

Investigating Chemical Safety in Menstrual Products: A Pathway to Understanding Polycystic Ovarian Syndrome Risk Factors

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Abstract: Menstruation is a fundamental biological process that impacts nearly half of a woman's life span, making effective menstrual management an essential aspect of women's health. Understanding the mechanisms underlying menstruation and its associated disorders is pivotal in advancing personalised healthcare solutions. PCOS, or polycystic ovarian syndrome, is a prevalent endocrinological condition among women and girls of reproductive age. Hormonal imbalance and ovarian malfunction are its hallmarks, and they frequently begin in adolescence. Inconsistent diagnosis criteria, disparities in clinician skill, and a lack of consensus make caring for women with PCOS more challenging. Concerns have been raised regarding possible environmental and lifestyle variables that may contribute to the development of PCOS, which is becoming more common in women and adolescent children. EDCs, dioxins, and artificial perfumes are among the substances found in many commercially available menstrual products that may disrupt hormonal balance. This study explores what women know and how they feel about the safety of menstrual hygiene products. This research is specifically looking for any links between product use and health issues like hormonal imbalances and PCOS. An online survey was conducted to examine usage habits, health concerns, and interest in sustainable options. The findings helped guide the creation of more effective public health campaigns, shape policy, and promote eco-friendly alternatives. This study aims to empower women worldwide with a better understanding of how menstrual health can impact reproductive health, especially concerning conditions like PCOS.

Keywords: Polycystic Ovary Syndrome (PCOS); Menstrual Products; Endocrine-Disrupting Compounds (EDCs); Sustainable Alternatives; Health Risks; Menstrual Health; Menstrual Management; Reproductive Health.

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1. Introduction

Menstruation is an essential component of a woman's overall health and a natural biological process that indicates reproductive health. It involves the cyclical shedding of the uterine lining, typically occurring monthly from puberty to menopause [1]. Even though menstruation is necessary for fertility, it is frequently disregarded when talking about women's health. Properly managing menstrual hygiene is essential for preserving mental and physical well-being, preventing infections, and ensuring comfort and dignity [2]. Despite its importance, menstrual health is often neglected, with millions of women worldwide lacking

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access to safe and hygienic menstrual products. Poor menstrual hygiene can result in discomfort, infections, and even chronic health problems [3]. Research has shown that period products include dangerous substances that could seriously affect health, especially for women with diseases like Polycystic Ovary Syndrome (PCOS). This raises questions about the safety of menstrual products beyond their hygienic benefits. PCOS is a complex endocrine disorder affecting approximately 6-12% of women of reproductive age [4].

Genetic, behavioural, and environmental factors all play a role in PCOS, which is characterised by symptoms like irregular menstrual cycles, ovarian cysts, and hormone imbalances [5]. Among these, exposure to endocrine-disrupting chemicals (EDCs) found in everyday products, including menstrual hygiene items, has garnered significant attention. In recent years, the safety of menstrual products has emerged as a major public health issue [6]. These products, which are essential for billions of women worldwide, often contain harmful chemicals such as parabens, dioxins, and phthalates. The problem is exacerbated by the lack of strict laws and transparency in the production of menstrual products [7]. This research investigates the link between menstrual health and PCOS, concentrating on the chemical safety of menstrual products. It also examines the prevalence of EDCs such as parabens, phthalates, and dioxins in these goods and shows how they may exacerbate PCOS symptoms [8]. The study also examines regulatory limitations, consumer awareness, and the viability of safer substitutes, such as herbal menstruation products. Protecting women's health and advancing the discussion of sustainable, non-toxic menstruation care depend on addressing these challenges [9].

2. Review of Literature

2.1. Understanding PCOS and Importance

PCOS is a complex endocrine condition that is typified by polycystic ovaries, hyperandrogenism, and persistent anovulation. PCOS, which affects millions of women globally, is linked to long-term health risks including endometrial cancer, cardiovascular disease, type 2 diabetes, and infertility [10]. It has a significant effect on women's reproductive health because it is the primary cause of ovulatory infertility [11]. To reduce these risks, PCOS must be diagnosed and treated early. However, because of its varied presentation and symptoms that match those of other conditions, the syndrome is frequently underdiagnosed [12]. Typical symptoms include weight gain, acne, excessive hair growth, and irregular menstrual cycles. In addition to making these symptoms worse, a delayed diagnosis raises the risk of metabolic and cardiovascular issues [18]. It may cause irregular ovulation, which makes conception more difficult. Additionally, PCOS has significant social and psychological effects [19]. Women with PCOS are at a higher risk of anxiety, depression, and poor self-esteem, often stemming from body image concerns and fertility challenges [13].

This emphasises the necessity of managing PCOS holistically, considering both mental and physical health. Endocrine-disrupting chemical (EDC) exposure is one of the environmental factors that significantly contributes to the pathophysiology of PCOS [14]. These chemicals, found in everyday items such as plastics, cosmetics, and menstrual products, disrupt hormonal regulation and exacerbate PCOS symptoms. Developing successful preventative and treatment plans requires an understanding of these environmental factors [15]. By bringing attention to PCOS and its possible environmental causes, this paper hopes to add to the larger conversation about women's health [16]. This study emphasises that early intervention, supported by greater insight into product safety, is critical. Through investigation and the application of functional, natural substitutes like *Mussaenda erythrophylla*, researchers can lead the way for the next generation of menstrual products that are not only safer but also support women's health and well-being [17].

2.2. Harmful Toxins in Menstrual Products

Tampons, pads, and menstrual cups are examples of menstrual goods that have become indispensable for maintaining monthly hygiene [20]. With millions of women worldwide using these products, there is increasing recognition of the importance of product safety and their potential long-term health impacts [21]. While these products are designed for comfort and functionality, concerns have been raised about the presence of toxic chemicals that can affect women's health, potentially leading to hormone disruption, reproductive problems, and even cancer [22]. Many of these menstrual products are manufactured using synthetic fibres, cotton, and rayon, and chemicals are frequently used in the bleaching, scenting, and absorption processes [23]. While some manufacturers claim to use “natural” or “organic” materials, there is limited regulation or transparency regarding the full list of chemicals used [24]. Many studies have found that, despite claims to be safe, menstrual products contain hazardous ingredients, some of which can pass through the vaginal walls and have long-lasting adverse effects [25]. This has led to growing public concern about the materials and chemicals used to produce these products [26] (Figure 1).

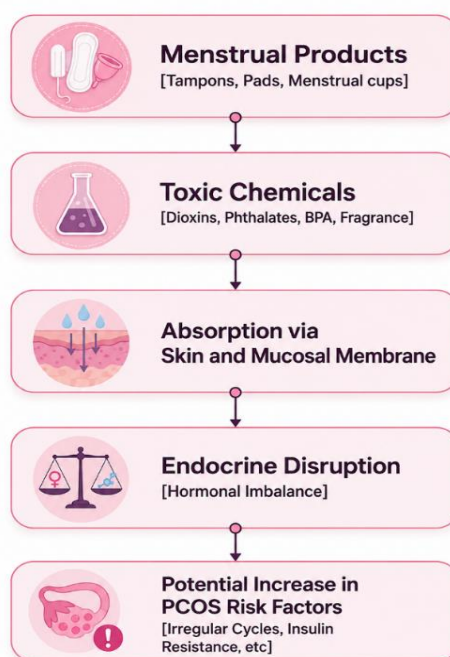


Figure 1: Proposed mechanism linking toxic chemicals in menstrual products to endocrine disruption and increased PCOS risk factors

Table 1 presents a selection of toxic chemicals and materials that may be present in menstrual hygiene products, along with their origins, chemical classifications, and potential health impacts. It points to substances including dioxins, phthalates, glyphosate, BPA, formaldehyde and heavy metals that are associated with endocrine disruption, reproductive toxicity, carcinogenic effects, immune system impairment and other adverse health outcomes. In general, Table 1 highlights the potential risks posed by chemical contaminants and synthetic materials in sanitary pads and tampons, underscoring the importance of product safety, transparency in manufacturing, and consumer awareness of exposure to harmful substances.

Table 1: Represents the various chemicals identified in commercial menstrual hygiene products

Toxin/Chemical Name	Source/Product	Chemical Class/Type	Health Impact
Dioxins	Bleached products (pads, tampons)	Persistent Organic Pollutant (POP)	Cancer, reproductive toxicity, immune suppression, endocrine disruption, bioaccumulation
Phthalates	Synthetic fragrances, plasticisers in tampons, pads	Endocrine Disruptor, Plasticiser	Reduced fertility, early puberty, hormonal imbalance, menstrual irregularities, endometriosis, PCOS
Glyphosate	Cotton-based products from GM crops (tampons, pads)	Herbicide, Probable Human Carcinogen (IARC Group 2A), Endocrine Disruptor	Cancer (breast, ovarian), decreased fertility, hormonal disruption, and immune system dysregulation
Polyethylene & Polypropylene	Outermost layers, absorbent cores, tampon strings	Synthetic Polymers, Microplastic Source	Release of microplastics, potential irritation, inflammation, and hormonal disruption (from additives like BPA and phthalates)
Rayon	Tampons, pads	Semi-synthetic fiber	Toxic Shock Syndrome (TSS) risk, potential dioxin formation (if bleached with chlorine), irritation from shedding microfibers

Formaldehyde	Adhesives, absorbent gels, finishing treatments	Volatile Organic Compound (VOC)	Carcinogen (IARC), skin and respiratory irritation, allergic reactions
Toxic Metals (Lead, Cadmium, Chromium, Mercury)	Dyes, adhesives, bleaching agents	Heavy Metals	Neurotoxicity, reproductive toxicity, kidney damage, carcinogenicity, and immune system suppression
Bisphenol A (BPA)	Plastic components (applicators, adhesives), polymer layers	Endocrine Disruptor	Hormonal imbalance, reproductive issues (infertility, PCOS), increased risk of hormone-sensitive cancers
Pesticides (general)	Conventional cotton products (tampons, pads)	Endocrine Disruptor, Carcinogen (e.g., glyphosate)	Endocrine disruption, reproductive toxicity, and increased cancer risk

3. Result and Discussions

To investigate the possible connection between menstrual products and polycystic ovarian syndrome (PCOS), researchers performed a survey which focused on the kinds of products that people use and how they believe the environment affects PCOS symptoms [27]. Survey data were collected from women across cities in multiple countries using a structured Google Form questionnaire [28]. The survey included participants across a wide age range, as shown in Figure 2, with the highest proportion of responses coming from women aged 20–22 years [29].

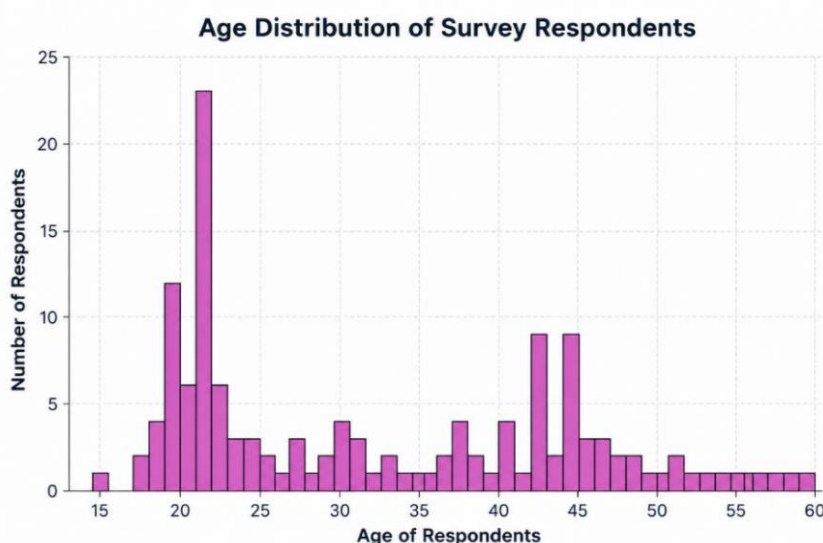


Figure 2: Illustrates the age distribution of the 132 women who participated in the survey, with the majority of respondents clustered around the age group of 20–22 years

The findings showed that while cloth pads, tampons, and menstrual cups are far less commonly used, a sizable majority of respondents utilise disposable sanitary pads [31]. This raises concerns about prolonged exposure to toxins commonly found in disposable pads, driven by this overwhelming demand [32]. Endocrine-disrupting chemicals (EDCs) such as phthalates, parabens, and dioxins have been found in commercial sanitary pads and have been connected to reproductive health issues and hormonal imbalances [33]. Graph (A) shows respondents' beliefs about whether menstrual products cause hormonal imbalances (Yes/No/Maybe) [34]. There remains a shortage of public awareness regarding the exact risks associated with menstrual products, though increasing scientific evidence points to EDC exposure as causing reproductive health problems [35]. However, it has been discovered that industrial chemicals and airborne pollutants interfere with ovarian function and insulin signalling, aggravating symptoms like weight gain, irregular menstruation, and elevated testosterone levels. Researchers also asked participants if they were aware of the connection between PCOS symptoms and environmental variables such as pollution and chemical exposure. As seen in graph (B), Long-term exposure to such environmental toxins has been shown to exacerbate metabolic syndrome and increase the risk of developing obesity, which is often observed in women with PCOS. According to the findings, more than 60% of respondents believe these factors affect PCOS, yet a sizable proportion are unsure (Figure 3).

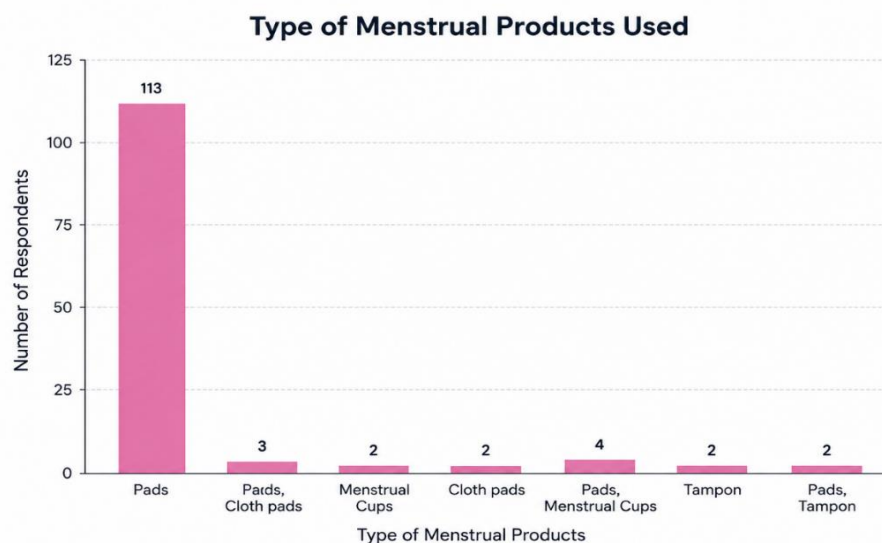


Figure 3: Types of menstrual products used

This supports previous findings that environmental contaminants, especially EDCs, might impair ovarian function, alter metabolic pathways, and worsen symptoms of PCOS. The role of chemical exposure is commonly underestimated within the traditional rhetoric surrounding PCOS, which often centres on lifestyle and genetic factors. PCOS is highly prevalent because of a mixture of chemical exposure and lifestyle factors precipitated by urbanisation and socioeconomic factors. Poor diet, physical inactivity, and high levels of stress are major environmental risk factors that have emerged over the past few decades. Stress has been on the rise due to urbanisation, air pollution, noise pollution, and occupational pressures, all of which affect endocrine balance. Chronic stress leads to a surplus of cortisol, which has been identified as one of the triggers for insulin resistance, a main causative factor of PCOS. Furthermore, it has been demonstrated that consuming a diet high in calories, low in nutrients, and high in trans fats and refined carbohydrates can lead to metabolic dysfunction and obesity. These two conditions are directly linked to the onset of PCOS (Figure 4).

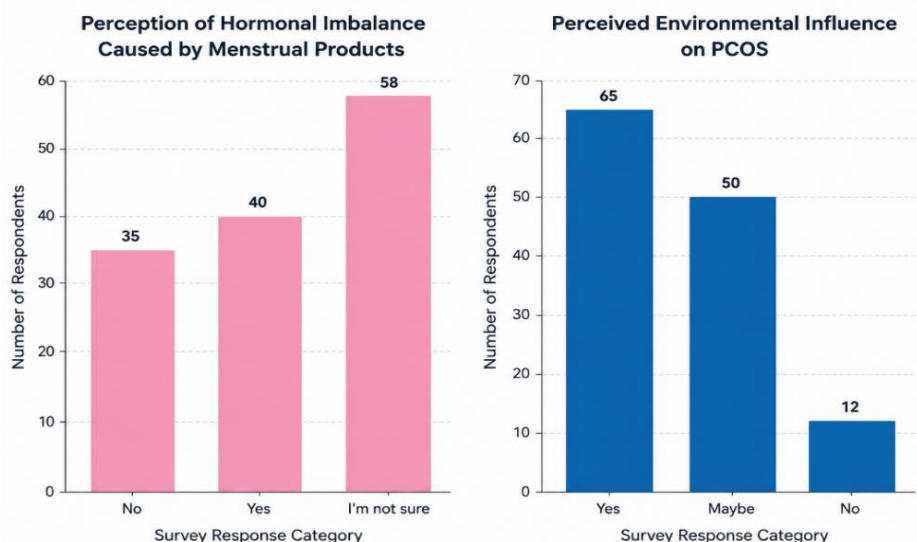


Figure 4: Graph (A) represents hormonal imbalances linked to chemicals in everyday products; graph (B) represents the environmental factors possibly influencing PCOS symptoms

According to the poll's findings, a significant number of people may not be fully aware of the risks associated with traditional menstrual products. According to a review by Marroquin et al. [18], many menstrual products include dangerous substances that may aggravate reproductive health conditions. In light of this data, educational programs are desperately needed to raise awareness and support safer menstrual hygiene habits. Promoting the use of safer, non-toxic menstrual products is essential to

reducing any possible health hazards. Reusable menstruation cups, biodegradable alternatives, and organic cotton pads are a few examples of options that can drastically reduce exposure to harmful chemicals. Stricter laws governing the disclosure of product ingredients might also enable customers to make more informed decisions about their reproductive health. According to research, switching to menstrual products free of chemicals may help reduce the incidence of issues connected to PCOS. In summary, endocrine-disrupting chemicals, pollutants, and lifestyle modifications are among the environmental factors that significantly contribute to the development and aggravation of PCOS. The rising incidence of PCOS around the world emphasises the need for more knowledge and comprehension of how environmental variables affect hormonal health. In addition to exposure to pollutants such as pesticides, endocrine-disrupting chemicals, such as BPA and phthalates, can alter hormonal balance, leading to insulin resistance and metabolic abnormalities—two major features of PCOS. Concurrently, the illness is made worse by the increase in urbanisation and changes in lifestyle, such as unhealthy eating patterns and elevated stress levels [30].

By addressing these environmental variables through individual lifestyle adjustments, public health initiatives, and legislative reforms, PCOS may become less common and women with the illness may experience an improvement in their general well-being. To develop more effective preventive and treatment plans, additional research is required to determine the precise mechanisms by which environmental factors contribute to PCOS and to ensure that menstrual health products do not cause long-term hormonal imbalances or reproductive diseases. Our findings highlight the significance of additional research, stricter regulation, and public education. Contemporary sanitary pads typically include synthetic substances, plastics, and a range of chemical additives. Although effective, these materials can contribute to environmental waste and may cause skin irritation or allergic reactions in some individuals. Additionally, poor menstrual hygiene can raise the risk of infection, especially in environments with limited resources. It is essential to seek a natural, safe, efficient, and sustainable substitute. There is still a large research gap regarding other species with unrealised potential, even though materials such as banana and coconut fibres have been investigated and utilised in a range of biodegradable products, including sanitary pads. These well-established substitutes often lack intrinsic therapeutic properties and instead focus on absorbency and biodegradability. With its well-established antimicrobial and anti-inflammatory qualities, the plant *Mussaenda erythrophylla* may be a useful natural ingredient in sanitary pads to help prevent infections and lessen discomfort, according to this paper's hypothesis.

3.1. *Mussaenda Erythrophylla*: A Solution

The genus *Mussaenda* is an important source of pharmacologically active natural products, particularly iridoids, triterpenes and flavonoids. The advantage of the species in this genus is its easier growth, pest- and disease-free status, and its ability to withstand heavy pruning (Figure 5).

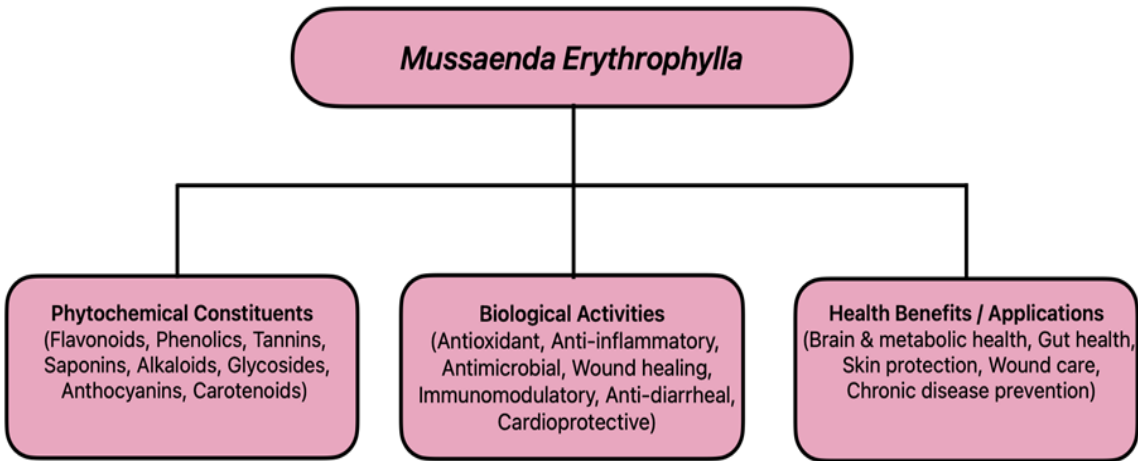


Figure 5: The flowchart represents the phytochemical profile, biological activities, and health applications of *Mussaenda erythrophylla*

Their medicinal activities include cytotoxicity and anti-inflammation. antiviral, antioxidant, and antibacterial properties, diuretic, antipyretic, effective in laryngopharyngitis, acute gastroenteritis, and dysentery, and also anti-fertility activity. *Mussaenda erythrophylla* is a tropical shrub known for its vibrant red bracts. *Mussaenda erythrophylla* is rich in valuable phytochemicals such as flavonoids, phenolics, tannins, saponins, alkaloids, glycosides, and anthocyanins. Research indicates that these compounds exhibit antimicrobial, anti-inflammatory, antioxidant, and wound-healing properties. This points to the

possibility of utilising *Mussaenda erythrophylla* in environmentally friendly sanitary pads. Incorporating its flower extracts into absorbent materials may help inhibit microbial growth, manage odour, and reduce the risk of infections commonly associated with menstrual hygiene products. Moreover, tannins and saponins could enhance local antimicrobial activity and protect the skin, while flavonoids and anthocyanins might alleviate irritation through their anti-inflammatory effects. Therefore, *Mussaenda erythrophylla* offers a sustainable, plant-derived alternative to synthetic additives in hygiene products, potentially improving users' health and reducing the ecological footprint of conventional pads. Although this concept remains theoretical and requires more investigation, it offers a novel approach to integrating traditional botanical knowledge with contemporary menstrual hygiene methods. Table 2 lists the major phytochemical constituents identified, along with their health benefits reported from previous scientific studies.

The phytochemical analysis of the plant reveals the presence of bioactive compounds, including flavonoids, phenolic compounds, tannins, saponins, alkaloids, glycosides, anthocyanins, carotenoids, and essential oils, which are attributed to the plant's medicinal properties. Flavonoids and phenolic compounds, among these constituents, have strong antioxidant and anti-inflammatory activities that protect cells from oxidative stress and reduce the risk of chronic diseases. Tannins and essential oils are antimicrobial and have wound-healing properties, while saponins are known to boost the immune system, fight fungal infections, and lower cholesterol. Alkaloids have analgesic and antimicrobial properties, while glycosides confer cardioprotective and anti-inflammatory benefits. Additionally, the anthocyanins and carotenoids that give the plant's flower pigment have antioxidant, anti-ageing, and skin protective effects. Conclusion Table 2 shows the significant therapeutic potential of *Mussaenda erythrophylla* based on its wide range of biologically active phytochemicals. Multiple studies have verified the antimicrobial capabilities of *Mussaenda erythrophylla*. The ethanolic and methanolic extracts of its flowers have shown significant inhibitory effects against prevalent bacterial pathogens, such as *Escherichia coli*, a major contributor to urinary tract infections, and *Staphylococcus aureus*, which can cause skin and soft tissue infections. This antimicrobial effect is primarily due to the elevated levels of tannins and flavonoids, which can damage bacterial cell membranes and prevent their proliferation.

Table 2: Presents the phytochemical constituents identified in *Mussaenda erythrophylla*

Component	Reported Health Benefits	Reference
Flavonoids (quercetin, kaempferol)	Strong antioxidants reduce inflammation, are neuroprotective, and cardioprotective.	Edeoga et al. [10], Okwu and Josiah [21]
Phenolic compounds	Free radical scavenging, anti-ageing, anti-inflammatory, and possible anti-cancer effects	Azziz et al. [4]
Tannins	Antimicrobial, wound healing, anti-diarrheal, astringent properties	Palombo [23]
Saponins	Immune-boosting, antifungal, cholesterol-lowering, anti-inflammatory	Okwu and Josiah [21]
Alkaloids	Analgesic, antimicrobial, anti-diarrheal, possible CNS activity	Edeoga et al. [10]
Glycosides	Cardioprotective, antioxidant, anti-inflammatory.	Astalakhshmi and Ganapathy [3]
Anthocyanins & carotenoids (flower pigments)	Antioxidant, anti-ageing, skin protective, supports eye health	Diamanti-Kandarakis et al. [7]
Essential oils (volatile compounds)	Antimicrobial, aromatic, wound healing, stress relief	Oladunmoye and Kehinde [22]

This data indicates that incorporating *Mussaenda erythrophylla* into sanitary pads might create a shield against infection. In addition to its antimicrobial properties, *Mussaenda erythrophylla* has strong anti-inflammatory and pain-relieving effects. In vivo research has demonstrated that leaf extracts can significantly reduce inflammation, with results similar to those of conventional anti-inflammatory medications such as indomethacin. The anti-inflammatory effect is thought to be triggered by its capacity to suppress pro-inflammatory mediators. This twofold effect, fighting infection and calming inflammation, renders the plant a perfect choice for menstrual products. The historical use of *Mussaenda erythrophylla* across different cultures indicates a history of safe utilisation. Nonetheless, additional studies are necessary to guarantee consumer safety. The compilation of current studies on the plant's antimicrobial, anti-inflammatory, and analgesic effects establishes a solid theoretical foundation for its application in sanitary pads. Researchers propose that adding *Mussaenda erythrophylla* extract to menstrual products could provide a natural, safe, and effective way to prevent infections and alleviate menstrual discomfort. This promising route requires further exploration, including in vitro and clinical trials, to verify its effectiveness and safety for widespread use.

4. Conclusion

This research has successfully highlighted the possible health risks associated with the hazardous chemicals found in traditional menstrual products, especially their role in different reproductive and overall health problems. These substances, including phthalates, bisphenol A (BPA), and dioxins, are recognised as endocrine-disrupting chemicals that may lead to hormonal imbalances. The regular and ongoing use of these products indicates a possibility for the long-term build-up of environmental toxins in the body, an issue associated with the increasing occurrence of conditions such as PCOS. The research also examined the potential of *Mussaenda erythrophylla* as a natural element for a safer, healthier option in menstrual care. Our examination of the literature on this plant has shown significant potential, suggesting that its use in sanitary pads could offer dual benefits: reducing exposure to harmful chemicals while imparting antimicrobial and anti-inflammatory properties that may deliver therapeutic benefits, such as lowering infection risk and alleviating menstrual pain. The documented effects of *Mussaenda erythrophylla* in inhibiting microbial growth and reducing inflammation underscore the urgent need for further research into natural and organic options. These natural options can be a great selection for women looking to steer clear of harmful chemicals and wishing to lessen exposure to elements that could worsen issues associated with hormonal imbalance.

With the ongoing consumer demand for safer, eco-friendly products, the menstrual care sector needs to focus more on developing sustainable, chemical-free options. Furthermore, this research emphasises the significance of reforming policies and implementing stricter regulations on the components used in menstrual products. Existing regulatory frameworks frequently fall short in sufficiently safeguarding consumers from hazardous chemicals in common products. Policymakers need to enact stricter regulations to guarantee that menstrual products are devoid of endocrine-disrupting chemicals, and manufacturers must be mandated to do so. Regulators need to enforce stricter rules to guarantee that menstrual products do not contain endocrine-disrupting chemicals, and producers should be mandated to disclose all materials utilised in their products. This study continues to advocate for a multidisciplinary response to the growing health issues associated with menstrual products. Fostering awareness of toxicity hazards, endorsing alternatives like those with natural components such as *Mussaenda erythrophylla*, and pushing for stricter regulations can help empower more women to make informed choices regarding their reproductive health. Additional research will be required over time to evaluate if plant-based products provide lasting advantages and are thus safe and effective for widespread use.

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