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Anti-hyperglycemic effect of black tea (*Camellia sinensis*) in rat

A. Gomes, J.R. Vedasiromoni, M. Das, R.M. Sharma, D.K. Ganguly*

Division of Pharmacology and Experimental Therapeutics, Indian Institute of Chemical Biology, 4, Raja S.C. Mullick Road, Calcutta 700032, India

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Abstract

Investigations were carried out to evaluate the effect of the hot water extract of black tea (*Camellia sinensis* (L.) O. Kuntze (Theaceae) on streptozotocin (STZ)-induced diabetes in rats. The extract significantly reduced the blood glucose level and was found to possess both preventive and curative effects on experimentally produced diabetes in rats. The study reveals that, like green tea, black tea also possesses antidiabetic activity.

Keywords: Diabetes; *Camellia sinensis* (L) O. Kuntze; Black tea; Blood glucose

1. Introduction

The medicinal value of tea has been historically well known for a plethora of pharmacotherapeutic efficacies (Krishnamoorthy, 1991). However, attempts to scientifically validate the medicinal properties of tea have only been made within the last decade, especially by Japanese workers, employing updated methodology. The 'Case of Tea' was reviewed by F.A.O. of UN in its meeting (9th session) on 'Tea Consumption and Human Health' in Rome in 1991. It recommended that serious efforts are to be made to evaluate the impact of tea drinking on human health. It was also emphasised that in doing so 'research should be directed towards the impact of tea on human health in its totality and not on certain isolated fractions'.

Taking the clue from folk remedy of antidiabetic property of tea (Koyanagi and Minowada, 1933; Konayagi and Minowada, 1935), a number of Japanese investigators have demonstrated the antidiabetic efficacy of green tea (Shimizu et al., 1988; Isigaki et al., 1991; Matsumoto et al., 1993). Both catechins and polysaccharides present in green tea have been claimed to be responsible for its antidiabetic efficacy (Isigaki et al., 1991; Matsumoto et al., 1993).

The pharmacotherapeutics of black tea, accounting for about 75% of the tea manufactured globally (Graham, 1991) has so far not been investigated. We report here, for the first time, the antidiabetic property of black tea in its totality.

2. Materials and methods

2.1. Animals

The experiments were carried out with male albino rats (Sprague Dawley strain) weighing 150–200 g. They were fed laboratory diet and were maintained under 12 h light/dark cycle at

* Corresponding author.

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25 ± 2°C. Although food uptake was not monitored, no change was observed in body weight of treated and untreated animals.

2.2. Source of the tea

Experiments were done with CTC BoP grade black clonal tea processed in October, 1991 and supplied by Tocklai Experimental Station, Jorhat, Assam, India. Green tea (MW-R-HAD) was supplied by M/S Goodricke Tea Co., Calcutta, India in March, 1993.

2.3. Preparation of hot water extract of the tea

20 g of tea (black or green) was soaked in 100 ml of boiling water. After 5 min it was filtered and the filtrate was fed intragastrically to rats at a temperature of 37 ± 1°C. The filtrate is designated as either 'black tea extract' or 'green tea extract'. Control rats were administered an equivalent volume of distilled water intragastrically at 37 ± 1°C.

2.4. Chemicals

Streptozotocin, purchased from Sigma, USA was dissolved in distilled water.

2.5. Methods

The rats were divided into 2 main groups as follows:-

Group I: each rat in this group was administered streptozotocin (STZ) 40 mg/kg intravenously into the tail vein. After 14 days the blood glucose of each animal was checked and those animals displaying more than 200–300 mg% blood glucose were separated and divided into 3 subgroups of 20 rats each. While rats in subgroup 1 received 2 ml/100 g body weight per day of distilled water intragastrically for 3 weeks (STZ control), rats of subgroups 2 and 3 received intragastrically 2 ml/100 g body weight per day of black tea extract and green tea extract, respectively for 3 weeks. The blood glucose of each animal was estimated at the end of every week.

Group II: rats in this group were divided into 3 subgroups of 20 animals each. Rats of subgroups 1, 2 and 3 received intragastrically 2 ml/100 g body weight per day distilled water, black tea extract and green tea extract, respectively for 2 weeks. At the end of 2 weeks all the rats were fasted for 24 h. They were then administered 40 mg/kg of STZ i.v. into the tail vein. The animals continued to receive the same volume of distilled water, black tea extract or green tea extract daily intragastrically for a further period of 5 weeks. Blood glucose of each animal was estimated at the end of every week.

2.6. Blood-glucose estimation

Blood samples (0.05 ml) were obtained by retro-orbital puncture using capillary tube and the blood glucose levels were estimated using glucostix on an Ames Glucometer II (Miles India Ltd., Baroda, India).

2.7. Statistics

Student's t-test and a probability level of $P < 0.05$ were chosen as the criterion of statistical significance. Values reported are mean ± S.E.M.

3. Results

3.1. Curative effect of tea extract on STZ-induced hyperglycemia in rats

Tea extract (both black and green) administration to rats, which were made hyperglycemic by STZ injection, significantly reduced the blood glucose level as compared to STZ control rats which received distilled water (Fig. 1). Black tea extract was marginally more effective in reducing the blood glucose when compared to green tea extract (Fig. 1).

3.2. Preventive effect of tea extract on STZ-induced hyperglycemia in rats

Injection of STZ (40 mg/kg i.v.) produced a gradual increase in blood glucose level in control rats. At the end of the third week after STZ injection the increase reached a maximum (92.5%). The blood glucose level declined gradually thereafter and reached the basal level at the end of fifth week after STZ injection (Fig. 2). While the elevation of blood glucose level in STZ-control group was found to be 92.5% and 20% in the 3rd and 4th week after STZ administration, the elevation of blood glucose level at the corresponding periods in the black tea treated group was found to be 5%

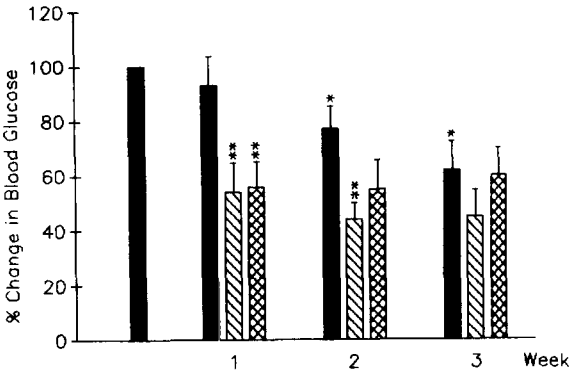

Fig. 1. Histogram showing the effect of black tea ▨ and green tea ▩ on blood-glucose level of STZ-induced diabetic rats. ■, Blood-glucose level of STZ-induced diabetic control rats. The values represent the mean of at least 20 experiments ± S.E M. Vertical bars show S.E.M.; *, denotes significant change as compared to control (STZ on '0' week) ($P < 0.05$); **, denotes significant change as compared to respective control ($P < 0.05$).

and 8%. The inhibitory effect of black tea extract on hyperglycemia induced by STZ was statistically significant. A similar regimen of green tea extract administration completely inhibited the STZ-induced increase in blood glucose level (Fig. 2).

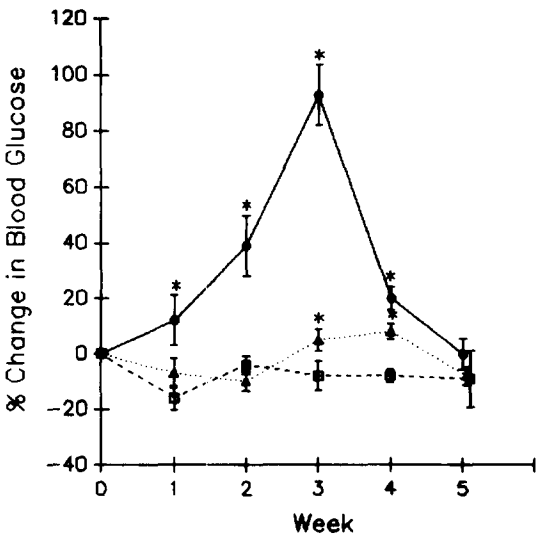

Fig. 2. Graph showing the effect of STZ (40 mg/kg i.v.) on blood glucose level in normal rats (–), black tea fed (.....) and green tea fed (– – –) rats. The values represent the mean of at least 20 experiments ± S.E.M. Vertical bars show S.E.M.; *, $P < 0.05$.

4. Discussion

The study reveals that like green tea, black tea also possesses antidiabetic activity. Black tea and green tea extracts were found to possess both preventive and curative effect on STZ-induced diabetes in rats. While green tea was more effective as a preventive, black tea was more effective as a curative.

It is well known that because of the special affinity of STZ for the β-cells of islets of Langerhans it is employed to induce diabetes in experimental animals (Calabresi and Chabner, 1991). After STZ treatment, there should be many surviving β-cells and the possibility of cell regeneration can not be ignored. No histological study was carried out to prove this. The animals receiving tea extract showed rapid normalisation of blood glucose level in comparison to the control (STZ treated) group (Fig. 1). Similarly, in the other study, the tea treated animals overcome the toxic effect of STZ (Fig. 2). So, it can be suggested that the tea extracts possibly protect the β-cells from the toxic effect of STZ and also help regeneration of the damaged cells.

Xiaoke tea, a traditional Chinese treatment for diabetes mellitus, lowered blood glucose level in STZ-induced diabetes in mice, but clinically it failed to reduce blood glucose level in non-insulin treated diabetic patients (Hale et al., 1989). Bailey et al. (1987) have suggested that, the slowly generated antihyperglycemic effect of Xiaoke in STZ-induced diabetic mice may involve an extrapancreatic effect on food intake, glucose production or glucose clearance and it has no effect on plasma insulin concentrations. Moreover, when insulin treatment was discontinued, Xiaoke failed to prevent hyperglycemia. Bai-Yu-Cha (BYC), another type of tea used as a Chinese folk medicine for diabetes has been reported to protect pancreatic islet cells from necrosis and cell degranulation in experimentally induced diabetic mice. They have shown that polyphenolic part is the anti-diabetic principle in BYC (Zhu et al., 1990). In comparison to the above mentioned Chinese tea used as antidiabetic medicine, black tea has been found to possess a better antidiabetic effect as it does not require insulin treatment to

unfold its antidiabetic property and it is consumed by 75% of the global population.

At the present juncture it is not possible either to pinpoint the mechanism of antihyperglycemic action of black tea or to identify the active constituents(s) responsible for this effect. However, based on earlier reports some suggestion can be made for the mechanism of the antihyperglycemic effect of black tea. It is reported that the transport and uptake of calcium by cardiac sarcoplasmic reticulum is decreased in diabetic rats (Lopaschuk et al., 1981; Ganguly et al., 1983). It has recently been reported from our laboratory that black tea facilitates neuromuscular function by releasing calcium at the intracellular release site of sarcoplasmic reticulum (Das et al., 1994). Thus, a possibility exists that the antihyperglycemic action of black tea may be mediated through its action on calcium.

It is also documented that the water soluble polysaccharide fraction of green tea is responsible for its antidiabetic effect (Shimizu et al., 1988; Isigaki et al., 1991). Studies are therefore warranted to verify whether the polysaccharides claimed to be responsible for the antidiabetic action of green tea are present in the black tea and to revalidate the antidiabetic property of the polysaccharides. At present we may conclude that the black tea, in totality, is effective in reducing the enhanced blood glucose level under our experimental conditions.

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