80	69.5±1.76	48.10±1.53
III	Glibenclamide	5 mg/kg p.o.	53.4±5.16	42.30±0.54
IV	Orlistat	60 mg/kg p.o.	46.4±2.71	37.10±0.60
V	*Momordica charantia* Linn.	200 mg/kg p.o.	66.00±3.50	51.50±3.80
VI	*Momordica charantia* Linn.	400 mg/kg p.o.	59.50±5.00	48.50±2.70
VII	*Eugenia jambolana* Linn.	200 mg/kg p.o.	65.40±5.10	50.60±2.80
VIII	*Eugenia jambolana* Linn.	400 mg/kg p.o.	60.00±4.50	47.55±1.70
IX	*Ziziphus maurantiana* Lam.	200 mg/kg p.o.	66.00±5.10	51.00±1.80
X	*Ziziphus maurantiana* Lam.	400 mg/kg p.o.	58.10±6.18	46.90±2.10
XI	AC Willd.	200 mg/kg p.o.	65.00±2.10	50.00±2.70
XII	AC Willd.	400 mg/kg p.o.	59.00±2.11	47.20±1.17
XIII	PHF	100 mg/kg p.o.	49.6±5.06	44.8±0.17
XIV	PHF	200 mg/kg p.o.	47.9±1.01	39.4±1.54

Values are expressed as mean±SEM. (n=6). Values are statistically significant at p<0.05 (one-way ANOVA followed by Dunnett's test). LDL: Low-density lipoprotein, VLDL: Very low-density lipoprotein, SEM: Standard error of the mean, AC: *Acacia catechu*

Table 5: Effect of various extracts on HDL in alloxan-induced diabetic rats after treatment

Group	Drug	Dose	HDL (mg/dl)
I	Normal	1% tween 80	35.00±1.54
II	Control	1% tween 80	32.50±1.70
III	Glibenclamide	5 mg/kg p.o.	42.50±1.10
IV	Orlistat	60 mg/kg p.o.	47.00±1.32
V	*Momordica charantia* Linn.	200 mg/kg p.o.	39.40±1.15
VI	*Momordica charantia* Linn.	400 mg/kg p.o.	40.30±1.50
VII	*Eugenia jambolana* Linn.	200 mg/kg p.o.	38.50±4.14
VIII	*Eugenia jambolana* Linn.	400 mg/kg p.o.	41.00±2.50
IX	*Ziziphus maurantiana* Lam.	200 mg/kg p.o.	39.00±2.14
X	*Ziziphus maurantiana* Lam.	400 mg/kg p.o.	41.00±1.80
XI	AC Willd.	200 mg/kg p.o.	39.15±2.11
XII	AC Willd.	400 mg/kg p.o.	40.20±2.38
XIII	PHF	100 mg/kg p.o.	43.9±2.13
XIV	PHF	200 mg/kg p.o.	45.8±4.38

Values are expressed as mean±SEM. (n=6). Values are statistically significant at p<0.05 (one-way ANOVA followed by Dunnett's test). HDL: High-density lipoprotein, SEM: Standard error of the mean, AC: *Acacia catechu*

as SGOT and SGPT are considered to be biochemical markers for assessing liver function. The PHF significantly reduced the liver enzymes levels in experimental animal's shows that combined therapy has hepatoprotective effect. During the experimentation, Wistar rats did not show any mortality or any other adverse effects when the rats fed orally with polyherbal extract at the doses of 100–200 mg/kg. Thus, the PHF has a good periphery of safety. However, when given in combination, i.e., diabetic + PHF hepatotoxicity was reduced and appeared comparable to negative control, serum biochemically as well as histologically. All diabetic-treated groups showed histopathological changes of varying degree of alveolar histiocytosis due to phospholipidosis. Histopathology data showed minimal hepatic degeneration and focal hepatocellular hypertrophy in negative control animals, which might be the effect of alloxan-induced free radical damage. Furthermore, these results indicated increased risk of hepatotoxicity in negative control animals than normal animals due to PHF and different extracts. Liver from diabetic + *M. charantia* Linn., *E. jambolana* Linn., *Z. maurantiana* Lam., and AC Willd. extract groups showed focal hepatocellular hypertrophy and degeneration indicating minimal hepatotoxicity due to increased peroxisome proliferation while diabetic + PHF group showed negligible potential of nephrotoxicity. The reduced histopathological changes in kidney from diabetic + PHF group indicated that combination improved nephrotoxicity in diabetic condition.

CONCLUSION

Obesity is associated with insulin resistance and cardiovascular disease risk factors. Therapeutic agents with both antidiabetic and antiobese

Table 6: Effect of various extracts on SGOT and SGPT in alloxan-induced diabetic rats after treatment

Group	Drug	Dose	SGOT (IU/L)	SGPT (IU/L)
I	Normal	1% tween 80	29.32±1.53	22.27±1.85
II	Control	1% tween 80	53.17±1.20	44.56±1.99
III	Glibenclamide	5 mg/kg p.o.	41.35±0.95	41.27±1.50
IV	Orlistat	60 mg/kg p.o.	34.01±1.10	29.89±1.98
V	*Momordica charantia* Linn.	200 mg/kg p.o.	45.30±1.50	43.00±1.40
VI	*Momordica charantia* Linn.	400 mg/kg p.o.	42.50±1.80	40.50±1.60
VII	*Eugenia jambolana* Linn.	200 mg/kg p.o.	44.40±1.40	42.50±1.60
VIII	*Eugenia jambolana* Linn.	400 mg/kg p.o.	41.80±1.78	39.50±1.70
IX	*Ziziphus maurantiana* Lam.	200 mg/kg p.o.	45.00±1.50	42.00±1.50
X	*Ziziphus maurantiana* Lam.	400 mg/kg p.o.	43.00±1.18	39.00±1.80
XI	AC Willd.	200 mg/kg p.o.	45.04±1.52	41.80±1.50
XII	AC Willd.	400 mg/kg p.o.	42.00±1.58	40.55±1.48
XIII	PHF	100 mg/kg p.o.	40.34±1.62	38.86±1.33
XIV	PHF	200 mg/kg p.o.	39.01±1.55	33.53±1.88

Values are expressed as mean±SEM (n=6). Values are statistically significant at p<0.05 (one-way ANOVA followed by Dunnett's test). LDL: Low-density lipoprotein, VLDL: Very low-density lipoprotein, SEM: Standard error of the mean, AC: *Acacia catechu,* SGOT: Serum glutamic oxaloacetic transaminase, SGPT: Serum glutamic pyruvic transaminase

effects are, therefore, particularly beneficial. Our results show that HFD rats treated with *M. charantia* Linn.*, E. jambolana* Linn.*, Z. maurantiana* Lam., AC Willd., and aqueous extract of all extracts underwent a time-dependent reduction in body weight and cholesterol, TGs as well as controlling the glycemia reflecting antiobesity and antidiabetic activity. The plant material may exert their antidiabetic and antiobesity effects through actions that improve insulin sensitivity and the balance between food intake and energy expenditure.

CONFLICTS OF INTEREST

All authors have none to declare.

AUTHOR'S CONTRIBUTION

All the authors have equally contributed.

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