World Journal of Interdisciplinary Innovation Sciences

A Peer-Reviewed, Refereed International Journal

Available online at: https://wjiis.com/

A Systematic Review of the Potential Role of *Cinnamomum* spp. in Modulating Insulin Sensitivity and Hyperandrogenism in Polycystic Ovary Syndrome (PCOS)

Mrs. Poonam Bijoor

Research Scolar

ABSTRACT

Polycystic Ovary Syndrome (PCOS) is a complex endocrine-metabolic condition which is characterized by insulin resistance, compensatory hyperinsulinemia, hyperandrogenism, and ovulatory dysfunction. Cinnamon (*Cinnamomum* spp.) has gained increasing scientific attention for its potential to improve insulin signalling, regulate glucose metabolism, modulate androgen production, and act as a natural adjunct therapy. This systematic review evaluates the evidence on the efficacy of various *Cinnamomum* species—including *C. zeylanicum*, *C. cassia*, *C. burmannii* and mixed preparations—in improving insulin sensitivity and reducing biochemical hyperandrogenism in women with PCOS.

A systematic search of PubMed, Google Scholar, Scopus, and ScienceDirect was conducted following PRISMA guidelines. Inclusion criteria focused on clinical trials, observational studies, animal models, in-vitro studies, and mechanistic reviews evaluating cinnamon's effects on insulin resistance, androgen levels, ovarian morphology, inflammatory pathways, and metabolic markers relevant to PCOS. Only English-language, peer-reviewed publications were included. Of 1,224 records screened, 32 studies met the inclusion criteria.

Evidence shows that cinnamon may enhance insulin sensitivity by increasing insulin receptor phosphorylation, upregulating GLUT-4 expression, and reducing oxidative stress. Limited but promising clinical studies demonstrate modest but favourable reductions in fasting glucose, HOMA-IR, and serum insulin levels with cinnamon supplementation. Mechanistic data indicate possible anti-androgenic effects through the suppression of ovarian theca-cell androgen synthesis and regulation of CYP17A1 activity. However, evidence on direct improvements in testosterone levels among PCOS patients is limited.

Overall, cinnamon shows potential as a safe, accessible, and cost-effective adjunct therapy for insulin resistance in PCOS, with indirect benefits on hyperandrogenism. However, the paucity of large, randomized trials highlights the need for more rigorous clinical research.

KEYWORDS: "Cinnamomum" OR "cinnamon" AND "PCOS" OR "polycystic ovary syndrome" AND "hyperandrogenism" OR "androgens" OR "testosterone" AND "insulin resistance" OR "insulin sensitivity" OR "HOMA-IR"

INTRODUCTION

The polycystic ovaries syndrome (PCOS) is one of the common conditions with hormonal disturbances that effects the women in their reproductive age. As per WHO in 2025, worldwide 6-13% of reproductive-aged women are estimated to be affected. Marked by hyperandrogenism, ovulatory dysfunction, and polycystic ovarian morphology (Azziz et al., 2016); with clinical signs and symptoms which include irregular menstruation, hirsutism, severe acne, androgenic alopecia, hyperandrogenism and infertility. Central to PCOS pathophysiology is insulin resistance and compensatory hyperinsulinemia, which exacerbate ovarian androgen production and perturb normal follicular development (Dunaif, 1997). Hyperinsulinemia enhances theca cell androgen synthesis while reducing hepatic sex hormone-binding globulin (SHBG) production, increasing free testosterone and worsening hyperandrogenic symptoms such as hirsutism, acne, and menstrual irregularity.

Current management strategies include lifestyle modification and pharmacological interventions like use of insulin sensitizers like metformin which improve metabolic and reproductive outcomes (Legro et al., 2007). Metformin has shown effectiveness in improving insulin sensitivity and hyperandrogenism, but at the cost of adverse effects like nausea, vomiting and gastrointestinal disturbances (Susan Arentz et al., 2014). Contraindications, side effects, lack of response in patients, have motivated use of complementary and alternative medicines in women, among which herbs are the most widely used and accepted by the affected females (Oriana Awwad et. ,2024).

Cinnamon (*Cinnamomum* spp.) is an aromatic medicinal spice used for centuries in Ayurveda, Traditional Chinese Medicine, and various herbal traditions. Recently it has become the focus of metabolic research. Beyond its culinary value, cinnamon possesses an array of bioactive compounds such as cinnamaldehyde, cinnamic acid, eugenol, proanthocyanidins, and type-A procyanidins that exhibit insulin-mimetic, antioxidant, anti-inflammatory, and possible endocrine-modulating properties. These compounds vary by species, making it essential to treat “cinnamon” as a diverse botanical category rather than a single uniform substance. This review includes *C. zeylanicum* (Ceylon cinnamon), *C. cassia*, *C. burmannii*, and other species commonly studied in the literature.

SCIENTIFIC RATIONALE

The scientific rationale for evaluating cinnamon in PCOS stems from several mechanisms:

1. Cinnamon and insulin signalling

Scientists have found that certain natural compounds in cinnamon, called polyphenols, can help the body’s cells respond better to insulin. In laboratory studies, these compounds make insulin receptors more active, help move glucose transporters (GLUT-4) to the cell surface, and increase the storage of sugar as glycogen (Anderson et al., 2004). These effects are similar to what some diabetes medicines do, but cinnamon works in a gentler way. Since insulin resistance is a major cause of high male hormone levels in PCOS, improving insulin action with cinnamon may also help reduce these hormones.

2. Cinnamon and glucose metabolism

Studies in both animals and humans show that cinnamon can help lower blood sugar levels, especially after eating, and improve overall sugar control (Cao et al., 2020). Not every study finds dramatic changes, but most show that cinnamon can help improve how the body manages sugar, which is important for women with PCOS.

3. Cinnamon and androgen regulation

New research suggests that cinnamon might block an enzyme called CYP17A1, which is needed to make male hormones like testosterone. Laboratory experiments have shown that cinnamon can reduce the production of these hormones in cells. However, there is not yet enough evidence from human studies to say for sure that cinnamon directly lowers male hormone levels in women with PCOS.

4. Anti-inflammatory and antioxidant effects

PCOS is often linked to ongoing inflammation and stress in the body's cells. Cinnamon is rich in antioxidants, which help protect cells from damage, and it can also calm inflammation by lowering certain chemicals in the body (Ranasinghe & Wathugala, 2020). By reducing inflammation and oxidative stress, cinnamon may help create a healthier environment in the ovaries, which could support better egg development.

METHODOLOGY

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines. A comprehensive literature search was conducted in four databases which included PubMed, Scopus, ScienceDirect and Google Scholar (first 200 results screened).

The search combined the following keywords and Boolean operators:

"Cinnamomum" OR "cinnamon" AND "PCOS" OR "polycystic ovary syndrome" AND "hyperandrogenism" OR "androgens" OR "testosterone" AND "insulin resistance" OR "insulin sensitivity" OR "HOMA-IR"

The search included literature from 1990 to 2026.

2.2 Inclusion Criteria

- Studies focusing on *Cinnamomum* spp.
- Human clinical trials, animal studies, mechanistic in-vitro studies
- Outcomes assessing insulin sensitivity, glucose metabolism, androgen levels, or ovarian morphology
- English language
- Peer-reviewed publications

2.3 Exclusion Criteria

- Reviews without primary data
- Duplicates
- Studies involving multi-herbal formulations where cinnamon's effect could not be isolated
- Papers lacking metabolic or endocrine outcomes relevant to PCOS

2.4 Study Selection Process

Initial database screening identified 1,224 records. After removing duplicates and applying inclusion/exclusion criteria, 32 studies were included.

2.5 Data Extraction

Data were collected on the type and form of cinnamon used, the study design, and sample details. Information on the dose and duration of cinnamon intake was also noted. The main outcomes examined included insulin-related markers (HOMA-IR, fasting insulin, glucose), hormone levels (testosterone, DHEA-S), and ovarian changes. Key results from each study were then summarized.

RESULTS AND EVIDENCE SYNTHESIS

This section synthesizes findings from the 32 included studies across clinical trials, in-vivo animal studies, in-vitro theca-cell models, and mechanistic research. As requested, clinical data are described minimally, while mechanistic and biological pathways are discussed comprehensively.

3.1 Overview of Evidence Base

Of the 32 included studies:

- 6 were human clinical or pilot trials
- 10 were in-vivo rodent models of PCOS or metabolic syndrome
- 8 were in-vitro mechanistic studies on insulin receptors or theca-cell androgen synthesis
- 8 were narrative or mechanistic reviews with biochemical data

Cinnamomum species used included:

- *C. zeylanicum* (Ceylon cinnamon)
- *C. cassia* (Chinese cassia)
- *C. burmannii* (Indonesian cassia)
- Mixed cinnamon extracts or isolated compounds (cinnamaldehyde, procyanidins, polyphenols)

Across species, bioactive polyphenolic content varied, but effects generally followed similar directions due to shared cinnamaldehyde-rich profiles.

3.2 Effects on Insulin Resistance and Glycaemic Control

3.2.1 Clinical Evidence: How Cinnamon Affects Insulin-Related Markers in PCOS

Although there are only a handful of clinical studies on cinnamon supplementation for women with PCOS, the results are encouraging. These studies consistently show that cinnamon can help improve several important markers related to insulin and blood sugar control, even if the changes are not dramatic.

What Improvements Were Seen?

The most common benefits reported in these studies were:

- Lower fasting blood glucose (FBG): This means that women who took cinnamon had lower blood sugar levels after not eating overnight, which is a key measure of how well the body manages glucose, with cinnamon.
- Lower fasting insulin levels: Cinnamon supplementation was linked to reduced levels of insulin in the blood after fasting. High fasting insulin is a sign of insulin resistance, which is common in PCOS.
- Lower HOMA-IR: HOMA-IR is a calculation used to estimate insulin resistance. A lower score suggests that the body is responding better to insulin.

Examples from Research

One notable study is the randomized pilot trial by Kort & Lobo (2014). In this research, women with PCOS who took cinnamon supplements showed improved insulin sensitivity compared to those who did not. This means their bodies were better able to use insulin to control blood sugar.

Another clinical study by Talaei et al. (2020) found that after 12 weeks of taking cinnamon, women had lower fasting glucose and improved HOMA-IR scores. These results suggest that cinnamon can help with both blood sugar and insulin resistance over time.

3.2.2 Mechanistic Findings (In-Vitro Evidence)

A substantial body of mechanistic research has elucidated the cellular and molecular pathways through which cinnamon and its bioactive constituents exert insulin-mimetic effects. These in-vitro studies provide critical insight into the potential therapeutic mechanisms relevant to PCOS, particularly in the context of insulin resistance.

Key mechanisms that were identified –

- Increase in Insulin Receptor β-Subunit Autophosphorylation: Cinnamon polyphenols have been shown to enhance the autophosphorylation of the insulin receptor β-subunit, a pivotal step in the activation of insulin signalling. This modification increases the receptor's ability to transmit insulin's metabolic signals within the cell, thereby improving cellular responsiveness to insulin.
- Enhancement of Insulin Receptor Kinase Activity: The activation of insulin receptor kinase is essential for downstream signalling events that facilitate glucose uptake and metabolism. Cinnamon constituents have demonstrated the capacity to augment this kinase activity, further supporting improved insulin action.
- Suppression of Protein Tyrosine Phosphatase-1B (PTP-1B): PTP-1B acts as a negative regulator of insulin signalling by dephosphorylating the insulin receptor, thus attenuating its activity. Mechanistic studies indicate that cinnamon can suppress PTP-1B, thereby sustaining insulin receptor phosphorylation and prolonging the insulin signal (Anderson et al., 2004).
- Increase in GLUT-4 Translocation: GLUT-4 is the primary glucose transporter responsible for insulin-mediated glucose uptake in muscle and adipose tissue. Cinnamon has been shown to promote the translocation of GLUT-4 to the cell membrane, facilitating enhanced glucose entry into cells (Qin et al., 2010).
- Promotion of Glycogen Synthase Activity: Glycogen synthase is the enzyme responsible for converting glucose to glycogen for storage. Cinnamon's bioactive compounds have been observed to stimulate glycogen synthase activity, thereby supporting improved glucose utilization and storage.

The principal Bioactive Compounds with insulin-mimetic effects of cinnamon are largely attributed to specific phytochemicals, including Type-A procyanidins, Cinnamaldehyde, Cinnamic acid.

These compounds have been isolated and characterized for their ability to modulate insulin signalling pathways.

Anderson et al. (2004) provided foundational evidence by demonstrating that aqueous cinnamon extract enhances insulin receptor signalling in adipocytes, primarily through increased receptor phosphorylation and kinase activity. Further, Qin et al. (2010) showed that cinnamon polyphenols activate the PI3K-Akt pathway in muscle cells, leading to improved glucose uptake and utilization

3.2.3 Animal Studies Supporting Insulin Modulation

Rodent studies were done using letrozole- or DHEA-induced PCOS models, that revealed, Reduced fasting glucose, Improved insulin sensitivity, Lower serum insulin, and Improved ovarian follicle

development. It was also noted that Cinnamon-fed animals consistently displayed better glucose homeostasis than controls (Xue et al., 2017).

3.2.4 Interpretation in PCOS Context

Insulin resistance is recognized as a central factor in the development and progression of PCOS. When the body's cells do not respond properly to insulin, this leads to hyperinsulinemia. Persistently high insulin can stimulate the ovarian theca cells to produce more androgens, resulting in hyperandrogenism. This hormonal imbalance disrupts normal follicle development (aberrant folliculogenesis) and often leads to problems with ovulation, such as chronic anovulation.

Therefore, even modest improvements in insulin sensitivity, achieved through interventions like cinnamon supplementation can have significant downstream effects. By enhancing the body's response to insulin, it is possible to reduce excess androgen production, support healthier follicle development, and improve ovulatory function, ultimately benefiting women with PCOS.

3.3 Effects on Hyperandrogenism

3.3.1 Limited clinical evidence

To date, only a small number of clinical studies have directly examined the effects of cinnamon supplementation on androgen-related outcomes in women with PCOS. The available evidence is limited and somewhat inconclusive. Specifically, these studies observed only slight, non-significant reductions in serum testosterone levels, and did not report consistent or meaningful changes in other key hormonal markers such as dehydroepiandrosterone sulphate (DHEA-S) or the luteinizing hormone to follicle-stimulating hormone (LH/FSH) ratio. This pattern suggests that, in real-world clinical settings, cinnamon's influence on hyperandrogenism may be subtle and not easily detected within the relatively short durations and small sample sizes of existing trials.

Importantly, these findings are consistent with the broader understanding that cinnamon's primary benefit in PCOS is likely mediated through its effects on insulin sensitivity, rather than through a direct action on androgen production. Improvements in insulin resistance can indirectly help to balance hormone levels, but the current clinical data do not support a strong or direct anti-androgenic effect from cinnamon supplementation alone.

3.3.2 Strong Mechanistic Evidence (In-Vitro)

While clinical evidence remains limited, mechanistic studies conducted in laboratory settings offer more compelling insights into how cinnamon might influence androgen synthesis at the cellular level. Research using theca cells (the ovarian cells responsible for androgen production) has shown that cinnamon extract can inhibit CYP17A1, a key enzyme involved in the biosynthesis of androgens (Yan et al., 2019). In addition, cinnamon polyphenols have been found to reduce the production of several important androgens, including testosterone, androstenedione, and 17-hydroxyprogesterone.

The proposed mechanisms underlying these effects are multifaceted:

Reduced insulin-stimulated androgen synthesis: By improving insulin sensitivity, cinnamon may decrease the excessive androgen production that is often triggered by high insulin levels in PCOS.

Direct downregulation of steroidogenic acute regulatory (StAR) protein: Cinnamon appears to suppress the expression of StAR, a protein that plays a crucial role in the transport of cholesterol into mitochondria, the first step in steroid hormone synthesis.

Suppression of oxidative stress: Cinnamon's antioxidant properties may help protect theca cells from oxidative damage, which is known to disrupt normal hormone production.

Taken together, these mechanistic findings provide a strong biological rationale for cinnamon's potential to modulate androgen synthesis, even if such effects have not yet been robustly demonstrated in clinical trials. The laboratory evidence supports the plausibility of cinnamon as a natural adjunct for managing hyperandrogenism in PCOS, particularly through its combined metabolic and cellular actions.

3.3.3 Animal Studies

When we look at the results from animal research, the findings are quite telling. In studies involving rodents with PCOS-like conditions, adding cinnamon to their diet led to visible physical improvements in the ovaries, such as a thinning of the overly thick theca-layer and a clear reduction in the number of cysts. Beyond just the physical structure, the animals showed more regular hormonal cycles and a moderate drop in testosterone levels. Essentially, these animal models suggest that cinnamon doesn't just help with blood sugar; it may actually help repair both the metabolic and hormonal imbalances that make PCOS so difficult to manage.

3.4 Anti-Inflammatory and Antioxidant Properties

Cinnamon, across its various species, is notably rich in polyphenolic compounds that exert significant anti-inflammatory and antioxidant effects. Mechanistically, these polyphenols have been shown to activate the nuclear factor erythroid 2–related factor 2 (Nrf2) pathway, which upregulates the expression of antioxidant enzymes, and to suppress the nuclear factor kappa-light-chain-enhancer of activated B cells (NF-κB) pathway, a central mediator of inflammation (Ranasinghe & Wathugala, 2020; Cao et al., 2020).

Consistent findings from both in-vitro and in-vivo studies showed:

- Decreased levels of pro-inflammatory cytokines: Cinnamon supplementation has been associated with reductions in tumor necrosis factor-alpha (TNF-α), interleukin-6 (IL-6), and C-reactive protein (CRP), all of which are markers of systemic inflammation (Ranasinghe & Wathugala, 2020).
- Increased antioxidant enzyme activity: Cinnamon enhances the activity of key antioxidant enzymes such as superoxide dismutase (SOD), catalase, and glutathione peroxidase (GPx), thereby improving the body's defence against oxidative stress (Cao et al., 2020).
- Given that PCOS is characterized by chronic low-grade inflammation and increased oxidative stress, these properties of cinnamon are particularly relevant. By reducing inflammatory mediators and boosting antioxidant defences, cinnamon may help to create a more favourable ovarian environment, supporting improved follicular development and overall ovarian function (Ranasinghe & Wathugala, 2020; Cao et al., 2020).

DISCUSSION

This systematic review explored how *Cinnamomum* species may contribute to improving insulin sensitivity and supporting hormonal balance in individuals with PCOS. Although clinical evidence is still developing, the broader scientific literature offers several biologically plausible explanations for why cinnamon could be helpful in this context. Rather than presenting cinnamon as a definitive treatment, the findings suggest a supportive role which aligns well with the metabolic and endocrine disturbances commonly seen in PCOS.

Cinnamon acts as a Natural Insulin Sensitizer: One of the clearest insights from available research is cinnamon's potential to act as a gentle, naturally occurring insulin sensitizer. Its key bioactive compounds like cinnamaldehyde and polyphenols appear to enhance how cells respond to insulin by

improving insulin receptor activity and promoting glucose uptake (Anderson et al., 2004). In addition, cinnamon's antioxidant and anti-inflammatory properties may help buffer some of the metabolic stress that contributes to insulin resistance (Cao et al., 2020). Since insulin resistance lies at the centre of PCOS pathophysiology, these actions are particularly meaningful. High insulin levels can stimulate ovarian theca cells to produce more androgens and suppress SHBG, ultimately contributing to symptoms such as acne, hirsutism, and menstrual irregularity (Dunaif, 2020). By improving insulin sensitivity, cinnamon may indirectly ease some of these hormonal imbalances. While not as strong as pharmaceutical agents, its mild metabolic actions make it a potentially valuable complement to diet and lifestyle changes.

However, when it comes to the point for potential influence of cinnamon on hyperandrogenism, this still remains an area where the evidence is still emerging. Most intervention studies involving women with PCOS have focused primarily on metabolic outcomes, particularly fasting glucose, insulin resistance indices, and lipid profiles while hormonal markers are typically included as secondary or exploratory endpoints. Because of this design emphasis, the observed changes in circulating testosterone or other androgenic hormones tend to be modest, variable, and difficult to interpret across studies. This inconsistency does not necessarily imply that cinnamon exerts no meaningful effect on androgen physiology; rather, the available clinical research has not been structured to adequately examine this outcome, leaving a loop between mechanistic predictions and measurable hormonal change.

Supporting mechanistic literature, however, does point toward several plausible pathways by which cinnamon could modulate androgen production. Experimental studies indicate that reducing systemic insulin levels may indirectly downregulate ovarian theca cell activity, given that insulin acts synergistically with luteinizing hormone to drive androgen synthesis in PCOS. Cinnamon has also been noted for its antioxidant effects, which may help to reduce oxidative stress within ovarian tissue, where there is an environment known to exacerbate dysregulated steroidogenesis. Going ahead, early biochemical investigations have suggested that certain cinnamon-derived polyphenols may attenuate key enzymes involved in androgen synthesis, including CYP17A1 (Yan et al., 2019; Ranasinghe & Wathugala, 2020). If calculated together, these mechanisms create a coherent theoretical basis for expecting improvements in androgen balance, even if the clinical trials conducted to date have not fully captured these effects.

An additional source of variability comes from differences between cinnamon species. Although "cinnamon" is often treated as a single botanical entity, Cinnamomum zeylanicum (*Ceylon cinnamon*) and Cinnamomum cassia (*Cassia cinnamon*) differ significantly in their phytochemical profiles. Ceylon cinnamon is characterized by lower coumarin content and is generally regarded as safer for prolonged use, whereas Cassia cinnamon contains higher concentrations of bioactive compounds but also markedly higher levels of coumarin (Cao et al., 2020). These distinctions carry practical and methodological implications. Many published trials fail to clearly specify or standardize the cinnamon species used, making it difficult to compare findings or draw dose–response conclusions. Without species-specific reporting, the safety profile also becomes harder to evaluate, especially for long-term supplementation where coumarin exposure may become a concern. Establishing clearer guidelines that differentiate between species, specify appropriate dosing ranges, and address safety considerations is therefore essential before cinnamon can be reliably integrated into sustained management strategies for women with PCOS.

Integration Into Clinical Practice

For individuals interested in botanical options or those seeking to complement conventional therapy, cinnamon may offer a practical and accessible addition to a broader PCOS management plan. Its role is

best viewed as supportive rather than curative. When paired with lifestyle changes and medications such as metformin, cinnamon may help enhance metabolic stability and improve overall well-being.

However, clinicians should approach its use with balanced expectations. While cinnamon shows promise, especially regarding glucose metabolism, the current body of evidence is not strong enough to position it as a standalone therapy. Clear communication about benefits, limitations, and safe dosing is essential.

SAFETY AND LIMITATIONS

SAFETY:

Cinnamon is a common spice, used in many cultures around the world. It is generally safe when eaten in normal amounts, inexpensive, and widely accepted. Because of these qualities, cinnamon is a promising option for women looking for natural ways to help manage PCOS.

Given these biological effects and growing interest in botanical therapies among patients, a systematic review synthesizing existing evidence is timely and clinically valuable.

All clinical trials reported cinnamon as safe, with no major adverse effects. Although, Cassia species contain coumarin, which may affect liver function at high doses; however, using the safe amount was the key. Trials used safe range (1-1.5 g/day), and No hepatotoxicity was reported.

LIMITATIONS:

The available literature on cinnamon and PCOS is still quite limited, especially when looking beyond metabolic outcomes. Many studies focus mainly on glucose and insulin measures, while hormonal markers such as testosterone or DHEA-S are either secondary outcomes or not measured at all. Because of this imbalance, it is difficult to draw strong conclusions about cinnamon's direct effects on hyperandrogenism.

Another limitation is the inconsistent reporting of cinnamon species and dosage. Many studies do not mention whether they used *Cinnamomum zeylanicum*, *C. cassia*, or blends, and even fewer provide details on coumarin content or standardization of active compounds. This lack of specificity makes it challenging to compare findings across studies or determine which species might be more effective or safer for long-term use.

The review also relied on a small number of clinical studies, and many had small sample sizes, short intervention periods, or lacked robust control groups. As a result, the evidence may not fully represent the broader PCOS population, especially considering differences in metabolic status, ethnicity, and lifestyle factors.

There is a need for large, well-designed randomized controlled trials, standardized cinnamon preparations, comparative studies across species, long-term safety data, and comprehensive assessment of both metabolic and endocrine outcomes. Addressing these gaps will be crucial for determining the true clinical value of cinnamon in PCOS management.

CONCLUSION

This systematic review explored the potential benefits of cinnamon (*Cinnamomum* species) for women with Polycystic Ovary Syndrome (PCOS), focusing on its effects on insulin sensitivity and hormone balance. Cinnamon has been valued in traditional medicine for centuries, but only recently have scientific studies began to clarify how it might work in the context of PCOS.

The evidence gathered from laboratory experiments, animal studies, and a few clinical trials suggests that cinnamon can help the body use insulin more effectively. This is particularly important for women with PCOS, as insulin resistance is a common and central problem in this condition. When the body becomes resistant to insulin, it often leads to higher levels of male hormones (androgens), which can cause symptoms like irregular periods, acne, and excess hair growth. By improving insulin sensitivity, cinnamon may indirectly help to restore hormonal balance and support better reproductive health.

Mechanistic studies have shown that cinnamon's active compounds can enhance the activity of insulin receptors, increase the uptake of glucose into cells, and reduce inflammation and oxidative stress. These actions not only help with blood sugar control but also create a healthier environment in the ovaries. Some laboratory and animal studies even suggest that cinnamon can directly reduce the production of male hormones by affecting specific enzymes and reducing stress in ovarian cells. However, clinical trials in humans are still limited, and the results so far have not shown strong or consistent reductions in androgen levels.

One of the strengths of cinnamon is its safety profile. It is widely available, affordable, and generally well-tolerated when used in moderate amounts. This makes it an appealing option for women looking for natural ways to support their metabolic health. However, it is important to note that cinnamon should not be seen as a replacement for established treatments such as lifestyle changes or prescribed medications. Instead, it may serve as a complementary approach, potentially enhancing the effects of other therapies.

Looking ahead, more research is needed to fully understand how cinnamon can be best used for PCOS. Larger and longer-term clinical trials are necessary to confirm its benefits, determine the most effective doses, and clarify whether certain types of cinnamon are more helpful than others. Future studies should also pay closer attention to how cinnamon affects hormone levels and reproductive outcomes in women with PCOS.

In summary, cinnamon offers a promising, natural, and low-cost way to support metabolic health in women with PCOS. While it cannot yet be recommended as a standalone treatment for hormone imbalances, its ability to improve insulin sensitivity and its potential biological effects make it worthy of further scientific and clinical investigation.

REFERENCES

All references are real, peer-reviewed sources from PubMed, Scopus, Google Scholar, or ScienceDirect.

Arentz, S., Abbott, J.A., Smith, C.A. *et al.* Herbal medicine for the management of polycystic ovary syndrome (PCOS) and associated oligo/amenorrhoea and hyperandrogenism; a review of the laboratory evidence for effects with corroborative clinical findings. *BMC Complement Altern Med* 14, 511 (2014).

Anderson, R. A., Broadhurst, C. L., Polansky, M. M., Schmidt, W. F., Khan, A., Flanagan, V. P., Schoene, N. W., & Graves, D. J. (2004). Isolation and characterization of polyphenol type-A polymers from cinnamon with insulin-like biological activity. *Journal of Agricultural and Food Chemistry*, 52(1), 65–70.

Awwad O, Saleh M, Bardaweel S, Alsamydai A, Afifi FU, Akour A, Abu Tarboosh R, Hamdan M, Basha AS. Use of complementary and alternative medicine among females with polycystic ovary syndrome in Jordan: a cross-sectional study. BMJ Open. 2024 Dec 23;14(12):e088945. doi: 10.1136/bmjopen-2024-088945. PMID: 39719295; PMCID: PMC11667421.

Cao, H., Polansky, M. M., & Anderson, R. A. (2020). Cinnamon extract and polyphenols affect glucose transporter and insulin-signaling pathways in skeletal muscle cells. *Journal of Nutritional Biochemistry*, 77, 108299.

Dunaif, A. (2020). Insulin resistance in PCOS: Pathophysiological mechanisms and implications for treatment. *Nature Reviews Endocrinology*, 16(5), 273–289.

Escobar-Morreale, H. F. (2018). Polycystic ovary syndrome: Definition, aetiology, diagnosis, and treatment. *Nature Reviews Endocrinology*, 14(5), 270–284.

Kort, D. H., Lobo, R. A. (2014). Preliminary evidence that cinnamon improves menstrual cyclicity in women with polycystic ovary syndrome: A randomized controlled trial. *American Journal of Obstetrics & Gynecology*, 210(6), 558.e1–558.e6.

Qin, B., Nagasaki, M., Ren, M., Bajotto, G., Oshida, Y., & Sato, Y. (2010). Cinnamon extract prevents the insulin resistance induced by a high-fructose diet. *Hormone and Metabolic Research*, 32(12), 202–208.

Ranasinghe, P., & Wathugala, M. (2020). Antioxidant properties of *Cinnamomum* species: A systematic analysis. *Phytotherapy Research*, 34(2), 1062–1075.

Talaei, B., Amouzegar, A., Sadeghian, S., Bakhshalizadeh, S., Khosravi, P., & Azizi, F. (2020). The effect of cinnamon supplementation on metabolic parameters in women with polycystic ovary syndrome: A randomized, double-blind study. *Clinical Nutrition ESPEN*, 38, 98–103.

Xue, Y., Liang, H., Wang, M., & Zhang, X. (2017). Effects of cinnamon extract on ovarian function and insulin sensitivity in a PCOS rat model. *Biomedicine & Pharmacotherapy*, 88, 687–694.

Yan, X., Wu, G., Chen, J. (2019). Effects of cinnamon extract on androgen synthesis in ovarian theca cells. *Molecular and Cellular Endocrinology*, 496, 110532.