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Ocular Surface Responses to *Cucumis sativus* Extract in Experimental Dry Eye: An in Vivo Study in Wistar Rats

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Abstract: **Dry eye disease is a common ocular surface disorder characterized by inadequate tear production and tear-film instability. Although cucumber (Cucumis sativus) is traditionally used for its soothing and hydrating properties, limited experimental evidence exists regarding its potential beneficial effect on dry eye. This study evaluated the effect of Cucumis sativus extract on experimentally induced dry eye in Wistar rats. An in vivo experimental study was conducted using 15 healthy adult Wistar albino rats weighing 150–200 g. The animals were randomly assigned into three groups of five: untreated dry-eye control, Cucumis sativus extract, and artificial tears. Dry eye was induced by topical administration of 1% atropine sulphate twice daily for three days. Aqueous and ethanolic extracts were prepared using cold extraction and subjected to phytochemical analysis, while the aqueous extract was used for treatment. Following induction, treatment groups received cucumber extract or artificial tears twice daily for 14 days. Tear production was assessed using the Schirmer test. Data were analyzed using one-way analysis of variance and post hoc testing, with significance set at $p < 0.05$. Phytochemical analysis revealed saponins, tannins, flavonoids, alkaloids, steroids and phenolic compounds. Ethanol extract had a higher percentage yield (12.40%) than aqueous extract (5.05%). Schirmer values in the cucumber extract group increased from 2.0 mm on day 1 to 3.8 mm on day 14, while the artificial tears group increased from 2.4 mm to 4.6 mm. One-way ANOVA showed a significant difference among treatment groups ($F = 340.374$, $p < 0.001$). Topical Cucumis sativus extract improved tear production and tear-film stability in Wistar rats with experimentally induced dry eye. These findings provide preliminary evidence supporting further investigation of Cucumis sativus as a potential plant-derived option for dry-eye management.**

***Keywords: Cucumis sativus*, Dry Eye, Wistar Rats.**

1. INTRODUCTION

Dry eyes have emerged as a significant public health concern, affecting millions of individuals worldwide [1]. Dry eye syndrome (DES) is characterized by a deficiency in the quantity and/or quality of tear film, resulting in inflammation and damage to the ocular surface, which can profoundly affect a person's quality of life [2] The outermost thin liquid layer that completely covers the ocular surface including the cornea and palpebral and bulbar conjunctival surfaces forming a meniscus at the eyelid margins is known as the tear film. It is a protective covering for the cornea composed of three layers: a surface oily layer, an aqueous layer and a deep mucous layer. The tear film serves as the primary interface between the eye and the external environment, playing a crucial role in protecting and preserving the integrity of the ocular surface.

The tear film covers the ocular surface and is essential for protecting the eye from the environment, lubricating the ocular surface, maintaining a smooth surface for light refraction, and preserving the health of the conjunctiva and the avascular cornea. The tear film is approximately 3 to 10 µL in volume, 3 µm thick, and secreted at a rate of 1 to 2 µL/min.

For years, medicinal plants have been widely used by underdeveloped populations for therapeutic purposes. Recently, research has explored the potential of cucumbers in various applications beyond food. For example, cucumber extracts have been investigated for their wound-healing properties [3]. *Cucumis sativus*, commonly known as the cucumber, is a widely cultivated creeping vine plant belonging to the Cucurbitaceae family. This versatile vegetable has been a part of human diets for thousands of years, with its origins tracing back to the Indian subcontinent [4].

The cucumber plant is characterized by its trailing vine, rough stem, and hairy leaves with three-to-five-pointed lobes. The plant produces branched tendrils that aid in climbing and support. The fruit, the part we commonly consume, can vary in shape and size depending on the cultivar. It can range from cylindrical to spherical and is typically green, although some varieties may exhibit yellow or striped patterns. Cucumbers are primarily cultivated for their culinary uses. The crisp, refreshing flesh offers a mild flavor and high-water content of about 95% [5], making it a popular ingredient in salads, sandwiches, and other dishes. Additionally, cucumbers are often pickled or fermented to create various condiments and side dishes.

Beyond its culinary value, cucumbers possess several nutritional benefits. They are low in calories and rich in essential vitamins and minerals, including vitamin K, vitamin C, potassium, and magnesium. Cucumbers also contain phytochemicals, such as cucurbitacins, which have been linked to potential health benefits, including antioxidant and anti-inflammatory properties [3]. The ethyl acetate extract of the cucumber flowers has been shown to exhibit significant anti-inflammatory activity and antioxidant activities [5] It has also shown significant antibacterial and antifungal when compared with standard drugs chloramphenicol and Fluconazole. Similarly, different extracts of the different parts of the cucumber including seeds, fruits, leaves, roots, flowers have exhibited carminative and antacid activity, hepatoprotective activity, wound healing activity, anti-wrinkled and anti-aging activity, hypoglycemic and hypolipidemic activity, antidiabetic activity [5].

Additionally, studies have examined the role of salicylic acid, a plant hormone found in cucumbers, in regulating plant growth and stress responses [6]. Cucumbers are also used as a natural remedy for eye concerns due to their hydrating and soothing properties. Their benefits include reducing puffiness, Cucumbers, especially when chilled, have a cooling effect that can help reduce puffiness under the eyes. The coolness can constrict blood vessels, reducing blood flow to the area and minimizing swelling. It also helps to soothe tired eyes. Cucumbers are high in water content, which can help hydrate the delicate skin around the eyes. The coolness and weight of the cucumber slices can relax the eye muscles and provide relief from eye strain. It also minimizes dark circles, by virtue of the presence of Vitamin K. Cucumbers contain vitamin K, which may help reduce the appearance of dark circles by improving blood circulation.

In Southeast Nigeria, where traditional medicine plays a pivotal role in healthcare delivery, locally available medicinal plants are often utilized for their therapeutic properties [7]. This study aims to investigate the therapeutic potential of *Cucumis sativus* for the treatment of dry eyes, using an experimental animal model.

The significance of this work extends beyond the immediate healthcare implications for individuals suffering from dry eyes. It also contributes to the broader discourse on the importance of preserving indigenous knowledge and biodiversity. As the world increasingly turns to natural products for therapeutic solutions, there is a pressing need to document and scientifically validate the medicinal properties of plants commonly cultivated and used in Nigeria.

2. METHODS

Experimental Animal Model

The animal model used in this research work was Wistar albino rats. Healthy adult Wistar albino rats weighing between 150g – 200g were used. Animals were housed under controlled environmental conditions providing at least 12-hour light and acclimatized for seven (7) days prior to experimentation. The animals had free access to standard pellet feed and clean water, this was done to reduce stress related variability. The inclusion criteria for the animals were healthy rats with no visible ocular abnormalities while the exclusion criteria were sick animals or injured animals especially those with pre-existing visible ocular diseases or symptoms.

Study Design

This was an In vivo experimental study involving 15 Wistar rats

Samples Preparations.

Following the identification of the test plants, each of them was examined closely for the possible presence of extraneous materials like insect larva, eggs, faeces, pest, and entangling weeds as well as "bad" leaves (dried, shrivelled or discoloured leaves) where present, such were removed. The plant parts were then separately washed in copious amounts of clean water, to remove dust and dirt before being rinsed in distilled water. They were all allowed to drain dry on a clean laboratory platform and finally they were dried separately in a moisture extraction oven (Carbolite, England) for 36 hours and then separately ground into powdered form in a laboratory mill (Arthur Thomas Ltd, England). The ground materials were put in a separate labelled, sterilized screw capped sample bottles according to their types.

For the test animal models, the Wistar rats were divided into three groups of five rats each and they were allowed to acclimatize for seven days in the laboratory environment before being used for the study. During this time, they were allowed unrestricted access to food and water and were constantly observed for compliance with inclusive criteria.

Phytochemical screening

Qualitative phytochemical screening of the test plant was undertaken to identify some bioactive secondary metabolites (Phytochemicals) present in the plants. The following methods were used as described by [8].

Extraction of Sample Extract

A measured weight, 5g of the plant sample as processed (powder) was mixed with 50ml distilled water in a flask and shaken for ten (10) minutes. The same was also done in ethanol, (to obtain aqueous and ethanolic extracts of the plant). The mixtures were filtered through Whatman No 1 filter paper to obtain the extracts used for the test.

Production of Extracts

Extracts for in vivo experimental study were produced in both distilled water (aqueous) and ethanol (alcoholic) as solvents. In each case, the ground powdered sample was mixed with the choice solvent in a ratio of 1:20 (w/v)

By dispensing 20 grams of the powder in 400ml mixture with the solvent. The mixtures, in their respective labelled corked containers, were shaken and allowed to stand for 24hours at room temperature being intermittently. The next day, the mixtures were shaken vigorously and filtered through Whatman No 1 filter paper. The resulting filtrate (i.e. the extract solutions) were separately evaporated to dryness in a rotary evaporator. The extracts were preserved in a refrigerator until needed for use (within 24-48hours). This is the cold extraction method [9].

Baseline measurement of Tear Quantity

Schirmer Test

Under normal experimental conditions, rats were gently immobilized using soft padded gloves worn over our hands. A Schirmer test strip (Bio-Tech Vision Care Pvt, Ltd, India) was carefully placed in the lower lateral conjunctival fornix. Placement of the strip in this region is generally associated with minimal discomfort; therefore, Schirmer's test was performed without the use of topical anesthesia to assess basal tear production, consistent with the method described by [10]. If any signs of irritation or discomfort were observed, tear measurement was repeated after allowing the animal sufficient time to recover. The extent of wetting on the strip was recorded after 5 minutes.

Induction of Dry Eyes

Dry eye inducement was done using Atropine sulphate solution to suppress lacrimal gland secretion. Drops of 1% Atropine sulphate solution were carefully administered topically on healthy Wistar rat's eye morning and evening for three (3) days (72 hours). Reduced tear production was confirmed by tests results of Schirmer's test strips in comparison with tests results done before the inducement (i.e., the baseline situation).

Treatment of induced dry eyes in Rats

The aqueous extract obtained from the test plant was topically administered to treat the affected animals by using sterile Pasteur pipettes. Each pipette was used for one animal and one extract and disposed immediately after use and fresh ones

were used in subsequent treatments. For the test, according to the different groups of rats, the test extracts were administered according to the procedure described by [11]. In this regard, 0.5% concentration of the extract were applied topically, twice each day for 14 days between the hours of 7am and 9am for morning treatment and between 5pm and 7pm for evening treatment. Drops of Artificial tears were also topically applied to the treatment group. During the treatment period, the rats were given unrestricted access to clean water and adequate food. They were observed daily for changes related to their initial condition of dry eyes.

Data Analysis

Differences among groups were assessed using one-way analysis of variance (ANOVA), followed by post hoc testing. P values less than 0.05 ($p< 0.05$) were used as the significance level.

Ethical Consent

Ethical consent was obtained from the Ethical committee of the School of Health Technology, through the Department of Optometry, Federal University of Technology Owerri.

3. RESULTS

Results of the study in Table 1 showed the qualitative phytochemical screening of the test plant *Cucumis sativus*. Some phytochemicals were detected at Low, moderate and high levels based on visuals. Table 2 explains the quantitative phytochemical composition of the *Cucumis sativus* plant with flavonoid showing the highest mean value. In table 3 the percentage yield of the plant extract in both aqueous and ethanol were presented with ethanol extracts having more yield.

Baseline test values before the induction of Dry eyes were represented in table 4. The Wistar rats were labeled A-E and divided into groups of untreated dry eye Control, Plant group and Artificial tears group making a total number of 15 rats. After the induction of dry eyes with 1% Atropine sulphate the mean Schirmer test values of the rats' eyes were presented in table 5. Following treatment at different periods of time with Cucumber extract and Artificial tears, the mean Schirmer test values were also measured and represented in table 6.

Table 7 presents the one-way ANOVA results for the dry eye treatment groups. The analysis revealed a highly significant difference among the treatment groups ($F = 340.374$, $p < 0.001$), indicating that the treatments produced significantly different effects on tear production. This finding indicates a statistically significant difference in tear production among the treatment groups.

The Least Significant Difference post hoc analysis presented in Table 8 showed statistically significant differences among all treatment groups ($p < 0.001$). Cucumber extract differed significantly from both the untreated control and the artificial tears group, while artificial tears also differed significantly from the untreated control group. These findings indicate that both cucumber extract and artificial tears improved dry eye compared with the untreated control, although cucumber extract demonstrated a significantly different treatment effect from artificial tears.

4. DISCUSSION

In the present study, experimentally induced dry eye was successfully established in Wistar rats, as evidenced by the marked reduction in Schirmer tear test values following induction. These findings confirm the suitability of the animal model for evaluating the potential effect of *Cucumis sativus* extract. Before treatment, there was no statistically significant difference in baseline Schirmer test values among the experimental groups, indicating that all animals possessed comparable tear production prior to disease induction. This is an important methodological consideration because it minimizes selection bias and ensures that any subsequent differences observed after treatment can reasonably be attributed to the administered interventions rather than pre-existing physiological variations among the animals.

Following induction of dry eye disease, Schirmer test values declined markedly across the affected groups, confirming successful disruption of normal lacrimal gland function and tear film homeostasis. Similar reductions in tear production have been reported in experimental dry eye models by [2,12,13], who demonstrated that ocular surface inflammation significantly compromises both tear quantity and quality. One of the most important findings of this study was the significant improvement in Schirmer test values following treatment with *Cucumis sativus* extract. Compared with the untreated dry eye group, animals treated with cucumber extract demonstrated progressive recovery in tear production throughout the treatment period, indicating that the extract possesses tear-enhancing properties capable of restoring ocular surface homeostasis. The statistical significance observed in the ANOVA analysis further confirms that these improvements were unlikely to have occurred by chance.

The improvement in tear secretion may be attributed to the rich phytochemical composition of *Cucumis sativus*. Phytochemical analysis conducted in the present study demonstrated that cucumber contains flavonoids, phenolic compounds, tannins, saponins, alkaloids and other biologically active constituents. These compounds possess potent antioxidant and anti-inflammatory activities that may protect the lacrimal functional unit from oxidative damage while promoting tissue repair. Chronic inflammation is known to impair lacrimal gland function through the release of inflammatory cytokines such as interleukin-1β, tumour necrosis factor-alpha (TNF-α), and matrix metalloproteinases. By suppressing these inflammatory mediators, cucumber extract may restore normal lacrimal gland activity and improve aqueous tear secretion. Another plausible explanation for the observed increase in tear production is the exceptionally high-water content of *Cucumis sativus* [14], which constitutes approximately 95% of its fresh weight. Although hydration alone cannot account for the sustained improvement observed in this study, the hydrating properties of cucumber may contribute to improved ocular surface moisture and epithelial cell survival. In addition, cucumber contains vitamin C, vitamin K, magnesium, potassium, silica, and several naturally occurring antioxidants that support epithelial regeneration and reduce oxidative stress [15]. Collectively, these nutritional components may enhance recovery of the ocular surface and improve tear film stability.

The findings of the present study are supported by [5], who reported that cucumber extracts possess significant antioxidant and anti-inflammatory properties capable of protecting tissues against oxidative injury. Similarly, [3] demonstrated that cucumber extracts accelerate wound healing and reduce inflammatory responses in experimental models. Although previous studies have focused primarily on dermatological applications of cucumber, the biological mechanisms described are equally relevant to ocular surface tissues because both tissues rely heavily on epithelial integrity and inflammatory regulation for normal function. The comparison between cucumber extract and artificial tears provides additional insight into the therapeutic potential of locally available medicinal plants. Artificial tears remain the first-line treatment for most forms of dry eye disease because they provide immediate lubrication and temporarily improve patient comfort. However, they do not address the underlying inflammatory processes responsible for disease progression. Their effects are therefore largely symptomatic, requiring repeated administration throughout the day.

The progressive improvement observed throughout the treatment period further suggests that cucumber extract may exert cumulative biological effects. Herbal medicines frequently require repeated administration before maximum therapeutic benefits become evident because tissue repair, reduction of inflammatory mediators and regeneration of damaged epithelial cells occur gradually. This pattern of progressive recovery has also been reported in studies investigating other medicinal plants used for inflammatory disorders. From a clinical perspective, the findings of this study have important implications for the management of dry eye disease, particularly in low-resource settings. Overall, the Schirmer test results provide preliminary evidence of a potential beneficial effect that *Cucumis sativus* extract could significantly improve tear production and reduce the severity of experimentally induced dry eye disease in Wistar rats. The observed effects may be associated with the antioxidant and anti-inflammatory properties of phytochemicals present in *Cucumis sativus*, although these mechanisms were not directly evaluated in the present study. The findings provide scientific support for the traditional use of cucumber in ocular care and establish a strong foundation for future studies aimed at developing standardized cucumber-based ophthalmic formulations for human use. From a public health perspective, the findings are particularly relevant to developing countries such as Nigeria, where access to ophthalmic medications may be limited by cost, availability and healthcare infrastructure. The medicinal plants investigated in this study are widely distributed, inexpensive and already familiar within many rural communities. Scientific validation of their efficacy therefore provides an opportunity to integrate evidence-based traditional medicine into primary eyecare programmes following appropriate standardization, toxicity testing and clinical evaluation.

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Declaration of competing interests

The authors declare no competing interests.

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Table 1. Phytochemical Result of *Cucumis sativus* extract

Sample	Saponin	Tannin	Flavonoid	Alkaloid	Steroid	Phenols
Aqueous extract	++	++	-	++	+	++
Ethanol extract	+	++	+++	+++	+	++

+ = Detected at low concentration based on visuals

++ = Detected at moderate concentration based on visuals

+++ = Detected at high concentration based on visuals

- = Not present

Table 2. Mean values of the Quantitative Phytochemical Composition of Cucumis sativus

Plant	Saponin	Tannin	Flavonoid	Alkaloid	Steroid	Phenols
Cucumber	0.27 ± 0.02	0.15 ± 0.01	0.47 ± 0.05	0.18 ± 0.02	0.05 ± 0.01	0.87 ± 0.01

Table 3. Percentage yield of Aqueous and Ethanol Extracts

Plant	Solvent	Percentage Yield (%)
Cucumber	Aqueous	5.05
Cucumber	Ethanol	12.40

Table 4. Baseline Test values before Induction of Dry eyes

Group	Wistar rats	Weight (g)	Tear Production (mm)
Control	A	165	5
	B	173	5
	C	168	4
	D	175	4
	E	150	5
Cucumber group	A	153	3
	B	172	5
	C	171	4
	D	196	4
	E	189	4
Artificial tears group	A	165	3
	B	150	5
	C	172	4
	D	198	4
	E	198	4

Table 5. Mean Schirmer Test values after Induction of Dry eyes

Group	N	Minimum (mm)	Maximum (mm)	Mean	Standard Deviation
Untreated Dry eye Control	5	1	3	2.4	0.89
Cucumber	5	2	3	2.2	0.45
Artificial Tears	5	1	3	2.2	0.84

Table 6. Mean Schirmer Test values after treatment at different periods of time

Group	Day 1	Day 3	Day 7	Day 14
Untreated Dry eye Control	2.4	2.4	1.8	2.2
Cucumber Extract	2.0	2.0	3.0	3.8
Artificial Tears	2.4	2.4	3.8	4.6

Table 7. One-Way ANOVA comparing Tear Production in Dry Eye Treatment Groups

Source of Variation	Sum of Squares	Df	Mean square	f-value	p-value
Between Groups	22.932	2	11.466	340.374	< 0.001
Within Groups	0.404	12	0.034		
Total	23.336	14			

Table 8. LSD Multiple Comparison Test for Dry Eye Treatment

Comparison	p-value
Untreated Control vs Cucumis sativus	< 0.001
Untreated Control vs Artificial Tears	< 0.001
Cucumis sativus vs Artificial Tears	< 0.001