A comparative study of alpha amylase inhibitory activities of common anti-diabetic plants at Kharagpur 1 block

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In India, the prevalence of diabetes mellitus is on the increase and needs to be addressed appropriately. In this study area, herbal remedies are considered convenient for management of Type 2 diabetes with postprandial hyperglycemia due to their traditional acceptability and availability, low costs, lesser side effects. Comparative evaluation of alpha amylase inhibitory activities of selected plants extracts. Kharagpur is situated in the Midnapur West district of West Bengal in India. In this district, diabetes prevalence is comparatively high. Ten common plants in IIT Kharagpur 1 Block namely, *Acalypha indica*, *Allium cepa*, *Allium sativum*, *Azadirachta indica*, *Musa sapientum*, *Mangifera indica*, *Murraya*, *Ocimum sanctum*, *Phyllanthus amarus* and *Tinospora cordifolia* were tested for their alpha amylase inhibitory activities to establish anti-diabetic potentials. The plant extracts were prepared sequentially with petroleum ether, hexane, chloroform, ethanol and aqueous. The extracts obtained were subjected to *in vitro* alpha amylase inhibitory assay using starch azure as a substrate and porcine pancreatic amylase as the enzyme. Statistical difference and linear regression analysis were performed by using Graphpad prism 5 statistical software. Ethanol extracts of *Mangifera indica*, *Azadirachta indica* and petroleum ether extract of *Murraya koenigii* (at a concentrations 10-100µg/ml) showed maximum percentage inhibition on alpha amylase activity with an IC_{50} value of 37.86 ± 0.32µg/ml, 62.99 ± 1.20µg/ml and 59.0 ± 0.51µg/ml respectively when compared with acarbose (IC_{50} value 83.33 ± 0.75µg/ml). The results showing that *Mangifera indica*, *Azadirachta indica* and *Murraya koenigii* might be effective in lowering post prandial hyperglycemia.

Key words: Alpha amylase inhibition, plant extracts, postprandial hyperglycemia

INTRODUCTION

The prevalence of Type 2 diabetes is on increase and literally it can be said that India including rural West Bengal also facing a diabetic explosion.[1] Khargpur, situated in West Midnapur district of Bengal is no exception and the disease prevalence is 5.2 in tribal populace and 8.6 in non tribes. The prevalence on being compared with other districts of West Bengal showed that an appropriate and effective step is needed in the district to control the disease spectrum[2] One of the therapeutic approaches in Type 2 diabetes is to lower the corresponding postprandial blood glucose values. Alpha amylase inhibitor plays major role in the management of postprandial hyperglycemia.[3] It inhibits the action of alpha amylase enzyme leading to a reduction in starch hydrolysis to maltose and consequentially lower postprandial hyperglycemia.[4] Various medications are available for the treatment of Type 2 diabetes like biguanides, sulphonylureas, thiozolidinediones etc. But they have also exhibited a number of undesired side effects associated with their uses and thus suggesting other effective alternatives.[5] Medicinal plants have been always an exemplary source of drugs. Traditional medicinal plants with their various biological constituents have been used effectively by the communities since long time to treat diseases. Plant extracts or bio-active herbal compounds have been reported scientifically for their biological activities. *Acalypha indica* leaf showed antioxidant activity due to presence of kaempferol glycosides, mauritianin, clitorin, nicotiflorin and biorobin[6] Administration a sulfur containing amino acid isolated from *Allium cepa* Linn called S-methyl cysteine sulphoxide (at a dose 200 mg/kg for 45 days) showed antidiabetic and hypoloipidemic effects in alloxanized rats.[7] Oral administration of 0.25 gm/kg allicin isolated from *Allium sativum* exhibited hypoglycemia in mildly diabetic rabbits.[8] Hydroalcoholic extract of *Azadirachta indica* showed hypoglycemic and anti-hyperglycemic effect in normal, glucose fed and streptozotocin induced diabetic rats.[9] A new compound isochroman-4-one was isolated from *Musa sapientum* L peel and reported to possess antihypertensive activity in hypertensive rats.[10] Mangiferin from stem bark of *Mangifera indica* Linn showed anti-diabetic and anti-atherogenic effects.[11] *Murraya koenigii* leaves has been reported to possess hypoglycemic activity due to presence of carbazole alkaloids namely murrayanine, mahanimbine, girinimbine, murrayacine and isomurrayazoline.[12]

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Eugenol (l-hydroxy-2-methoxy-4-allylbenzene), the active constituent present in *Ocimum sanctum* exhibited antifertility, anticancer, antidiabetic, antifungal, antimicrobial, hepatoprotective, cardioprotective, antiemetic, antispasmodic, analgesic actions.[13] Whole plants of *Phyllanthus amarus* showed anti-hepatitis and anti-diabetic activities due to presences of chemical compounds phyllanthin, hypophyllanthin, phylletetralin, nirtetralin and lintetralin, querectin, quercitrin, rutin.[14] *Tinospora cordifolia* leaves exhibited anti-diabetic, anti-periodic, anti-spasmodic, anti-inflammatory, anti-arthritic, antioxidant, anti-allergic, anti-stress, anti-leprotic, anti-malarial due to presence of alkaloids, diterpenoid lactones, glycosides, steroids, sesquiterpenoid, phenolics, aliphatic compounds and polysaccharides.[15] The ethno-botanical information reports about 800 plants may possess anti-diabetic potentials.[16] Various natural sources including plant products have been investigated with respect to glucose production suppression from carbohydrates in the gut or glucose absorption from the intestine.[17,18] The present study compares the alpha amylase inhibitory activities of some commonly available plants from Kharagpur 1 block namely *Acalypha indica* Linn, *Allium cepa* Linn, *Allium sativum* Linn, *Azadirachta indica* A Juss, *Musa sapientum* Linn, *Mangifera indica* Linn, *Murraya koenigii* (L) Sprengel, *Ocimum sanctum* Linn, *Phyllanthus amarus* Linn, *Tinospora cordifolia* Miers.

MATERIALS AND METHODS

Chemicals

Starch azure, porcine pancreatic amylase, and Tris-HCl buffer all were procured from Sigma Chemicals (USA). Other reagents like dimethyl sulfoxide (DMSO), acetic acid, calcium chloride, petroleum ether, hexane, chloroform and ethanol were purchased from Merck (India). Acarbose was obtained as a gift from a company (Zota Pharmaceuticals Private Limited located in Chennai, India).

Plant Materials

Carefully inspected healthy plant parts of *Acalypha indica*, *Allium cepa*, *Allium sativum*, *Azadirachta indica*, *Musa sapientum*, *Mangifera indica*, *Murraya koenigii*, *Ocimum sanctum*, *Phyllanthus amarus*, *Tinospora cordifolia* were collected from the various localities of Indian Institute of Technology at Kharagpur (West Bengal, India) in the month of September 2007. All selected plant parts were botanically identified and authenticated by a Plant Biotechnologist (M. Senthilkumar, Faculty, Prathyusha Institute of Technology and Management, Chennai). A voucher specimen of each species was deposited in the herbarium of Prathyusha Institute of Technology and Management [Table 1]. All selected plant parts were dried at room temperature (27–30°C) for 25–30 days maintaining hygienic conditions. After complete drying, the each dried plant part materials were grounded to form a powder using a domestic electric grinder (Product: GX 21, Bajaj appliances, Mumbai, India) and then stored in brown bottle to conduct the experimental protocols.

Table 1: Plant species studied

Plant species	Family	Part used	Voucher sample
Acalypha indica Linn	Euphorbiaceae	Whole plant	PITAM/CH/ 00025/2007
Allium sativum Linn	Alliaceae	Bulb	PITAM/CH/ 00021/2007
Allium cepa Linn	Alliaceae	Bulb	PITAM/CH/ 00010/2007
Azadirachta indica A Juss	Meliaceae	Leaves	PITAM/CH/ 00015/2007
Musa sapientum Linn	Musaceae	Flowers	PITAM/CH/ 00017/2007
Mangifera indica Linn	Ancardiaceae	Stem barks	PITAM/CH/ 00007/2007
Murraya koenigii (L) Sprengel	Rutaceae	Leaves	PITAM/CH/ 00009/2007
Ocimum sanctum Linn	Lamiaceae	Leaves	PITAM/CH/ 00018/2007
Phyllanthus amarus Linn	Euphorbiaceae	Whole plant	PITAM/CH/ 00011/2007
Tinospora cordifolia Miers	Meninspermaceae	Leaves	PITAM/CH/ 00013/2007

Preparation of Extracts

Each Plant powder (30 g) was subjected to successive maceration with 300ml of petroleum ether, hexane, chloroform, ethanol and water in a shaker system at room temperature. Then each extracts were filtered. The filtrate was subjected to evaporation under reduced pressure to obtain dried extract. The percentage yield of each dried plant extract was calculated [Table 2]. Each dried extracts were subjected to alpha amylase inhibitory assay.

In Vitro Alpha Amylase Inhibitory Assay

The assay was carried out following the standard protocol with slight modifications.[19] Starch azure (2 mg) was suspended in a tube containing 0.2ml of 0.5 M Tris-Hcl buffer (pH 6.9) containing 0.01 M calcium chloride (substrate). The tube was boiled for 5 min and then preincubated at 37°C for 5 min. 1ml of 0.1% of dimethyl sulfoxide was used to dissolve 1 mg of dried plant extract in order to obtain concentrations of 10, 20, 40, 60, 80 and 100 μg/ml. Then 0.2 ml of plant extract of a particular concentration was put in the tube containing the substrate solution. 0.1 ml of porcine pancreatic amylase in Tris-Hcl buffer (2 units/ml) was added to the tube containing the plant extract and substrate solution. The process was carried out at 37°C for 10 min. The reaction was stopped by adding 0.5 ml of 50% acetic acid in each tube. The reaction mixture was then centrifuged (Eppendorf -5804 R) at 3000 rpm for 5 min at 4°C. The absorbance of resulting supernatant was measured at

Table 2: Percentage yields of extracts (%W/W)

Plant species	Parts used	Petroleum ether	Hexane	Chloroform	Ethanol	Aqueous
Acalypha indica	Whole plant	1.3	2	2.6	3.3	4
Allium sativum	Bulb	1	1.6	2.3	3	3.6
Allium cepa	Bulb	0.6	1.3	1.6	2	2.3
Azadirachta indica	Leaves	0.6	1	1.6	2.3	2.6
Musa sapientum	Flowers	1	1.6	1.8	2	2.1
Mangifera indica	Stem barks	0.6	1	1.3	2	2.6
Murraya koenigii	Leaves	1	1.3	1.6	2	2.3
Ocimum sanctum	Leaves	0.6	1	1.6	2	2.3
Phyllanthus amarus	Whole plant	1	1.3	1.6	2	2.3
Tinospora cordifolia	Leaves	0.6	1	1.3	1.6	2

595 nm using spectrophotometer (Perkin Elmer Lambda 25 UV-VIS). Same procedure was followed for all other plants extracts (petroleum ether, hexane, chloroform, ethanol and aqueous) to test the alpha amylase inhibitory effects. The experiments were repeated thrice using the same protocol.

Method for Calculation of α-amylase Inhibitory Activity

Absorbance was calculated by using following formula

The α-amylase inhibitory activity = (Ac+) – (Ac-) – (As-Ab) / (Ac+) – (Ac-) × 100

Where, Ac+, Ac-, As, Ab are defined as the absorbance of 100% enzyme activity (only solvent with enzyme), 0% enzyme activity (only solvent without enzyme), a test sample (with enzyme) and a blank (a test sample without enzyme) respectively.[19]

Statistical Analysis

All values were expressed mean ± standard deviation. Statistical difference and linear regression analysis were performed using Graphpad prism 5 statistical software.

RESULTS

The results showed that various extracts of selected plants exhibited different degree of alpha amylase inhibitory activities by *in vitro* assay using starch azure as a substrate.

Positive Control

Acarbose is a known drug for alpha amylase inhibitor. Acarbose (at a concentrations 10-100µg/ml) showed alpha amylase inhibitory activity from 18.75 ± 1.17 to 58.54 ± 1.20% with an IC_{50} value 83.33 ± 0.75 µg/ml [Table 3].

Table 3: IC50 values of acarbose on alpha amylase inhibition

Standard drug	Concentrations (µg/ml)	% inhibition	IC_{50} value
Acarbose	100	58.54±1.17	83.33±0.75
	80	48.27±0.38	
	60	38.74±0.64	
	40	29.73±0.60	
	20	22.41±1.38	
	10	18.75±1.20	

Extracts with Maximum Inhibitory Effects on the Alpha Amylase Activity

Ethanol extracts of *Mangifera indica*, *Azadirachta indica* and also petroleum ether extract of *Murraya koenigii* (at a concentrations 10-100µg/ml) showed maximum alpha amylase inhibitory activity from 35.79 ± 0.33 to 62.49 ± 0.34%, 16.50 ± 1.23 to 66.66 ± 0.93% and 21.57 ± 1.46 to 60.78 ± 0.55% with an IC_{50} value of 37.86 ± 0.32 µg/ml, 62.99 ± 1.20 µg/ml and 59.0 ± 0.51 µg/ml, respectively [Table 4].

Extracts with Moderate Inhibitory Effects on the Alpha Amylase Activity

In the study, it was observed that hexane and ethanol extracts of *Phyllanthus amarus* (at a concentrations 10-100µg/ml) showed moderate alpha amylase inhibitory activity from 25.86 ± 86 to 48.90 ± 0.38% and 30.75 ± 0.40 to 51.28 ± 0.35% with an IC_{50} values 82.82 ± 0.45µg/ml and 83.64 ± 0.48 µg/ml, respectively [Table 5].

Extracts with Minimum Inhibitory Effects on the Alpha Amylase Activity

The chloroform extracts of *Musa sapientum, Allium cepa, Murraya koenigii* and *Acalypha indica* (at a concentrations 10-100µg/ml) showed minimum alpha amylase inhibitory activity from 12.23 ± 1.55 to 46.50 ± 0.45%, 9.71 ± 0.46 to 31.75 ± 0.44%, 6.37 ± 1.37 to 27.44 ± 0.55% and 7.98 ± 0.98 to 29.53 ± 0.52% with an IC_{50} values 97.87 ± 0.73 µg/ml, 166.38 ± 0.48µg/ml 191.88 ± 0.65µg/ml, 173.53 ± 0.21µg/ml. In addition, ethanol extracts of *Allium sativum, Acalypha indica, Tinospora cordifolia* and *Ocimum sanctum* (at a concentrations 10-100µg/ml) also exhibited minimum alpha amylase inhibitory effects from 8.84. ± 0.86 to 39.77 ± 0.30%, 13.53 ± 2.25 to 31.16 ± 0.11%, 12.32 ± 0.79 to 36.41 ± 0.39% and 14.89 ± 0.75 to 40.53 ± 0.65% with an IC_{50} values 120.24 ± 0.25µg/ml, 180.86 ± 0.23µg/ml, 138.80 ± 0.16µg/ml and 178.55 ±

Table 4: Extracts with maximum inhibitory effects on the alpha amylase activity

Plant	Extract	Concentrations (µg/ml)	% inhibition	IC_{50} value (µg/ml)
Mangifera indica	Ethanol	100	62.49±0.34	37.86±0.32
		80	61.74±0.69	
		60	60.24±0.69	
		40	58.01±0.34	
		20	44.68±0.37	
		10	35.79±0.33	
Azadirachta indica	Ethanol	100	66.66±0.93	62.99±1.20
		80	66.11±0.15	
		60	47.30±1.27	
		40	37.12±1.45	
		20	27.06±3.06	
		10	16.50±1.23	
Murraya koenigii	Petroleum ether	100	60.78±0.55	59.0±0.51
		80	59.21±0.55	
		60	57.25±0.55	
		40	45.86±0.95	
		20	37.25±1.46	
		10	21.57±1.46	

0.45µg/ml respectively. Furthermore, the aqueous extract of *Azadirachta indica* and hexane extract of *Mangifera indica* (at a concentrations 10-100µg/ml) showed minimum alpha amylase inhibitory effects from 14.89 ± 0.75 to 40.53 ± 0.65 and 8.63 ± 1.26 to 40.24 ± 0.34 with an IC_{50} value of 124.62 ± 0.15 and 114.13 ± 0.22µg/ml respectively [Table 6].

Extracts Showing no Effects on the Alpha Amylase Activity

Aqueous extracts of *Acalypha indica*, *Allium cepa*, *Allium sativum*, *Musa sapientum*, *Mangifera indica*, *Murraya koenigii*, *Ocimum sanctum*, *Phyllanthus amarus* and ethanol extracts of *Musa sapientum Murraya koenigii* showed no inhibitory effects on the alpha amylase activity. Chloroform extracts of *Allium cepa*, *Allium sativum*, *Azadirachta indica, Mangifera indica*, *Ocimum sanctum*, *Phyllanthus amarus*, *Tinospora cordifolia* and hexane extracts of *Acalypha indica*, *Allium cepa*, *Allium sativum*, *Azadirachta indica*, *Musa sapientum*, *Murraya koenigii, Ocimum sanctum*, *Tinospora cordifolia* had no alpha amylase inhibitory effects. Furthermore, Petroleum ether extracts *of Acalypha indica*, *Allium cepa, Allium sativum*, *Azadirachta indica*, *Musa sapientum*, *Mangifera indica*, *Ocimum sanctum*, *Phyllanthus amarus* and *Tinospora cordifolia* also showed no inhibitory effects on alpha amylase activity [Table 7].

Table 5: Extracts with moderate inhibitory effects on the alpha amylase activity

Plant	Extract	Concentrations (µg/ml)	% inhibition	IC_{50} value (µg/ml)
Phyllanthus amarus	Hexane	100	48.90±0.38	82.82±0.45
		80	41.66±0.41	
		60	39.93±0.40	
		40	38.21±0.40	
		20	35.44±0.57	
		10	25.86±0.70	
Phyllanthus amarus	Ethanol	100	51.28±0.35	83.64±0.48
		80	49.71±0.41	
		60	47.12±0.40	
		40	41.95±0.41	
		20	38.79±0.70	
		10	30.75 ± 0.41	

DISCUSSION

Many herbal extracts has been reported for their anti-diabetic activities and being used in Ayurveda for the treatment of diabetes. Herbal extracts has been used directly or indirectly for the preparation of many modern medicines. However, medicinal plants have not gained much importance as medicines and one of the important factors is lack of specific standards being prescribed for herbal medicines and scientific support.

In the present study, ten common plants from IIT Kharagpur 1 block, namely *Acalypha indica*, *Allium sativum*, *Allium cepa*, *Azadirachta indica*, *Musa sapientum*, *Mangifera indica*, *Murraya koenigii*, *Ocimum sanctum*, *Phyllanthus amarus* and *Tinospora cordifolia* were evaluated for their respective alpha amylase inhibitory activity. The results showed that ethanol extracts of *Mangifera indica* and *Azadirachta indica* as well as the petroleum ether extract of *Murraya koenigii* showed more percentage inhibition on alpha amylase activity. This may be due to presence of potential alpha amylase inhibitors (alkaloids, flavonoids, terpenoids or glycosides). Interestingly, petroleum ether, hexane, chloroform and aqueous extracts of *Mangifera indica* and *Azadirachta indica* and hexane, chloroform, ethanol and aqueous extracts of *Murraya koenigii* did not show much effect on alpha amylase inhibitory activity.

Many plant extracts and natural products have been investigated with respect to suppression of glucose production from carbohydrates in the gut or glucose absorption from the intestine.[20] Alpha amylase catalyses the hydrolysis of 1, 4-glucosidic linkages of starch, glycogen and various oligosaccharides into simpler sugars which can be readily available for the intestinal absorption. Inhibition of alpha amylase enzyme in the digestive tract of human is being considered to be effective in controlling diabetes by decreasing the absorption of glucose from starch.[21]

Aqueous extracts of the *Mangifera indica* leaves and stem bark have been reported to possess anti-diabetic activities

Table 6: Extracts with minimum inhibitory effects on the alpha amylase activity

Plant	Extract	Concentrations (µg/ml)	% inhibition	IC_{50} value (µg/ml)
Musa sapientum	Chloroform	100	46.50±0.45	97.80±0.73
		80	45.36±0.71	
		60	37.91±0.43	
		40	31.80±1.14	
		20	20.18±0.75	
		10	12.23±1.55	
Allium cepa	Chloroform	100	31.75±0.44	166.38±0.48
		80	30.45±0.86	
		60	26.72±1.17	
		40	22.32±0.44	
		20	16.34±1.17	
		10	9.71±0.46	
Murraya koenigii	Chloroform	100	27.44±0.55	191.88±0.65
		80	26.61±0.61	
		60	25.09±0.91	
		40	20.39±0.55	
		20	15.65±0.51	
		10	6.37±1.37	
Acalypha indica	Chloroform	100	29.53±0.52	173.53±0.21
		80	28.81±0.49	
		60	21.87±1.47	
		40	19.09±1.30	
		20	11.45±0.85	
		10	7.98±0.98	
Allium sativum	Ethanol	100	39.77±0.30	120.24±0.25
		80	38.84±1.01	
		60	30.69±0.89	
		40	25.17±1.17	
		20	17.78±1.28	
		10	8.84±0.86	
Acalypha indica	Ethanol	100	31.16±0.11	180.86±0.23
		80	30.58±0.47	
		60	24.68±1.30	
		40	20.48±1.29	
		20	15.36±0.92	
		10	13.53±2.25	
Tinospora cordifolia	Ethanol	100	36.41±0.39	138.80±0.16
		80	35.01±0.39	
		60	31.93±0.68	
		40	27.45±0.39	
		20	17.92±0.39	
		10	12.32±0.79	
Ocimum sanctum	Ethanol	100	27.81±0.40	178.55±0.45
		80	26.87±0.38	
		60	26.66±0.85	
		40	16.66±0.1.13	
		20	13.32±0.42	
		10	6.05±1.13	
Azadirachta indica	Aqueous	100	40.53±0.65	124.62±0.15
		80	39.40±0.28	
		60	33.33±0.46	
		40	30.03±0.46	
		20	23.15±1.16	
		10	14.89±0.75	
Mangifera indica	Hexane	100	40.24±0.34	114.13±0.22
		80	39.00±0.34	
		60	36.78±0.34	
		40	21.97±0.92	
		20	16.29±1.81	
		10	8.63±1.26	

Contd....

Table 1 *(Contd....)*

in diabetic rats.[22,23] Hydro alcoholic extract of *Azadirachta indica* showed hypoglycemic effects in normal, glucose fed and streptozotocin diabetic rats.[24] Feeding of *Murraya koenigii* leaves in the diet (10% w/w) for 60 days to normal rats showed hypoglycemic effects.[25] Curry leaves powder supplementation (12 g providing 2.5 g fibre) for a period of one month in diabetic patients exhibited hypoglycemic action.[26] Oral administration of 0.25 mg/kg of ethanol, petroleum ether and ethyl ether extract of *Allium sativum* showed 18.9%, 17.9% and 26.2% hypoglycemic actions respectively in alloxan induced diabetic rabbits.[27] Daily oral feeding of garlic extract (100 mg/kg) showed prevention of cardiac complications in streptozotocin rats.[28] Single dose (0.25 mg/ml) of ether soluble fraction of onion (*Allium cepa*) exhibited hypoglycemic effects in normal fasted rabbits.[29] Further, oral administration of 250mg/kg of ethanol, petroleum ether, chloroform and acetone extracts of onion (*Allium cepa*) showed hypoglycemic actions in alloxan induced diabetic rabbits.[30] Oral administration of various doses (150, 200 and 250 mg/kg) of chloroform extract of *Musa sapientum* flowers for 30 days showed hypoglycemic effect in alloxanized rats.[31] The ethanol (70%) leaves extract of *Ocimum sanctum* showed reduction of blood sugar level in normal and streptozotocin induced diabetic rats.[32] Diet containing *Ocimum sanctum* leaf powder (1%) exhibited reduction in fasting blood sugar, uronic acid, total amino acid, total cholesterol, triglycerides and total lipids.[33] Oral administration of a preparation of the whole plant of *Phyllanthus amarus* (5 gm/day in divided doses) for 10 days reduces blood glucose in diabetic as well as nondiabetic subjects.[34] Oral administration of 400 mg/kg of aqueous extract of *Tinospora cordifolia* for 15 weeks showed hypoglycemia of 70.37%, 48.81% and 0% in mild (plasma sugar >180 mg/dl), moderate (plasma sugar >280 mg/dl) and severe (plasma sugar >400 mg/dl) diabetic rats respectively[35] Oral administration of water extract of *Tinospora cordifolia* roots showed significant reduction in blood glucose in alloxanized diabetic rats.[36] *Acalypha*

Table 7: Extracts that showed inhibitory effects on alpha amylase

Plant species	Parts used	Petroleum Ether	Hexane	Chloroform	Ethanol	Aqueous
Acalypha indica	Whole plant	-	-	+	+	-
Allium sativum	Bulb	-	-	-	+	-
Allium cepa	Bulb	-	-	-	+	-
Azadirachta indica	Leaves	-	-	-	++ + *	+
Musa sapientum	Flowers	-	-	+	-	-
Mangifera indica	Stem barks	-	+	-	+ + + *	-
Murraya koenigii	Leaves	++ + *	-	+	-	-
Ocimum sanctum	Leaves	-	-	-	+	-
Phyllanthus amarus	Whole plant	-	+ + *	-	+ +*	-
Tinospora cordifolia	Leaves	-	-	-	+	-

[+++ *] indicated extracts with high inhibitory effects on alpha amylase activity. [++*] indicated extracts with Moderate inhibitory effects on alpha amylase activity. [+] indicated extracts with minimum inhibitory effects on alpha amylase activity. [-] indicated extracts with no inhibitory effects on alpha amylase activity.

indica is used in Indian traditional medicinal system and it has been reported that chloroform and hexane extracts to possess alpha amylase activities.[37]

In this study, we compared IC_{50} value of alpha amylase inhibitory effects of some plant extracts with previous studies. In previous study, ethanol extract of *Allium sativum* and *Allium cepa* has been reported for alpha amylase inhibitory effects with an IC_{50} valve 17.95 and 16.36mg/ml.[38] Oleanolic acid and ursolic acid was isolated from *Phyllanthus amarus* and showed potent alpha amylase inhibitory effects with IC_{50} values of 2.01μg/ml.[39] In our study, ethanol extract of *Allium sativum Allium cepa* and *Phyllanthus amarus* exhibited alpha amylase inhibitory effects with an IC_{50} valve of 120.24 ± 0.25, 166.31 ± 0.18 and 83.64 ± 0.13 μg/ml. In addition, hexane extract of *Phyllanthus amarus* showed alpha amylase inhibitory effects with an IC_{50} valve of 82.36 ± 0.21 μg/ml. However, ethanol extract of *Mangifera indica, Azadirachta indica* and petroleum ether extract of *Murraya koenigii* showed more percentage inhibition on alpha amylase activity.

The present study indicated that *Mangifera indica, Azadirachta indica* and *Murraya koenigii* could be useful in management of postprandial hyperglycemia. The results of this study directs further researches to evaluate the therapeutic potentialities of *Mangifera indica*, *Azadirachta indica* and *Murraya koenigii* in the management of postprandial hyperglycemia and Type 2 diabetes either alone or in a combinatorial therapy.

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