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# Chemical characterization and bio evaluation of cinnamon (*Cinnamomum verum*) extract against glycated haemoglobin and hyperglycemia in human female subjects with polycystic ovarian syndrome

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**Abstract**: Polycystic ovarian syndrome, in which females have high androgen levels, causes reproductive difficulties, insulin resistance, hyperglycemia, weight gain, irregular reproductive cycles, and hormonal imbalance. Cinnamon sticks reduce insulin resistance and hyperglycemia. This study examined how cinnamon stick powder affected hyperglycemia in polycystic ovarian syndrome women. Treatment groups I and II received 250mg and 500mg encapsulated cinnamon stick powder. 45 ladies with polycystic ovarian syndrome had their random, fasting and HbA1c assessed on days 0 and 60. All results were analyzed using a two-sample t-test with the help of software IBM SPSS Statistics 20 version. It contained moisture at 24.1%, ash at 17.82%, nitrogen-free extract at 36.12%, crude protein at 8.32%, crude fiber at 6.98% and crude fat at 6.87%. Means for minerals in mg/g were zinc 2.37mg, iron 0.69mg, chromium 0.31mg, calcium 83.28mg, magnesium 23.17mg, sodium (0%), manganese 21.01mg, phosphorus 43.01mg and potassium 133.87mg were determined. The cinnamon powder contained 20.12mg gallic acid equivalent of total phenolic content and 2.73mg quercetin equivalent of total flavonoid content. Treatment groups showed significant ($p<0.05$) reduction in blood sugar levels and glycated hemoglobin in response to the cinnamon oral dose. Treatment group II showed better results as compared to treatment group I at a higher dose of 500mg.

**Keywords**: Hyperglycemia, cinnamon, antihyperglycemic, HbA1c, phytochemicals, minerals, proximate, cinnamic acid, phytochemical, antioxidant, random blood sugar, fasting blood sugar.

## INTRODUCTION

Polycystic ovary syndrome (PCOS) is a condition of elevated secretion of the male hormone androgen which leads to the release of immature follicles from ovaries. Elevated androgen levels in the female body lead to the development of insulin resistance, weight gain, sleep apnea, hyperglycemia, irregular reproductive cycle, male pattern hair growth and hirsutism in females suffering from polycystic ovary syndrome. Apart from insulin resistance, these women with PCOS also experience inflammation (Kahsar-Miller *et al.,* 2001). Every 1 out of 9 women of reproductive age is suffering from polycystic ovary syndrome. Insulin resistance in these females is a major challenge. Many medications are used to overcome the symptoms of PCOS including metformin, Glucophage, and others. Scientists have investigated many medicinal plants to control the symptoms of PCOS. Cinnamon in this regard is a spice with exceptional properties of controlling insulin resistance and hyperglycemia (Wang *et al.,* 2007).

Cinnamon (*Cinnamomum verum)* has been a well-known and often used spice that is not only used for culinary purposes but also for medicinal properties. Cinnamon contains exceptional properties for managing hypertension, hyperglycemia, inflammations, joint pains, colds, and irregular menstruation. It is widely used in the toothpaste industry and dermal products. Cinnamon is used in the regulation of blood glucose metabolism and lipid metabolism (Singletary, 2019). Cinnamon has cinnamic acid which contains α-glucosidase inhibitors which are useful in regulating carbohydrate metabolism and insulin resistance. Cinnamon is a tremendous spice with anti-inflammatory and anti-hyperglycemia properties (Mohamed Sham Shihabudeen *et al*., 2011). This study investigated the medicinal effect of cinnamon on insulin resistance parameter HbA1c and blood sugar levels. The objective of this study was to investigate the therapeutic effect of cinnamon against insulin resistance and elevated level of blood glucose levels in females diagnosed with polycystic ovarian syndrome. It had also investigated the chemical characterization, mineral determination and phytochemical analysis of cinnamon.

## MATERIALS AND METHODS

### *Collection of raw materials and preparation*

Cinnamon sticks were collected from the market. Cinnamon was identified by comparing with

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characteristics explained in literature and other physicochemical characteristics (Gupta, 2021). First, they were cleaned and then washed with distilled water twice. After washing, cinnamon sticks were dried in indirect sunlight for two weeks after the removal of the seeds. First, dried cinnamon sticks were ground coarse and then refined after passing through the sieve. This refined powder was then stored in air-tight jars (Chen *et al*., 2015).

***Chemical composition of cinnamon sticks***

*Proximate analysis of cinnamon sticks*

Cinnamon sticks powder was analyzed for the following proximate profile including moisture content, ash, carbohydrates, crude protein, crude fiber and nitrogen-free extract (NFE) according to the AOAC method (Matsuo *et al*., 2019).

***Minerals analysis of cinnamon sticks***

The following minerals zinc, magnesium, iron, phosphorus, potassium, sodium and copper were analyzed in cinnamon stick powder by using atomic absorption spectrometry (Hernández *et al*., 2005).

***Phytochemical composition of cinnamon sticks***

Cinnamon sticks were investigated for the determination of total phenolic content (TPC) and total flavonoid content (TFC) in ethanolic extract via phytochemical analysis. The amount of TPC and TFC were measured in mg of quercetin equivalents (QE) per g of dry weight basis of the sample (Matsuo *et al*., 2019).

***Investigation of antihyperglycemic potential of cinnamon sticks***

*Selection of subjects*

45 female subjects of age 18-45 years were randomly selected from the population.

***Exclusion criteria***

Female patients with other complications like ischemic heart disease were not included in the study.

***Inclusion criteria***

All female subjects diagnosed with PCOS via ultrasonography went through blood biochemical analysis by checking their random blood sugar (RBS), fasting blood sugar (FBS), and HbA1c at the start of the study were included.

***Study duration and study design***

The study was conducted for 60 days, and it was a controlled randomized trial.

***Treatment groups and treatment plan***

Female subjects were divided into three groups of 15 subjects in each group. The control group was given no treatment. Treatment group-I and treatment group II were given encapsulated cinnamon stick powder in doses of 250mg and 500mg respectively (Hasanzade *et al*., 2013). Treatment groups and treatment plans are as follows:

$T_0$: Control group with 15 diabetic patients; No treatment.

Treatment group-I with 15 diabetic patients; 250mg of encapsulated cinnamon stick powder twice a day.

$T_2$: Treatment group II with 15 diabetic patients; 500mg of encapsulated cinnamon stick powder twice a day

***Ethical approval***

Ethical approval was taken from biosafety and ethical review committee of the institution.

## STATISTICAL ANALYSIS

Descriptive statistical analysis using the two-sample t-test under a Completely Randomized Design (CRD) was carried out to investigate the level of significance ($p<0.05$). Results are shown are mean± S.D. All statistical analyses are done with IBM SPSS Statistics 20.

## RESULTS

This research study has been designed to determine chemical composition, phytochemical content, mineral contents, and changes in blood glucose levels by consuming cinnamon stick powder in PCOS patients. Parameters including random blood sugar (RBS), fasting blood sugar (FBS) and glycated hemoglobin (HbA1c) were measured on the 0-day and 60$^{th}$ day.

**Table 1**: Mean ± S.D for proximate % composition of cinnamon stick powder on dry weight basis

| Proximate analysis | Composition (%) |
|---|---|
| Moisture | 4.09±0.13 |
| Ash | 2.38±0.61 |
| Nitrogen free extract | 55.8±3.52 |
| Crude protein | 3.61±0.19 |
| Crude Fat | 3.86±0.33 |
| Crude fiber | 34.12±0.21 |

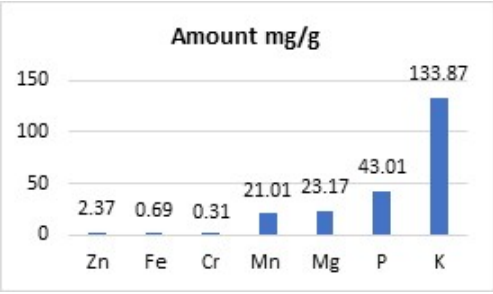


**Fig. 1**: Mineral content in mg/g of cinnamon stick powder

***Proximate composition of cinnamon stick powder***

The cinnamon stick powder was investigated for varied characterizations, such as moisture, ash, crude fiber, crude proteins, fat and nitrogen-free extract (NFE) depicted in

table 2. It contained moisture (24.1±1.78)%, ash (17.82±2.13)%, nitrogen free extract (36.12±3.52)%, crude protein (8.32±0.83)%, crude fiber (6.98±2.31)%, and crude fat(6.87±0.21)%.

**Table 2**: Mean ±S.D for phytochemical analysis of cinnamon stick powder on dry weight basis

| Antioxidant | Antioxidant content |
|---|---|
| TPC (mg GAE per g) | 20.12±0.23 |
| TFC (mg QE per g) | 2.73±0.42 |

***Mineral analysis of cinnamon stick powder***

In the current study, cinnamon stick powder was also analyzed for the determination of mineral content including calcium, potassium, sodium, chromium, iron, zinc, phosphorus, magnesium, manganese and sodium depicted in table 3. Mineral analysis of cinnamon stick powder was performed via atomic absorption spectrophotometer for Ca, Zn, Fe, Mg, Mn, K, P, Cr and Na. Mean±S.D for minerals in mg/g were zinc (2.37±0.32), iron (0.69±0.02), chromium (0.31±0.001) calcium (83.28±1.69), magnesium (23.17±1.52), sodium (0%), manganese (21.01±0.05), phosphorus (43.01±1.25) and potassium (133.87±8.87) were determined.

***Phytochemical characterization of cinnamon stick powder***

The cinnamon powder was analyzed for total phenolic content (TPC) and (TFC) analysis. It carries a significant amount of TPC and TFC shown in table 3. TFC was measured as mg Quercetin equivalent per g on a dry weight basis and TPC was measured as mg Gallic acid equivalent per g on a dry weight basis. The cinnamon powder contained 20.12±0.23mg GAE of TPC and 2.73±0.42mg QE of TFC.

***Exploration of the antihyperglycemic effect of cinnamon stick powder***

The objective of this study was to investigate the therapeutic effect of cinnamon on random blood sugar levels, fasting blood sugar and glycated hemoglobin (HbA1c) in females suffering from polycystic ovarian syndrome. Participants of the control group ($T_0$) were given no treatment while participants of treatment group-I ($T_1$) and treatment group-I- II ($T_2$) were given encapsulated cinnamon stick powder in doses of 250mg and 500 mg to groups I and II for 60 days respectively.

***Random blood sugar levels of female subjects***

The investigation showed a significant ($p<0.05$) reduction in random blood sugar levels in both treatment groups. Group-I showed a reduction in random blood sugar level from 262.58±3.83g/dl to 233.42±4.93 g/dl while group II showed a reduction in random from 268.45±4.67g/dl to 227.81±5.21g/dl. However, the control group showed an increase in random blood sugar levels on the 60$^{th}$ day as compared to the 0-day. All results were taken significant at $p<0.05$.

**Table 3**: Mean ±S.D for random blood sugar level of female subjects in g/dl.

| Duration | $T_O$ | $T_1$ | $T_2$ |
|---|---|---|---|
| 0 day | 267.03±10.07 | 262.58±3.83 | 268.45±4.67 |
| 60$^{th}$ day | 270.17±11.32 | 233.42±4.93* | 227.81±5.21* |

$T_0$ = No Treatment, $T_1$=10mg of cinnamon powder, $T_2$=15mg of cinnamon powder.

**Table 4**: Mean ±S.D for Fasting Blood Sugar Level of Female Subjects

| Duration | $T_O$ | $T_1$ | $T_2$ |
|---|---|---|---|
| 0 day | 148.43±9.87 | 151.20±11.17 | 157.20±10.26 |
| 60$^{th}$ day | 148.70±10.23 | 138.30±10.72* | 127.40±13.78* |

$T_0$ = No Treatment, $T_1$=10mg of cinnamon powder, $T_2$=15mg of cinnamon powder.

***Fasting blood sugar level of female subjects***

Both experimental groups showed significant ($p<0.05$) reduction in fasting blood glucose levels from 151.20±11.17g/dl to 138.30±10.72g/dl and from 157.20±10.26g/dl to 127.40±13.78 g/dl in $T_1$ and $T_2$ respectively. All results were taken significant at $p<0.05$.

**Table 5**: Mean ±S.D for HbA1c level of female subjects

| Duration | $T_O$ | $T_1$ | $T_2$ |
|---|---|---|---|
| 0 day | 7.89±2.10 | 7.52±0.31 | 8.01±1.32 |
| 60$^{th}$ day | 7.91±1.42 | 6.16±0.52* | 7.21±1.12* |

$T_0$ = No Treatment, $T_1$=10mg of cinnamon powder, $T_2$=15mg of cinnamon powder.

***HbA1c levels of female subjects***

The investigation showed a significant ($p<0.05$) decrease in HbA1c levels in both treatment groups. Group-I showed a reduction in HbA1c from 7.52±0.31mmol/mol to 6.16±0.52mmol/mol while group II showed a reduction in random from 8.01±1.32mmol/mol to 7.21±1.12 mmol/mol. However, the control group showed an increase in random blood sugar levels on the 60$^{th}$ day as compared to the 0-day. All results were taken significant at $p<0.05$.

## DISCUSSION

The study was designed to explore the therapeutic effect of cinnamon stick powder on the elevated blood glucose level and insulin resistance biomarkers in females of reproductive with polycystic ovary syndrome. A proximate analysis of the cinnamon stick was performed to determine the quality of the raw material used. Findings showed that the major component of the cinnamon stick is a nitrogen-free extract which was

correlated to the findings of previous literature which reported the same results. Minor differences were due to variations in weather conditions and the place where cinnamon was cultivated (Gul & Safdar, 2009). Mineral analysis showed that cinnamon did not contain any sodium and had potassium majorly in its composition. Mineral analysis of cinnamon also showed that it contained chromium which imparts the characteristic properties of cinnamon and helps in the regulation of insulin resistance. These findings were similar to the previously reported studies (Sana et al., 2019). Phytochemical analysis showed that cinnamon contained phenolic content and flavonoids in considerable amounts. These phytochemicals helped lower oxidative stress, inflammation, and insulin resistance in women with PCOS. The presence of phytochemicals was also reported in previous studies (Wijewardhana *et al.,* 2019). Cinnamon showed a reduction in random and fasting blood sugar levels. HbA1c was also reduced in both treatment groups. Cinnamon inhibited α-glucosidase activity thus helping in reducing random blood sugar levels (Mohamed Sham Shihabudeen *et al*., 2011). The study reported a reduction in fasting blood sugar levels and HbA1c in female subjects. These findings were correlated to another study that investigated the effect of an oral dose of 120mg and 360mg per day of cinnamon extract on fasting blood sugar and HbA1c in diabetic Chinese (Lu *et al.,* 2012). Another study reported a similar finding which showed a reduction in insulin resistance in females with the polycystic ovarian syndrome in response to cinnamon in a pilot study that supported the findings of this investigation on cinnamon for insulin resistance (Wang *et al*., 2007). However, another study, that investigated the effect of a 500 mg encapsulated cinnamon dose on diabetes showed contrary results in HbA1c and blood sugar levels which did not show any difference between the control group and the treatment group (Hasanzade *et al*., 2013). The results of this study were correlated to a study that determined the efficacy of cinnamon supplementation on increased blood glucose levels and insulin resistance in a randomized controlled trial (Zare *et al*., 2020). Nearly 16 randomized controlled trials including more than one thousand patients reported that cinnamon had the potential of regulating glucose metabolism and showed improvement in blood glucose parameters both random and fasting. These trials had also concluded that cinnamon can reduce insulin resistance and associated symptoms (Zhou *et al.,* 2022).

## CONCLUSION

Cinnamon is a widely used spice for culinary and medicinal purposes. Characteristic taste and aroma make cinnamon the best choice in the food industry and nutraceutical properties make cinnamon a mesmerizing herb to obtain therapeutic benefits. Cinnamon contains cinnamic acid which imparts properties like anti-inflammatory, anti-diabetic, antioxidant and anti-hyperglycemic. This study has determined the medicinal potential of cinnamon in females with PCOS. It also reported a reduction in insulin resistance and hyperglycemia in patients with PCOS. Thus, it can be used as a therapeutic approach to ameliorate symptoms of PCOS.

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