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EDITORIAL

It is with great pleasure that I present this compilation of research works published in the volume 2, number 1 edition of the Journal of Multidisciplinary Research and Innovations, to the academic community. It was indeed a journey of hope as we awaited the manuscripts to turn in and finally, we are here.

Congratulations to the Academic Staff Union of Polytechnics, The Federal Polytechnic, Bida Chapter (ASUP-BD) for this publication and edition. Kudos to the current Chapter Executive Committee (CEC) of ASUP-BD who envisioned this project and has given the right hand of fellowship to make the progress thus far recorded. We congratulate also the Management of the Institution for this recorded progress.

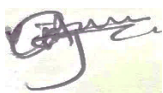
This edition, though contained the least number of articles since the birth of this Journal, is nonetheless rich in its contents. The articles cover the broad fields of Arts and Humanities, Business and Management, and, Engineering and Sciences. It missed out on the contributions from Environmental Studies.

All contributors, our assessors, editorial advisers and everyone who worked remotely to ensure the success of this edition are much appreciated. Thank you all.

We again hereby call for contributions of manuscripts. Such should be done through the appropriate channel. Do note the requirements. The journey to the next edition has begun. Progress is being made on online publication and would soon be a reality. JMRI has come to stay for the good of all.

Finally, I say a big well done, and thank you to the Editorial Board. You have been a very wonderful team. Your labours are much appreciated. Thank you for being there. Keep strong, serving God and humanity. The good works will keep speaking and God will bless all the efforts.

Thank you.



Dr. O.I. Ajari
Editor-in-Chief

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ARTS AND HUMANITIES

A MYTH CRITICISM ANALYSIS OF SUPERSTITION IN CHIGOZIE OBIOMA'S *THE FISHERMEN*

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ABSTRACT

Chigozie Obioma's *The Fishermen* (2015) is a richly layered novel that interweaves superstition with cultural and familial dynamics in 1990s Nigeria. This article employs myth criticism, as articulated by Northrop Frye and Joseph Campbell, to analyze the theme of superstition, focusing on the prophecy of the madman Abulu and its mythic resonance. By examining archetypal patterns, symbolic imagery, and narrative structures, this study argues that superstition in *The Fishermen* functions as a modern myth, reflecting universal human experiences while grounding them in Igbo cultural specificity. The analysis situates the novel within the African literary tradition, highlighting its dialogue with postcolonial realities and mythic story-telling.

Keywords: Myth criticism, superstition, Igbo cosmology, oral traditions, symbolism

INTRODUCTION

Chigozie Obioma's debut novel, *The Fishermen* (2015), shortlisted for the 2015 Man Booker Prize, is a poignant exploration of family, fate, and societal tensions in postcolonial Nigeria. Set in Akure during the 1990s, the novel follows four brothers Ikenna, Boja, Obembe, and Benjamin whose lives unravel after a local madman, Abulu, prophesies that Ikenna will be killed by a "fisherman," implying one of his brothers. This prophecy, steeped in superstition, triggers a tragic chain of events, blending realism with mythic undertones.

"Myth criticism", rooted in the works of Northrop Frye (1957) and Joseph Campbell (1949), offers a robust framework for analyzing the theme of superstition in *The Fishermen*. This theory examines literature through universal archetypes, symbols, and narrative patterns drawn from myths, viewing superstitions as contemporary expressions of mythic structures. This work argues that superstition in *The Fishermen* serves as a mythic catalyst, embodying archetypal motifs of prophecy, *the trickster*, and *the fall*, while reflecting Igbo cosmology and postcolonial Nigerian realities. This study illuminates how Obioma reworks mythic traditions to explore human agency, belief, and cultural identity.

THEORETICAL FRAMEWORK

Myth criticism posits that literature reflects universal patterns and archetypes that resonate across cultures and eras. Frye (1957) describes literature as "displaced myth," where modern narratives adapt ancient mythic structures to address contemporary concerns. Campbell's (1949) concept of the "monomyth" emphasizes recurring motifs, such as the hero's journey, prophecy, and the trickster,

which shape narrative meaning. Superstition, often rooted in cultural beliefs about the supernatural, aligns with mythic archetypes by encoding collective fears and aspirations.

In *The Fishermen*, superstition particularly Abulu's prophecy functions as a mythic archetype, driving the narrative and symbolizing broader societal tensions. As Finnegan (1970) notes, African oral traditions often blend myth and reality, using supernatural elements to interpret human experiences. Obioma's novel draws on this tradition, positioning superstition as a modern myth that bridges Igbo cosmology and postcolonial challenges. Myth criticism allows us to analyze how these superstitious elements reflect universal archetypes while remaining culturally specific.

MYTH CRITICISM ANALYSIS OF *THE FISHERMEN*

Narrative Structure and the Monomyth: *The Fishermen* follows a mythic narrative arc, resembling Campbell's (1949) monomyth, where a call to adventure disrupts the ordinary world, leading to trials and transformation. The novel begins with the Agwu brothers' idyllic childhood, disrupted by their father's absence and their secret fishing trips to the forbidden Omi-Ala River. Abulu's prophecy serves as the "call," thrusting the brothers into a tragic journey. Benjamin, the narrator, recounts this as an adult, framing the story as a mythic reflection on loss and redemption.

The prophecy aligns with the mythic archetype of the oracle, a common motif in Greek and African traditions. As in Sophocles' *Oedipus Rex*, where prophecy drives the

tragic outcome, Abulu's prediction shapes Ikenna's paranoia and the family's disintegration. However, Obioma grounds this archetype in Igbo cosmology, where diviners and spirits hold sway, as noted by Quayson (2009). The narrative's episodic structure, with chapter titles like "Sparrow," "Leech," and "Locusts," reinforces its mythic quality, using animal metaphors to evoke biblical and Igbo oral traditions (Obioma, 2015;).

Archetypal Figures: Abulu as Trickster and Prophet: Abulu, the madman, embodies the mythic archetype of the trickster prophet, a figure who disrupts order while revealing truths. In Campbell's (1949) framework, the trickster challenges societal norms, often catalyzing transformation. Abulu's prophecy that Ikenna will die at the hands of a "fisherman" is both disruptive and ambiguous, as the brothers' fishing hobby makes them potential agents of fate. His role recalls Igbo beliefs in *dibia* (diviners) who mediate between the human and spiritual realms, as discussed by Finnegan (1970).

Abulu's mythic significance is twofold. First, he symbolizes chaos, his "crazed yammering" perceived as divine insight by the community. Secondly, he reflects postcolonial Nigeria's fractured state, where superstition fills the void left by political instability. As Sharp (2016) argues, Abulu may symbolize British colonialism, but his complexity as a character transcends allegory, embodying the trickster's dual role as destroyer and truth-teller. Myth criticism reveals how Abulu's prophecy transforms superstition into a mythic force, driving the narrative toward tragedy.

Symbolism: The Omi-Ala River as Mythic Space: The Omi-Ala River, a forbidden and polluted site, serves as a mythic symbol of danger and transformation. In Igbo cosmology, rivers are often sacred, associated with spirits and taboos (Achebe, 1958). The brothers' fishing violates this taboo, aligning with the mythic motif of the "forbidden act" that invites divine retribution. Frye (1957) notes that mythic spaces, like rivers, symbolize transitions between life and death, order and chaos. The Omi-Ala, described as a "spectral space" where "past and future environments coexist," embodies this duality, linking the brothers' personal tragedy to Nigeria's ecological and colonial wounds.

The river's pollution, a legacy of colonial resource extraction, enhances its mythic resonance, evoking what

Garuba (2003) calls "animist materialism," where spiritual and material realities intertwine. The brothers' fishing hooks, used later to kill Abulu, further symbolize their entanglement in the prophecy's mythic cycle, reinforcing the novel's theme of inevitable fate.

Superstition as Modern Myth: Superstition in *The Fishermen* functions as a modern myth, blending Igbo spiritual beliefs with universal archetypes. Ikenna's belief in Abulu's prophecy reflects David Hume's (1748) concept of "necessary conjunction," where human minds link events causally based on experience. In the novel, this psychological tendency amplifies the prophecy's power, as Ikenna's paranoia transforms his brothers into potential threats. Myth criticism interprets this as a retelling of the Cain and Abel story, with Ikenna and Boja's conflict mirroring biblical fratricide. However, Obioma adapts this archetype to Igbo culture, where communal beliefs in prophecy and fate shape individual actions

The novel's superstitious elements also engage with postcolonial themes. As Datta (2025) argues, *The Fishermen* challenges nationalist narratives by presenting superstition as a response to Nigeria's colonial legacy, where forced unification disrupted traditional social structures. The prophecy becomes a mythic metaphor for this disruption, illustrating how belief in the supernatural can both unite and fracture communities.

Scholarly Engagement: Scholarly engagement with Chigozie Obioma's *The Fishermen* reveals a fascinating critical conversation centered on the novel's genre, its dialogue with African literary tradition, and its thematic complexities. The novel is widely acknowledged for its mythic qualities, but scholars have debated whether these elements serve to enrich or potentially exoticize its Nigerian context. A closer examination of these scholarly perspectives is crucial for understanding the novel's place within contemporary African literature.

The Mythic and the Magical: Much of the critical conversation surrounding *The Fishermen* stems from its mythic and allegorical structure. Scholars like Helon Habila (2015) have described the novel as a "supernatural fable," arguing that it masterfully blends the narrative traditions of Chinua Achebe and Ngũgĩ wa Thiong'o with a distinctive, mythical narrative style reminiscent of Igbo oral storytelling. The novel's central conflict, driven by a

curse-like prophecy from a local madman, operates as a fate-driven force that propels the brothers' tragedy. This reliance on prophecy, a potent force of superstition, situates the novel within a broader discourse on African magical realism. Ato Quayson (2009) situates Obioma's work within this framework, where superstition is not merely a backdrop but an active narrative device. It serves to illuminate the psychological and social tensions that arise when traditional belief systems collide with the realities of modern life and the pressures of postcolonial society. This mythic structure is not just an aesthetic choice; it provides a powerful lens through which to explore the profound impact of unseen forces on human agency and social relations.

Conversely, other critics, such as Elena Morosetti (2015), have expressed concern that the novel's mythic elements, while compelling, risk exoticizing Nigerian culture for a Western audience. This critique posits that a heavy reliance on superstition and folklore can unintentionally reinforce stereotypical notions of Africa as a mystical, pre-modern continent, catering to a Western desire for a "magical" African narrative. The argument is that by foregrounding these elements, the novel might obscure the nuanced socio-political realities of postcolonial Nigeria in favor of a more marketable, fantastical plot.

However, a strong counter-argument emerges from myth criticism, which emphasizes the universal resonance of Obioma's chosen archetypes. This perspective asserts that Obioma's mythic structure does not exoticize but rather elevates the specific cultural context to a universal plane. The family's tragedy, while rooted in Nigerian cultural and political specificity, is built on an archetype as old as time itself: the story of sibling rivalry and betrayal. As scholars like Tsouderos (2015) note, the novel's retelling of the biblical story of Cain and Abel against the specific backdrop of Nigeria in the 1990s underscores this crucial balance. It demonstrates how a timeless, universal human drama can be adapted to a particular cultural moment, allowing it to resonate across different cultures without losing its specific cultural and political weight.

DIALOGUES WITH THE LITERARY CANON

Beyond its mythic structure, *The Fishermen* also engages in a direct and significant dialogue with Chinua Achebe's seminal work, *Things Fall Apart* (1958). Achebe's novel similarly uses an oracle's prophecy as a central dramatic

device that drives the tragic downfall of its protagonist, Okonkwo. Obioma's use of superstition as a powerful, mythic force echoes Achebe's groundbreaking exploration of Igbo spirituality and cosmology, which was a deliberate effort to counter colonial portrayals of Africa as godless.

However, Obioma's work adapts this narrative heritage to a distinctly postcolonial context. While Achebe's tragedy unfolds against a backdrop of pre-colonial and colonial life, Obioma's is situated in the modern landscape of Nigeria in the 1990s. The family's tragedy, therefore, becomes a powerful allegory for the "lost promise" of modern Nigeria itself. The brothers' once-harmonious relationship, shattered by a prophecy and internal strife, mirrors the breakdown of the Nigerian state following military coups and the erosion of national unity. Tsouderos (2015) highlights this connection, arguing that the novel's retelling of a universal tale against a specific national backdrop underscores its ability to speak to both the timeless human condition and the particular postcolonial struggles of a nation grappling with its identity and history. By engaging with and updating the Achebe tradition, Obioma solidifies his place within a rich African literary lineage while forging a new, urgent narrative relevant to contemporary readers.

The discussion surrounding *The Fishermen* is distinguished by the novel's sophisticated use of superstition, which operates as a mythic framework to bridge individual, familial, and national narratives. This approach positions Obioma's work firmly within, and in dialogue with, African literary traditions.

The Mythic as Cultural and Social Commentary: In contrast to many Western novels where superstition is often relegated to the irrational or used for gothic effect, Obioma presents it as a valid and powerful cultural force. This aligns with Ruth Finnegan's (1970) seminal observations on African oral traditions, where myth is not a fantasy but a crucial tool for interpreting social realities, explaining the unexplainable, and transmitting communal values. The prophecy from the madman in the novel is not a mere plot device; it is a manifestation of Igbo belief systems concerning fate and the interconnectedness of individual actions with a larger cosmic order. This deep-seated belief system provides a

lens through which the characters, and by extension the reader, can make sense of a chaotic and uncertain world.

The novel's setting in postcolonial Nigeria, marked by profound political corruption and ethnic tensions, further emphasizes the significance of this mythic framework. Superstition, in this context, becomes a response to societal uncertainty. As the promise of the nation fractures, the family's tragedy spurred by a seemingly irrational prophecy becomes a metaphorical way to process the national disillusionment. The brothers' inability to escape their fate mirrors the nation's struggle with its own tragic history, suggesting that the "lost promise" of Nigeria is a force as relentless as a curse. This thematic use of superstition echoes earlier works in African literature, such as Amos Tutuola's *The Palm-Wine Drinkard* (1953), which similarly blends folklore with the contemporary, creating a literary space where the spiritual and the social coexist and inform each other.

INTERTEXTUALITY AND THE NARRATIVE OF DECOLONIZATION

Beyond its grounding in African oral traditions, *The Fishermen* also engages in a sophisticated practice of intertextuality, creating what Kunkel (2020) terms a "kaleidoscopic network" of mythic influences. Obioma draws upon biblical, Greek, and Igbo myths, weaving them together to tell a story that is simultaneously universal and culturally specific. This relational approach serves a powerful purpose: it challenges colonial power structures by reinterpreting canonical stories through a distinctly African lens. By retelling the story of Cain and Abel, a foundational narrative of Western civilization, Obioma reclaims it, placing it within the Igbo context and infusing it with new meanings shaped by Nigerian history and culture. This act of discursive decolonization asserts the validity of African experiences and cosmologies as central to understanding universal human dilemmas.

The novel's ending provides a profound culmination of this mythic cycle. The family's journey is one of tragic descent, echoing a classic mythic fall. However, Benjamin's survival, his transformation from the narrator of the past to a figure of the future, offers a glimmer of hope. His symbolic presence as an "egret" a bird often associated with purity and a new beginning suggests a mythic cycle of renewal and redemption. This aligns with Northrop Frye's (1957) view of myth as a narrative that

often moves toward reconciliation or the promise of a new dawn after tragedy. The novel's conclusion, therefore, becomes a powerful statement about hope in the face of despair. It implies that while the past tragedy of the family (and by extension, the nation) is a powerful, inescapable mythic force, the survival of a new generation offers the possibility of breaking the cycle and creating a different future.

CONCLUSION

Through a myth criticism lens, *The Fishermen* reveals superstition as a modern myth that weaves universal archetypes with Igbo cultural specificity. Abulu's prophecy, the Omi-Ala River, and the brothers' tragic arc evoke mythic motifs of prophecy, the trickster, and the fall, while addressing postcolonial Nigeria's fractured identity. By blending Igbo cosmology with biblical and African oral traditions, Obioma crafts a narrative that resonates universally yet remains distinctly African. This analysis underscores the novel's contribution to African literature, affirming its status as a mythic elegy to lost promise and a hopeful vision for renewal.

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DRAMA AND THE EMPOWERMENT OF THE AFRICAN WOMAN IN TEWFIK AL-HAKIM'S *THE SULTAN'S DILEMMA* AND IYORWUESE HAGHER'S *MULKIN MATA*

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ABSTRACT

This paper examines the representation and empowerment of African women in Tewfik Al-Hakim's *The Sultan's Dilemma* (1960) and Iyorwuese Hagher's *Mulkin Mata* (1990) within the context of African drama. Both plays, rooted in distinct socio-political and cultural landscapes, utilize the dramatic form to explore the agency, resilience, and challenges faced by women in patriarchal societies. Through a feminist lens and thematic analysis, this study investigates how these works challenge traditional gender roles, critique oppressive systems, and advocate for women's empowerment. The analysis reveals that while Al-Hakim employs allegory and existentialist undertones to depict women's subtle resistance within a constrained socio-political order, Hagher uses collective heroism and social movement strategies to portray women as active agents of change. This comparative study underscores the role of drama as a tool for conscientizing audiences about gender dynamics and promoting socio-cultural transformation in African contexts.

Keywords: African drama, women's empowerment, feminism, patriarchy, agency

INTRODUCTION

This study explores Drama as an art form and its potentials to provide a platform for articulating and interpreting the realities and aspirations of the society. According to Onochie (2015), drama provides a platform for evaluating social, cultural, economic and political situations of its immediate environment and the larger society. Using educational and entertainment functions, drama as a dynamic force, awakens people's consciousness and plays a crucial role in national development by shaping and conditioning the realities of the society that produces it. The dramatist therefore, heralds the dawn of a brand-new society that is devoid of oppression and intimidation, a society that celebrates justice and equity. The dramatist builds the nation by positively shaping or influencing the social, cultural, economic and political aspects of human life. The concept of women empowerment according to the European Institute for Gender Equality (2024), has five components: women's sense of self-worth, women's rights to have and determine choices, women's right to access opportunities and resources, women's right to have power to control their own lives, and women's ability to influence social change to create a more just social and economic order, nationally and internationally.

Aside patriarchy and its related challenges, intra-gender conflicts have been identified as a major setback on the women's struggle to emerge from the rear. Sarki (2000), observes that, before the 1960s, African women were not considered as serious subjects of discourse. They did not

receive serious attention from male writers and critics of African Literature. According to Ojo-Ade (1979), African literature is a male created, male oriented, chauvinistic art. Ojo-Ade maintains that it is such names of male writers as Chinua Achebe, Mungo Beti, Wole Soyinka, Ngugi Wa'Thiongo, Ousmane Sembene or critics like Gerald More, Eustace Palmer, Eldred Jones, E. Obiechina, that dominate the African literacy scene.

African drama has long served as a medium for reflecting socio-political realities and advocating for social change. In the post-colonial era, African playwrights have increasingly used drama to address gender dynamics, particularly the marginalization of women in patriarchal societies (Odi, 2018). Tewfik Al-Hakim's *The Sultan's Dilemma* and Iyorwuese Hagher's *Mulkin Mata* stand as significant contributions to this discourse, each engaging with the theme of women's empowerment within distinct cultural and historical contexts. Al-Hakim, an Egyptian playwright, employs allegory and existentialist themes to explore power dynamics and individual agency, while Hagher, a Nigerian dramatist, draws on social movement strategies to depict collective resistance against oppression. This study explores the dangers of gender violence against the African woman and the ways of addressing the forms of violence is essential in enhancing a better African society.

THEORETICAL FRAMEWORK

This study adopts a feminist critical approach to analyze the representation of women in *The Sultan's Dilemma* and

Mulkin Mata. Feminist theory, as articulated by scholars like Hooks (2000), emphasizes the need to challenge patriarchal structures that marginalize women and to highlight their agency in resisting oppression. Additionally, the study draws on Fairclough's (1992) Critical Discourse Analysis (CDA) to examine how language and dramatic structure in both plays reinforce or subvert gender stereotypes. CDA is particularly useful in uncovering the ideological assumptions embedded in the texts and their implications for women's empowerment. By combining feminist theory with CDA, this analysis explores how the plays construct female agency and critique patriarchal power dynamics.

Contextualizing the Plays: Foundations for

Interrogation: Understanding the chosen plays, Tewfik Al-Hakim's *The Sultan's Dilemma* and Iyorwuese Hagher's *Mulkin Mata*, is crucial for examining how dramatic narratives dissect the subtle mechanisms of power and the intricate web of social relations. Each play, from its distinct cultural and philosophical vantage point, offers a compelling lens through which to explore the influence of dominant ideologies and the processes of hegemonic control or its subversion. These works move beyond mere storytelling, becoming rich allegories or direct social commentaries on governance, justice, and the transformative potential of collective agency, especially concerning gender.

Tewfik Al-Hakim's *The Sultan's Dilemma*: Tewfik Al-Hakim, widely regarded as a pivotal figure in modern Arabic drama, masterfully employs a philosophical and allegorical approach to theatre, a style particularly effective for critiquing power structures in contexts where direct political commentary might be constrained. His 1960 play, *The Sultan's Dilemma*, is set in a deliberately fictionalized medieval Islamic society, creating a timeless stage for exploring universal themes of power, justice, and individual agency. The play's central conflict revolves around a Sultan grappling with a profound crisis of legitimacy. He must choose between upholding a rigid legalistic interpretation that demands the execution of a slave girl, thereby maintaining his authority through the display of uncompromising force, or freeing her, an act that could jeopardize his perceived legitimacy and the established social order built on consent.

The Sultan's dilemma is, in essence, a profound exploration of the tension between coercive power and hegemonic consent. His authority isn't just about his ability to command; it's about his legitimacy in the eyes of his subjects; a legitimacy deeply intertwined with the prevailing religious and legal ideologies of his time. The play meticulously demonstrates how the Sultan's power is not solely derived from his position but from the accepted ideological frameworks (religious law, traditional governance) that legitimize his rule. The female character, though technically a slave, plays a surprisingly pivotal role in exposing the inherent contradictions within this patriarchal and absolutist power structure (Ihidero, 2017). Her very existence forces the Sultan to confront the limits of his authority and the intersection of religious doctrine and political expediency. Her situation highlights how rigid patriarchal ideologies, often buttressed by religious interpretations, constrain individual freedom and define acceptable social relations. The play's existentialist undertones, as noted by Oko and Iwuoha-Chibueze (2021), elevate this struggle beyond a mere political plot, emphasizing the universal quest for individual freedom against oppressive systems. For women, in particular, this exploration of freedom within a rigidly defined patriarchal ideology makes *The Sultan's Dilemma* fertile ground for analyzing the subtle forms of oppression and the nascent stirrings of agency, even if constrained by historical context. It invites us to consider how societal consent to established norms can become the strongest barrier to individual liberty.

Iyorwuese Hagher's *Mulkin Mata*: In stark contrast to Al-Hakim's allegorical philosophizing, Iyorwuese Hagher, a distinguished Nigerian playwright and scholar, anchors his theatre firmly in social engagement, directly confronting issues of governance, corruption, and gender inequality within tangible African realities. His 1990 play, *Mulkin Mata* (meaning "Women's Rule" or "Women's Power"), is a vibrant depiction of the collective resistance by women against a corrupt patriarchal leadership within a fictionalized African community. Unlike the individualized existential crisis in *The Sultan's Dilemma*, Hagher's work spotlights collective action and the direct challenge to established hegemonic structures.

Mulkin Mata draws deeply on the Tiv cultural context in Nigeria, allowing Hagher to explore how specific cultural

norms can both perpetuate patriarchal oppression and simultaneously provide avenues for women's unique forms of resistance. The play powerfully employs traditional social movement strategies, such as women's collective protests and the invocation of customary taboos (e.g., *mulkin mata* traditions where women can assert power in times of crisis), to depict women as formidable agents of change (Illah & Hagher, 2002). This active subversion directly confronts the dominant ideologies of male supremacy and corrupt governance that have become "common sense" within the community. The corrupt male leaders, relying on traditional notions of male authority, face a crisis of legitimacy when confronted by women who, through collective solidarity, reclaim their agency and challenge the prevailing social order.

Hagher's approach is firmly grounded in the socio-political realities of post-colonial Nigeria, a context rife with challenges of governance, widespread corruption, and a history where women's roles in political and social activism have been historically significant, though often marginalized in official narratives (Odi, 2018). *Mulkin Mata* therefore serves as a potent commentary on the lived experiences of women who actively work to dismantle patriarchal hegemonic structures. It not only exposes the flaws of a corrupt system but also celebrates the resilience and strategic ingenuity of women in forging new social relations built on justice and accountability. By contrasting Al-Hakim's more abstract, allegorical method with Hagher's direct engagement with socio-political realities and collective agency, these two plays offer a rich comparative framework for analyzing the diverse ways in which dramatists engage with ideology, hegemony, and the struggle for women's empowerment across different cultural and historical landscapes.

Representation and Empowerment of Women in *The Sultan's Dilemma*: In Tewfik Al-Hakim's *The Sultan's Dilemma*, the unnamed slave girl serves as the catalytic figure for the central conflict, compelling the Sultan to confront a crisis of his own legitimacy. While her role is explicitly secondary in terms of direct action and dialogue, her very presence and predicament fundamentally challenge the patriarchal and religious structures that underpin the Sultan's absolute authority. The slave girl's dire situation facing execution or forced enslavement poignantly symbolizes the severely limited agency of women within a male-dominated, religiously

rigid society where their bodies and lives are often subject to male decree. Her silence and vulnerability are not indicative of an absence of power, but rather underscore the insidious nature of an ideological system that renders women voiceless and powerless by design.

However, Al-Hakim skillfully uses her character to launch a subtle, yet profound, critique of the hypocrisy and moral compromises inherent in such power structures. As Ihidero (2017) aptly notes, the play's allegorical framework intricately ties religious dogma and political authority to entrenched gender dynamics. The slave girl's fate becomes a stark illustration of the moral dilemmas faced by patriarchal governance when its rigid ideological principles clash with humanistic considerations. Her plight forces the Sultan, the ultimate embodiment of this power, into an existential bind, exposing the inherent contradictions of a system that claims legitimacy through divine right or strict law but struggles with the moral consequences of its own tenets. The slave girl's 'empowerment' in this context is not overt; she does not engage in direct protest or articulate her demands. Instead, her power lies precisely in her capacity to disrupt the established order by simply *being* a moral quandary, thereby exposing the Sultan's moral and political vulnerabilities and challenging the unquestioned "common sense" of his rule. By strategically placing this marginalized figure at the very heart of the dilemma, Al-Hakim underscores the often-overlooked potential of the ostensibly powerless to inadvertently influence and even reconfigure power dynamics, compelling the dominant force to reevaluate its foundations.

This subtle approach aligns with feminist readings that emphasize the subversive potential of seemingly powerless women in patriarchal settings (Ahmed, 1992). Such readings suggest that even within highly restrictive ideological frameworks, marginalized figures can, through their very existence or by forcing moral reckoning, inadvertently or passively resist the dominant order. However, it is crucial to acknowledge that the play's pervasive existentialist tone significantly limits the slave girl's agency to a philosophical rather than a practical or revolutionary level. Her "empowerment" is largely confined to eliciting moral introspection from the powerful, reflecting the profound socio-cultural constraints on women's active agency within her

historical context. The play thereby critiques the system without necessarily depicting a clear path to women's liberation from it, foregrounding the psychological and ethical dilemmas of the powerful, while the oppressed remain largely objects of the dilemma. This serves as a commentary on the deeply ingrained nature of patriarchal ideology and the difficulty of its direct challenge from within.

Representation and Empowerment of Women in *Mulkin Mata*

In stark contrast to the subtle and philosophical portrayal in *The Sultan's Dilemma*, Iyorwuese Hagher's *Mulkin Mata* presents a far more explicit and assertive depiction of women's empowerment. Set firmly within a fictional African community grappling with the harsh realities of corrupt leadership, the play's female characters are not catalysts for a male protagonist's dilemma but are, themselves, the collective protagonists actively challenging the entrenched patriarchal elite. Hagher's work champions the concept of collective heroism, a hallmark of revolutionary African drama that portrays marginalized groups as agents of profound social change (Olatunji et al., 2020). The women in *Mulkin Mata* move beyond individual acts of resistance to organize strategic protests, directly confront the corrupt leadership, and ultimately, dismantle the prevailing hegemonic power structures.

Their collective action reflects a significant shift from individual to communal empowerment, challenging the traditional portrayal of women as passive, submissive, or relegated to the domestic sphere. Hagher draws directly on robust historical examples of women's activism in Nigeria, such as the iconic Aba Women's Riot of 1929 (Odi, 2018), grounding the play's narrative in a legacy of powerful female agency. This grounding makes the women's collective power not just a dramatic device but a resonant echo of real-world struggles against colonial and post-colonial patriarchal oppression. The women in *Mulkin Mata* engage in deliberate, organized efforts to disrupt the status quo, leveraging their numerical strength and social cohesion to demand accountability and justice from a system that has historically excluded and exploited them. Their methods are assertive, demonstrating a clear understanding that confronting a hegemonic order often requires direct, collective action to challenge its presumed legitimacy.

Hagher's meticulous use of language and dramatic structure further reinforces the women's robust agency. The dialogue is richly infused with Tiv proverbs, idioms, and cultural references, grounding the play firmly in a specific cultural context that, paradoxically, also harbors traditions celebrating women's resilience and their capacity for collective assertion in times of crisis (Illah & Hagher, 2002). This cultural specificity illustrates how local traditions can be re-appropriated and mobilized as resources for challenging dominant ideologies, offering indigenous pathways to empowerment. Unlike the slave girl in *The Sultan's Dilemma*, whose voice is largely symbolic, the women in *Mulkin Mata* are vocal, assertive, strategic, and unapologetically confrontational. They embody a feminist ideal of agency that transcends victimhood, actively participating in the dismantling of systemic oppression through their collective power. Their empowerment is depicted as both a cultural imperative—rooted in their traditional roles and a reinterpretation of them and a direct political act, aligning perfectly with bell hooks' (2000) assertion that true feminist resistance involves dismantling systemic oppression through unified, collective action rather than mere individual advancement.

In comparing these two plays, one observes a spectrum of women's representation and empowerment. Al-Hakim presents a nuanced, almost philosophical critique through the indirect power of a marginalized individual, highlighting the internal contradictions of an oppressive system and the limits of individual freedom within it. Hagher, conversely, offers a vibrant, direct celebration of collective female agency, demonstrating how organized women can actively dismantle entrenched patriarchal hegemony. Both plays, however, converge on the central theme that social relations are not fixed but are constantly shaped and contested by prevailing ideologies and the dynamic processes of hegemonic control and counter-hegemonic resistance, with women often at the forefront of these transformative struggles.

Language and Dramatic Structure: The language in *The Sultan's Dilemma* is formal and philosophical, reflecting Al-Hakim's intellectual approach to drama (Oko & Iwuoha-Chibueze, 2021). The slave girl's silence is a powerful linguistic device, symbolizing the voicelessness of women in patriarchal societies.

Conversely, *Mulkin Mata* uses vibrant, culturally rooted dialogue to amplify the women's voices. Hagher's use of Tiv oral traditions, such as proverbs and songs, empowers the female characters by grounding their resistance in cultural authenticity (Illah & Hagher, 2002). Fairclough's (1992) CDA framework reveals how these linguistic choices reinforce or challenge gender stereotypes, with Al-Hakim's play critiquing patriarchy indirectly and Hagher's confronting it head-on.

Socio-Cultural Implications: Both plays contribute to the discourse on women's empowerment in African drama, but their implications vary. *The Sultan's Dilemma* raises awareness of gender inequalities within a broader critique of power and religion, appealing to a universal audience (Ihidero, 2017). *Mulkin Mata*, however, is deeply rooted in the Nigerian context, making it a call to action for local audiences. Its emphasis on collective resistance aligns with the broader trend of African drama as a tool for social conscientization (Olatunji et al., 2020).

CONCLUSION

Tewfik Al-Hakim's *The Sultan's Dilemma* and Iyorwuese Hagher's *Mulkin Mata* offer distinct yet complementary perspectives on the empowerment of African women. Al-Hakim's allegorical approach highlights the subtle, symbolic resistance of women within oppressive systems, while Hagher's revolutionary drama celebrates their active agency through collective action. Together, these plays underscore the power of African drama to challenge patriarchal norms and advocate for gender equality. By portraying women as both victims and agents of change, Al-Hakim and Hagher contribute to a broader feminist discourse that seeks to transform socio-cultural realities.

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EFFECT OF CELEBRITY EXPERTISE AND TRUSTWORTHINESS ON PURCHASE INTENTIONS OF BETTING PRODUCTS AMONG TERTIARY INSTITUTION STUDENTS IN BIDA LGA, NIGER STATE

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ABSTRACT

Consumer purchase intentions are critical for companies operating in highly competitive markets. This process involves evaluating a product's attributes alongside individual consumer preferences and can be significantly influenced by external factors such as celebrity trustworthiness and expertise. In Nigeria's rapidly evolving market, characterized by technological advancement and a dynamic youth demographic, understanding these factors is essential, especially among tertiary institution students. This study investigates the effect of celebrity expertise and trustworthiness on the purchase intentions of students in tertiary institutions within the Bida Local Government Area (LGA), Niger State. The study employed a descriptive research design. From a total population of 12,495, a stratified random sampling method was employed to select 383 students from various tertiary institutions in Bida LGA. Primary data were collected from respondents through a questionnaire using a five-point Likert scale. Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). Results indicate that both celebrity expertise and trustworthiness significantly influence consumers' purchase intentions. The study concluded that both celebrity expertise and celebrity trustworthiness are highly significant contributors to purchase intention. Based on these findings, marketers and advertisers are advised to select celebrities with high levels of expertise and trustworthiness and to continuously evaluate their strategies to maximize purchase intentions.

Keywords: Celebrity expertise, celebrity trustworthiness, structural equation modeling, purchase intentions, consumer preferences

INTRODUCTION

In today's digital age, marketing strategies have been profoundly transformed, with celebrity endorsements becoming a powerful tool in influencing consumer behaviour. Celebrities—individuals with widespread public recognition—hold substantial sway over brand perception and consumer purchase decisions. The interplay between popular culture and advertising has led marketers to leverage celebrity status to increase product visibility and appeal (Silvera & Austad, 2024). Consumer purchase intentions are crucial for success in competitive markets like the betting industry, as these intentions result from evaluating product attributes alongside individual preferences. External factors such as celebrity trustworthiness and expertise notably affect this process. Existing literature highlights a multifaceted relationship between a celebrity endorser's trustworthiness, expertise, and consumer buying decisions, influenced by demographic variables like age and socioeconomic status (Jamal & Al-Marri, 2022). Furthermore, this relationship is particularly pronounced among younger consumers, such as tertiary institution students, who tend to be more susceptible to influences stemming from social trends and celebrity culture (Lee & Hutchinson, 2021). These factors collectively foster stronger emotional connections between consumers and endorsed products, thereby

shaping purchase intentions. Young consumers in tertiary institutions serve as key drivers of market trends, often shaped by peer influence and celebrity endorsement (Okwu & Kalu, 2018). Research by Ukpebor and Moideenkutty (2021) shows that Nigerian youth often see celebrities as role models whose choices affect their shopping habits and brand loyalty. Consequently, celebrities' trustworthiness and expertise can significantly impact not only product preferences but also overall brand engagement.

Nigeria's evolving market sector, with rapid technological uptake and a digitally active youth population, underscores the importance of understanding factors influencing purchase intentions, particularly in regions like Bida LGA, Niger State. Students in this area are highly engaged with digital media and responsive to celebrity-led advertising (Oguzor & Uche, 2022; Nwankwo, 2016).

Despite the importance of this demographic and the growing use of celebrity endorsements in marketing betting products, limited empirical research exists on how celebrity trustworthiness and expertise influence purchase intentions among tertiary students in Bida LGA. This study therefore investigates these effects to fill this gap.

In light of the study's objectives, the following research questions and null hypotheses were formulated.

- i. Does celebrity expertise affect the purchasing intentions of consumers of betting house products in Tertiary institutions in Bida L.G.A?
- ii. Does celebrity trustworthiness affect the purchasing intentions of consumers of betting house products in Tertiary institutions in Bida L.G.A?

H₀₁: Celebrity expertise does not affect the purchasing intentions of consumers of betting products in tertiary institutions in Bida LGA of Niger State.

H₀₂: Celebrity's trustworthiness does not affect the purchasing intentions of consumers of betting products in tertiary institutions in Bida LGA of Niger State.

LITERATURE REVIEW

Concept of Trustworthiness: Trustworthiness in the context of celebrity endorsement can be defined as the degree to which a consumer believes that the celebrity has their best interests at heart, effectively translating to a sense of sincerity and reliability. It's simply an endorser's honesty, integrity and believability by their audience and followers. It can also be referred to as the perceived integrity, reliability, and credibility of a celebrity, which influences the public's willingness to believe in, accept endorsements, and model behaviour according to the celebrity's image and actions (Freeman, 2023). Rahman and Rahman (2021) argued that the effectiveness of a celebrity endorser is significantly predicated on their credibility, with trustworthiness being a key component of this credibility.

Concept Expertise: Celebrity expertise refers to the perceived knowledge, skills, and proficiency of a famous individual in a particular field or industry (Ahn et., al., 2021). Elliot et., al, (2019) defined it as the level of proficiency, experience, and specialized knowledge that a well-known individual possesses in a specific field or subject matter. It encompasses the extent to which a celebrity is seen as competent, authoritative, and knowledgeable in their area of expertise, whether it be in entertainment, sports, fashion, or any other domain.

This expertise is often demonstrated through the celebrity's accomplishments, credentials, and demonstrated skills, which contribute to their perceived authority and credibility among fans, followers, and the general public.

Concept Purchase Intention: Purchase intention refers to the likelihood of a consumer to purchase a product or service in the future, (O'Malley, et. al., 2021). Several factors influence consumers' purchase intention, including brand image, product quality, price, and endorsement by celebrities. Research has shown that celebrity endorsements can positively influence consumers' purchase intention, as they perceive the product to be of higher quality and desirability when endorsed by a celebrity.

Empirical Review: The perceived trustworthiness and expertise of celebrities have been widely studied to understand their influence on consumer behaviour. In a study by Choi et al. (2005), it was found that the perceived trustworthiness of a celebrity had a strong positive influence on attitude towards the advertisement and purchase intention. Moreover, the study found that the perceived trustworthiness of a celebrity was more important than the attractiveness of the celebrity.

Similarly, Gupta and Johnson (2009) found that the perceived expertise of a celebrity significantly influenced consumer attitudes towards the product and purchase intention. Furthermore, the study found that the effectiveness of celebrity endorsements depended on the match between the celebrity and the product/service being endorsed. This is supported by Choi and Rifon (2007) who found that the match between the celebrity and the product was a critical factor in determining the effectiveness of the endorsement.

Theoretical Review: The social learning theory, developed by Albert Bandura, suggests that individuals learn from observing others' behaviours, attitudes, and outcomes. According to this theory, people acquire new behaviours and modify existing ones by observing and imitating models within their social environment. The theory provides valuable insights into how consumers are influenced by celebrities and their behaviours.

Celebrity endorsements involve famous personalities endorsing products or services in advertising campaigns, aiming to influence consumer behaviour positively. According to the social learning theory, individuals learn by observing others. Celebrities are often seen as influential models followed by their fans. Consumers may

observe celebrities using or endorsing a product and imitate their behaviour, assuming that the product is desirable or superior. When celebrities endorse a product and showcase its benefits or satisfaction, consumers may believe that using the endorsed product will lead to similar positive outcomes for themselves.

METHODOLOGY

This study adopted a descriptive research design, using a cross-sectional survey design to collect and analyze data on the effect of celebrity expertise and celebrity trustworthiness on the purchase intention of tertiary institutions' students in Bida LGA of Niger State.

The population of the study includes the all-available students of the selected tertiary institutions (The Federal Polytechnic Bida, Niger State College of Administration and Business Studies Bida (CABS). The estimated student population of the Federal Polytechnic Bida stood at approximately 9,995 for the 2024/2025 academic session (Federal Polytechnic Bida Registrar, 2024). Meanwhile, the Niger State College of Administration and Business Studies (CABS) in Bida have an enrollment

estimate of about 2,500 students, as reported by the Campus news (2024). The sample size will be determined using Taro Yamane formula to get 388 respondents, and the stratified random sampling method will be adopted to sample the students, with Federal Polytechnic Bida ($9,995 / 12,495 \times 388 \approx 310$) and Niger State College of Admin and Business Studies (CABS) Bida ($2,500 / 12,495 \times 388 \approx 78$) forming the two strata. Within each stratum, students were randomly selected to participate in the study to ensure each subgroup was fairly represented.

Method of Data Analysis: The data collected is analyzed using partial least squares structural equation modeling (PLS-SEM) technique to measure the correlation between observation variables and latent variables through a reflective measurement model. Partial least squares structural equation modeling (PLS-SEM) is an analysis technique for detecting or constructing predictive models. Especially for the causal model analysis between latent variables, it is better than the general linear structural relationship model, which is very suitable for exploratory research (Pavlou, & Fygenson, M. (2016); Melchor & Julián, (2018)).

RESULTS AND DISCUSSION

The demographic characteristics of respondents were summarized in Table 1

Table 1. Demographic Characteristics of the Respondents

Variable		Frequency	Percentages
Gender	Male	206	41.53
	Female	290	58.47
Age Bracket	Below 20	250	50.40
	21-30 years	150	30.24
	31-40 years	65	13.10
	40 Above	31	6.25
Programme	Pre-National Diploma	102	20.56
	National Diploma (ND)		
	Higher National Diploma (HND)	250	50.40
	Postgraduate Diploma	100	20.16
		44	8.87

Source: Field work (2025)

On gender, 206(41.53%) of the respondents are male, while the remaining 290(58.47%) are female. On age bracket, 190(38.31%) are below 20 years, 150(30.24%) are within 21-30 years, while 125(25.20%) are within the age bracket of 31-40 years and 31(6.5%). The implication

of this is that the majority of our respondents are very young people who are more exposed to celebrity endorsement in adverts than adults. On programme, 102(20.56%) are pre-national diploma students only, 250(50.40%) are National diploma student, 100(20.16%)

are Higher National diploma students, while 44(8.87%) are running a postgraduate diploma. The implication of this is that the majority of the respondents 250(54.40%)

are students below the age of 20 years therefore disposed to give valid and usable information needed for the study.

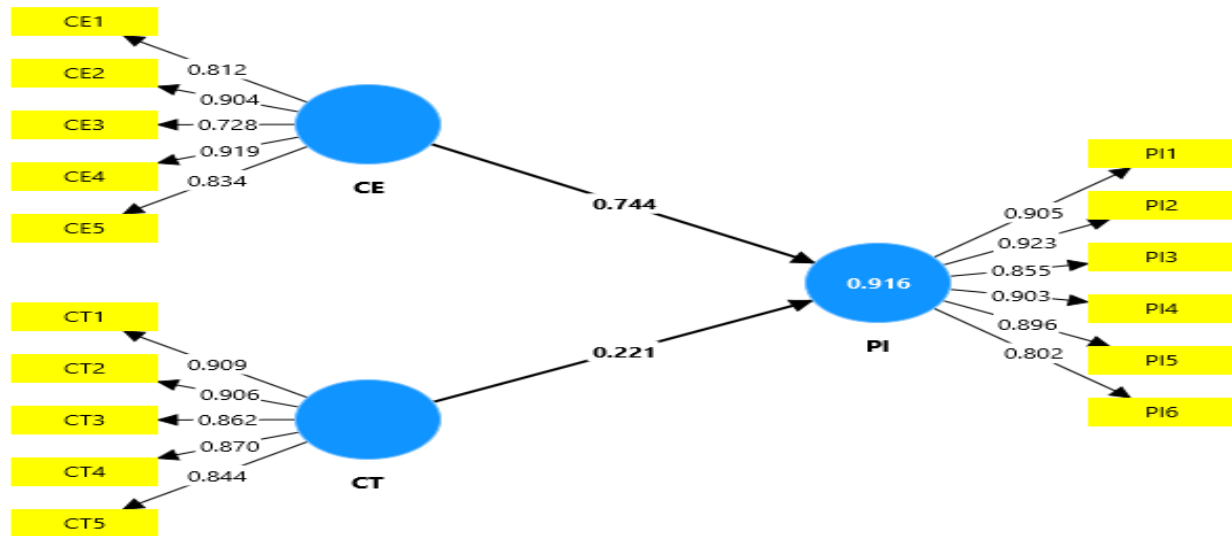


Figure 1 Construct Reliability and Validity

Table 2. Measurement Model (Reliability and Validity Test)

S/N	Dimensions	Question Items	Factor Loading	Cronbach's α	CR	AVE
1.	Celebrity Expertise (CE)	CE1	0.812	0.936	0.951	0.795
		CE2	0.904			
		CE3	0.728			
		CE4	0.919			
		CE5	0.834			
2.	Celebrity Trustworthiness (CT)	CT1	0.909	0.892	0.906	0.710
		CT2	0.906			
		CT3	0.862			
		CT4	0.870			
		CT5	0.844			
3.	Purchase Intention (PI)	PI1	0.905	0.926	0.930	0.722
		PI2	0.923			
		PI3	0.855			
		PI4	0.903			
		PI5	0.896			
		PI6	0.802			

Source: authors' computation (2025) using SmartPls 4.1.1.4

For this study, the reliability of the research instrument was determined using factor loading, composite reliability and Cronbach's test. The result in Table 2 indicated that the factor loading, composite reliability and Cronbach's test are all above 0.7, recommended by Hair, et. al. (2014). Specifically, the composite reliabilities are 0.951, 0.902, for Celebrity Expert, Celebrity Trustworthiness, respectively, and 0.949 for Purchase

Intention. It shows an internal consistency and that all constructs are within acceptable levels and reliability. Additionally, convergent validity is shown in Table 2. It is clear that the average variance extracted for each measure exceeded 0.50. This suggests that the construct, on average, explains greater than half of the variance of its indicators (Chin, 2010; Hair et al. 2014).

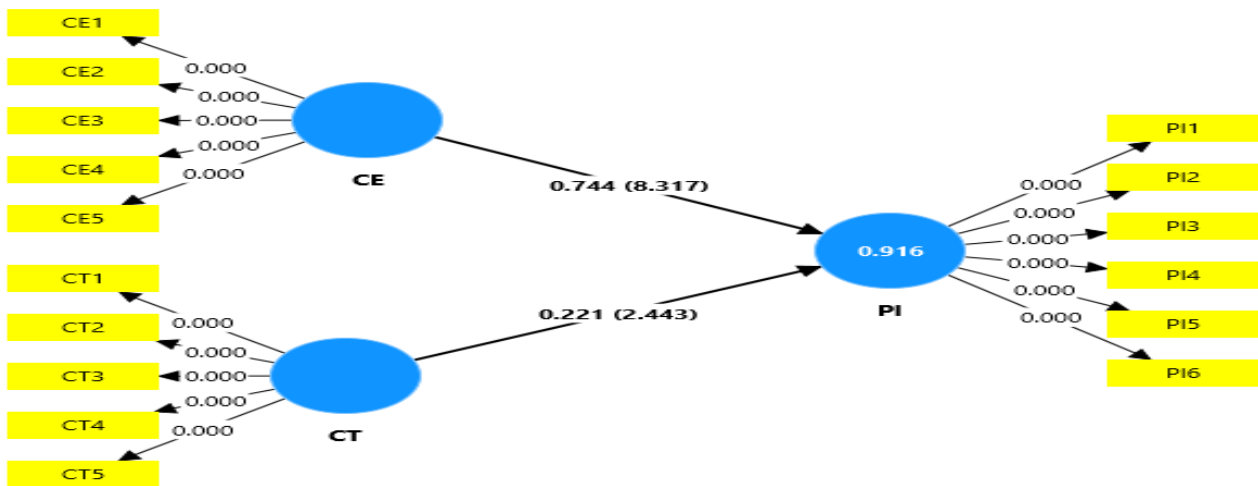


Figure 2 Structural Model (Bootstrapping)

Table 3. Heterotrait-Monotrait Ratio (HTMT) Discriminant Validity Test

Constructs	Celebrity Expertise (CE)	Celebrity Trustworthiness (CT)	Purchase Intention (PI)
Celebrity Expertise (CE)	-		
Celebrity Trustworthiness (CT)	0.597	-	
Purchase Intention (PI)	0.726	0.748	-

Source: authors' computation (2025) using SmartPls 4.1.1.4

The Heterotrait-Monotrait (HTMT) ratio analysis shows that all HTMT values are below the conservative threshold of 0.85, indicating good discriminant validity between constructs. The highest HTMT value (0.748) is between Celebrity Trustworthiness and Purchase

Intention, and the lowest HTMT value (0.597) is between Celebrity Expertise and Celebrity Trustworthiness. These results confirm that the three constructs are empirically distinct from each other, supporting the discriminant validity of the measurement model.

Table 4. Path Coefficients and Hypotheses Testing

Relationship	Path Coefficient (β)	T-Statistics	P-Value	R ²	Q ²	f ²	VIF	Decision
CE $\rightarrow$ PI	0.744	8.317	0.000	0.916	0.469	0.284	2.224	Rejected
CT $\rightarrow$ PI	0.211	2.443	0.000	-	-	0.322	2.521	Rejected

value*** < 0.01, P value** < 0.05, P value* < 0.10.

Source: author's computation (2025) using SmartPls 4.1.1.4.

From Table 4 above, path Coefficients (β) of Celebrity Trustworthiness have a slightly stronger effect ($\beta = 0.744$) on Purchase Intention compared to Celebrity Expertise ($\beta = 0.211$). Both relationships show positive and significant effects ($t = 8.317, 2.443, p < 0.001$) at 0.05 level of significance, thereby providing a basis to reject the null hypotheses and accept the alternate hypotheses. The coefficient of Determination (R^2) value of 0.916 indicates that approximately 91.6% of the variance in

Purchase Intention is explained by Celebrity Expertise and Celebrity Trustworthiness. This represents a moderately strong explanatory power according to Chin's (1998) criteria.

The Predictive Relevance (Q^2) value of 0.469 is substantially above zero, indicating strong predictive relevance of the model. This suggests the model has good capability to predict Purchase Intention, while the effect

Size (f^2) for Celebrity Trustworthiness shows a strong effect size ($f^2 = 0.322$), and Celebrity Expertise demonstrates a medium to strong effect size ($f^2 = 0.284$). Both effect sizes are considered substantial according to Cohen's (1988) guidelines. All VIF Analysis (Multicollinearity Assessment) values are below 3.0, from 2.224 to 2.521. This indicates no problematic multicollinearity issues according to the acceptable range, $VIF < 5.0$ (Hair et al., 2011).

DISCUSSION OF FINDINGS

From the empirical analysis and hypotheses tested above, the results revealed that the independent variable proxy with celebrity expertise and celebrity trustworthiness exact a significant positive effect on the purchasing intentions of tertiary institutions students in Bida LGA of Niger State.

The study found that celebrity expertise has a significant positive effect on the purchasing intentions of tertiary institutions' students in Bida LGA of Niger State. The result is, however in consistence with the study of Oyeniyi (2014) in his study on celebrity endorsement and product performance, which revealed that the trust level of expertise has a positive impact on purchase intentions. The study also revealed that celebrity trustworthiness has a significant positive effect on the purchasing intentions of tertiary institutions' students in Bida LGA of Niger State. The results support the study and findings of Khan and Lodhi (2016), where findings revealed celebrity-endorsed advertisements to create brand awareness and recognition and also help capture the target audience.

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CONCLUSION AND RECOMMENDATIONS

This paper has explored the relationship between celebrity expertise, celebrity trustworthiness and consumer purchase intentions of consumers of betting house products in tertiary institutions in Bida, LGA, Niger state. Based on the above analysis and discussion, a number of important conclusions were drawn from the study. The analysis reveals that both celebrity expertise and celebrity trustworthiness are significant predictors of purchase intention of consumers of betting house products in tertiary institutions in Bida LGA. The model demonstrates good discriminant validity, substantial explanatory power, and strong predictive relevance. Celebrity trustworthiness shows a slightly stronger effect than celebrity expertise, though both are highly significant contributors to purchase intention.

The study recommended the use of trusted celebrities for endorsement purposes in order to avoid celebrity scandals. Marketers, advertisers and companies should, therefore, ensure that trusted hands are selected for the marketing campaign if they want to gain the market of youths who constitute a larger proportion of students in tertiary institutions. For this reason, appropriate machinery should be put in place to vet the background of the celebrity to ensure that it is devoid of scandals and multiple endorsements in the past. This could be achieved if the companies have an existing selection policy on the ground to screen out celebrities that do not meet the laid-down requirements of the company.

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GENERATIVE PRETRAINED TRANSFORMERS (GPT) TOOLS' AWARENESS AND UTILIZATION BY ENTREPRENEURS IN RIVERS STATE UNIVERSITIES' CAMPUSES FOR BUSINESS STARTUP SUCCESS.

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ABSTRACT

This study examined the Generative Pretrained Transformers (GPT) Tools' awareness and utilization by entrepreneurs in Rivers State Universities' Campuses for business startup success. The study was guided by two specific objectives, two research questions, and two hypotheses. The study adopted the correlational survey design. The population of the study consisted of three hundred and sixty (360) entrepreneurs operating business ventures in the two state universities in Port Harcourt. The sample size for the study was one hundred and eighty-six (186) entrepreneurs. The Cronbach Alpha statistic was used to determine the reliability of the instrument and a coefficient of 0.74 was obtained. One hundred and sixty (160) copies of the distributed questionnaire were retrieved, representing an eighty-six (86 %) percent return rate and used for data analysis. The collected data were analyzed using Pearson Product Moment Correlation Coefficient (PPMCC). The p-value associated with the correlation coefficients was used to test the hypotheses at a 0.05 level of significance. The findings of the study showed that entrepreneurs in Rivers State Universities' Campuses were not fully aware of and not effectively utilizing GPT tools for business startup success. The study recommended, among others, that budding entrepreneurs should undertake entrepreneurial workshops, seminars and on-the-job training in business schools and universities to become fully aware of Generative Pre-trained Transformers so that they can effectively utilize them for business start-ups success.

Keywords: Generative Pretrained Transformers (GPT) Tools, Awareness, Utilization, Entrepreneurs, Business Startup Success

INTRODUCTION

In recent years, the business environment has experienced significant changes due to unprecedented technological breakthroughs and the emergence of Artificial Intelligence (AI) capabilities. Artificial intelligence emulates human cognition, enabling computers to think and behave like humans through tasks such as learning and problem-solving (Zhang & Lu, 2021). Generative Artificial Intelligence (Gen AI) is regarded as a subset of Artificial Intelligence, and defined by Altares-Lopez et al (2024), as a form of artificial intelligence capable of producing novel content, including text, graphics, or music, hence enhancing creativity and innovation in business settings. Generative Pretrained Transformers (GPT) tools, which are based on deep learning models, have been widely adopted across multiple sectors, including business, education, and marketing. Generative Pre-trained Transformer (GPT) tools have attracted considerable interest for their ability to transform numerous facets of corporate operations and entrepreneurial activities. GPT tools, such as Chat GPT, can assist in tasks such as content generation, customer interaction, and even strategic decision-making for start-ups. ChatGPT is a powerful OpenAI GPT tool that allows business startups to

leverage their capabilities. These capabilities cover nearly every aspect of running a business, making it a must-know for startup owners and entrepreneurs looking for an innovative way of improving their operations (Pawlan, 2023). He further opined that start-up entrepreneurs could leverage ChatGPT for essential startup processes covering product development, streamlining business development, and creating internal software applications (Virtual Assistants) a business needs to manage and facilitate various processes and operations. GPT tools can also be used to support customer service and sales by providing systems that can easily and accurately analyze customer data and automate customer service tasks such as answering customer queries or resolving any issues customers may have in the process of interfacing with the business start-up (Singh, 2023). In marketing, GPT can be used to assist business startups with automating marketing tasks such as drafting email campaigns, social media posts, and marketing and sales copy. GPT tools are also very helpful in conducting preliminary content research, optimizing marketing campaigns, and creating search engine optimization content. In addition, GPT tools can also assist start-up entrepreneurs in generating text for Web, Blog, and

social media, advertisements, and keyword and topic research (Pawlan, 2023).

Although leveraging GPT tools to streamline start-up processes can be an effective and efficient way to reach potential customers, there are some challenges and drawbacks that need to be taken into consideration when using GPT tools in fostering business processes (Pawlan, 2023). It should be noted, however, that GPT tools have some limitations and drawbacks. These limitations include lack of expertise in GPT tools for start-ups, poor knowledge in issuing effective prompts, and data privacy and security concerns, among others. Thus, successfully incorporating GPT tools into business operations necessitates meticulous evaluation and strategic execution. Entrepreneurs must address problems including data quality assurance, ethical norm maintenance, and the equilibrium between AI-generated insights and human judgment and creativity (Patel, 2024). In the same vein, Singh (2023) opined that to successfully leverage GPT tools, training, data security, continuous monitoring, and human backup should be taken into consideration. Other factors to consider include initial setup complexity, user acceptance, cost of integration, and technology limitations (Pawlan, 2023). The ethical ramifications of employing GPT techniques in commercial settings necessitate thorough examination. As these tools advance and gain more acceptance, concerns emerge around data privacy, intellectual property rights, and the possibility for AI-generated content to deceive or manipulate consumers (Garcia et al., 2024). Thus, learning how to effectively use AI can simplify the process of running a small business and help businesses grow (Gevelder, 2024).

Entrepreneurship is a challenging journey; having the right tools can make all the difference. One such innovative tool is ChatGPT, an advanced AI language model developed by OpenAI, that can help entrepreneurs unlock new creative possibilities and achieve growth in their businesses (Scotland, 2024). Entrepreneurship is depicted in entrepreneurial attitudes, intentions, and behavior. It is also shown in new and existing businesses. Entrepreneurship is therefore evident in the establishment of sustainable and profitable ventures that serve demand and need objectives (Akpomi, 2009). Entrepreneurship is the act of establishing a firm, arranging business transactions, and taking risks to

profit from developed entrepreneurial abilities (Usman, 2023). Business Startups are small ventures that operate with less than ten (10) employees. They may be new ventures or offshoots of existing organizations, which is active in providing some service or goods. Thus, according to Skawinska and Zalewski (2020), a start-up is a relatively new, independent, and active venture with a small number of employees and a limited amount of funding. Startup businesses have a positive impact on the economy of a given country (Griva et al., 2021). In the Nigerian economy, small businesses represent a viable mechanism for self-sustaining industrial development and an indigenous enterprise culture (Aladejebi, 2020). Startup businesses contribute to employment generation and poverty reduction (Endris & Kassegn, 2022). Business startups account for about 97% of Nigeria's economic activities, but about 80% of these ventures fail within the first five (5) years of operation (Gumel, 2019). The high rate of failure of business startups has been attributed to a general lack of entrepreneurial skills and poor management practices (Akeke, 2020). In addition, in Nigeria, among the factors that contribute to business failure is the inability of Nigerian businessmen and entrepreneurs to be innovative, and creative and to adapt to process management to accomplish goals (Dugguh, 2013). Thus, a need for small enterprise owners to understand their business environment to enable risk-taking, innovation, and autonomous proactive implementation of competitive strategies necessary to become successful (John-Hart, 2023). Innovativeness means that entrepreneurship should be based on targeted innovation to open new value through the combination of resources and the development of new products or services to establish the profitability of the entrepreneurial organization (Pan et al., 2022).

Nonetheless, the sheer presence of such potent instruments does not ensure their effective application, particularly among nascent entrepreneurs and business students. Recognizing GPT tools and their possible applications in business is an essential initial step to leveraging their advantages. Johnson and Lee (2024) reveal that despite the growing recognition of AI technology, many students and early-career professionals still lack enough understanding of GPT tools and their applications in business contexts. This deficiency in awareness poses both a difficulty and an opportunity for Business Education programs, especially at

the postgraduate level. Postgraduate students in Business Education, as future startup owners and entrepreneurs, are optimally situated to utilize GPT instruments for innovation and competitive advantage. Individuals must first gain knowledge about the existence, capabilities, and potential applications of these tools in practical business contexts to effectively achieve this (Wang & Li, 2023).

The correlation between awareness and employment of GPT tools is intricate and multifarious. Although awareness is essential for use, it does not ensure adoption or efficient application. Perceived utility, ease of use, and alignment with corporate objectives are critical factors influencing the integration of GPT technologies into business operations (Davis & Thompson, 2022). This association highlights the necessity of not just familiarizing students with GPT technologies but also offering them practical experience and insights into the application of these tools for addressing real business situations. Furthermore, the prospective influence of GPT tools on the success of business start-ups enhances the importance of this study. Entrepreneurship is frequently defined by limitations in resources, especially regarding time, knowledge, and financial capital. GPT technologies can mitigate certain limitations by automating tasks, facilitating rapid access to information and insights, and enhancing the skills of small teams (Chen et al., 2023). A start-up may utilize GPT tools to produce preliminary drafts of business plans, perform market research, or develop tailored marketing content, expediting their go-to-market strategy and enhancing their likelihood of success.

Recent research has emphasized the favourable association between AI literacy and entrepreneurial success. Start-ups established by entrepreneurs proficient in AI technologies, including GPT tools, had a 30% higher likelihood of obtaining funding and attaining profitability within their initial three years than those lacking such expertise (Chen et al., 2023). This research highlights the significant influence that awareness and application of GPT technologies may exert on the success of business start-ups among postgraduate students in Business Education. Nonetheless, it is crucial to acknowledge that the correlation between GPT tool usage and business success is not merely deterministic. Market conditions, team chemistry, and overarching business strategy remain essential in

influencing start-up outcomes. According to Raj et al., (2023), GPT tools should be viewed as facilitators that enhance decision-making, foster efficiency, and uncover new opportunities, not as infallible solutions that guarantee success. It is therefore crucial that entrepreneurs are not only cognizant of GPT technologies but also effectively utilize them for business start-up success in an AI-augmented corporate landscape.

The rapid advancements in Artificial Intelligence (AI) and its applications have significantly transformed business landscapes in recent years. GPT-based tools, powered by OpenAI's Generative Pretrained Transformers, offer considerable potential in supporting various aspects of business operations, including customer engagement, marketing strategies, and data analysis (Dwivedi et al., 2023). Despite GPT's potential for transforming business processes such as automating customer engagement, refining market analysis, and optimizing operational efficiencies, many entrepreneurs either lack awareness of these capabilities or face challenges in effectively utilizing them. This knowledge gap results in missed opportunities for growth and innovation in start-ups, especially within competitive markets where technological awareness and utilization is a key differentiator.

Furthermore, while business education curricula often emphasize traditional management and entrepreneurial skills, there is limited research on how technological tools, particularly AI-driven applications like GPT, can enhance business startup success (Ogunyemi & Afolabi, 2021). The integration of these tools could significantly improve productivity, decision-making, and customer relations, but the extent to which entrepreneurs in Rivers State are leveraging these tools remains unclear. Therefore, there is a critical need to investigate the extent to which entrepreneurs are aware of GPT tools for start-up success, and the factors affecting the utilization of these tools in their business strategies.

The purpose of this study is to examine the relationship between awareness and utilization of GPT tools for business start-up success in Rivers State Universities' campuses. Specifically, the objectives of the study are:

1. To find out the relationship between entrepreneurs' awareness of GPT tools and business start-up success in Rivers State Universities' campuses.
2. To find out the relationship between entrepreneurs' utilization of GPT tools and business start-up success in Rivers State Universities campuses.

The following research questions were formulated to guide the study:

1. What is the relationship between entrepreneurs' awareness of GPT tools and business start-up success in Rivers State Universities' campuses?
2. What is the relationship between entrepreneurs' utilization of GPT tools and business start-up success in Rivers State Universities' campuses?

The following formulated null hypotheses of the study were tested at a 0.05 level of significance:

1. There is no significant relationship between awareness of GPT tools and the business start-up success of entrepreneurs in Rivers State Universities' campuses.

2. There is no significant relationship between the utilization of GPT tools and the business start-up success of entrepreneurs in Rivers State Universities' campuses.

METHODOLOGY

The study adopted a correlational and descriptive research design. This research design was adopted for this study because it is suitable for determining the relationship between variables and obtaining the opinions of respondents on current phenomenon. The research design, therefore, enabled the researcher to find out the relationship between entrepreneurs' awareness and utilization of GPT tools and business start-up success and the opinions of respondents on the challenges they faced in utilizing GPT tools for business start-up success in Rivers State Universities' campuses. This study was conducted on entrepreneurs who own business ventures in two Rivers State Universities' campuses. These universities are the Rivers State University and

Table 1: Population Distribution

S/N.	Name of Institution	No of Registered Business Ventures
1.	Rivers State University	179
2.	Ignatius Ajuru University of Education	181
	Total	360

Source: DVCs offices of Rivers State University and Ignatius Ajuru University of Education, Port Harcourt (2024)

Ignatius Ajuru University of Education, both in Port Harcourt. The population of the study comprised three hundred and sixty business owners (entrepreneurs) in the two universities as shown in Table 1.

The sample size for the study was one hundred and eighty-six (186) business start-up owners. This sample size was drawn from the Krejcie and Morgan (1970) sample size determination table. The instrument for data collection was a self-constructed and structured questionnaire divided into two sections titled: GPT Tools' Awareness and Utilization by Entrepreneurs Questionnaire (GTAUEQ), and Business Start-up Success Questionnaire (BSSQ), which consisted of six clusters and was administered on the business owners. The instrument was constructed using a 4-point rating scale of Strongly Agree (SA - 4 points), Agree (A - 3 points),

Disagree (D - 2 points), and Strongly Disagree (SD - 1 point). Three experts validated the instruments, two in Business Education and one in Measurement and Evaluation from Rivers State University. The internal consistency of the instrument was tested using the Cronbach Alpha correlation coefficient, which yielded a reliability of 0.93, 0.70, 0.76, 0.62, 0.72, and 0.71 for clusters A, B, C, D, E, and F respectively, giving an average of 0.74. Based on the coefficient ratings, the instruments were considered reliable for the study. One hundred and eighty-six copies of the questionnaire were administered to the respondents through personal contact. One hundred and sixty were duly retrieved after filling, representing an eighty-six (86 %) percent return rate. The collected data were analyzed using Pearson Product Moment Correlation (PPMC) based on the value and direction of the correlation coefficient. The p-

values associated with the correlation coefficients were used to test the stated two hypotheses at a 0.05 level of significance. The analysis was done using the Statistical Package for Social Sciences 23 (SPSS 23). For the hypotheses, the decision rule was that where the significant p-value was less than the alpha value, the null hypothesis was rejected (there is a significant relationship). Otherwise, where the significant p-value was greater than the alpha

value at 0.05, the null hypothesis was not rejected (there is no significant relationship).

RESULTS

Hypothesis 1: There is no significant relationship between awareness of GPT tools and the business start-up success of entrepreneurs in Rivers State Universities' campuses.

Table 2: Relationship between entrepreneurs' awareness of GPT tools and Business Startup Success in Rivers State Universities' campuses

Source of Variation		Entrepreneurs' awareness of GPT tools (X)	Business Start-up Success (Y)
Entrepreneurs' awareness of GPT tools (X)	Pearson Correlation	1	.849**
	Sig. (2-tailed)		.000
	N	160	160
Business Start-up Success (Y)	Pearson Correlation	.849**	1
	Sig. (2-tailed)	.000	
	N	160	160

Source: Researcher's Field Survey (2025)

Table 2 above shows a p-value of 0.000 at a significance level of 0.05. This indicates that it is highly significant at alpha 0.05 since p-value = 0.000 is less than 0.05. Thus, the null hypothesis is rejected and the alternative is accepted, signifying a strong positive relationship between awareness

of GPT tools and the business start-up success of entrepreneurs in Rivers State Universities' campuses.

Hypothesis 2: There is no significant relationship between the utilization of GPT tools and the business start-up success of entrepreneurs in Rivers State Universities' campuses.

Table 3: Relationship between entrepreneurs' utilization of GPT tools and Business Startup Success in Rivers State Universities' campuses.

Source of Variation		Entrepreneurs' utilization of GPT tools (X)	Business Start-up Success (Y)
Entrepreneurs' awareness of GPT tools (X)	Pearson Correlation	1	.763**
	Sig. (2-tailed)		.000
	N	160	160
Business Start-up Success (Y)	Pearson Correlation	.763**	1
	Sig. (2-tailed)	.000	
	N	160	160

Source: Researcher's Field Survey (2025)

Table 3 above shows a p-value of 0.000 at a significance level of 0.05. This indicates that it is highly significant at alpha 0.05 since p-value = 0.000 is less than 0.05. Thus, the

null hypothesis is rejected and the alternative is accepted, signifying a strong positive relationship between the

utilization of GPT tools and the business start-up success of entrepreneurs in Rivers State Universities' campuses.

DISCUSSION OF FINDINGS

Relationship between entrepreneurs' awareness of GPT tools and business start-up success of entrepreneurs in Rivers State Universities' campuses: The first finding revealed a strong positive relationship between awareness of GPT tools and the business start-up success of entrepreneurs in Rivers State Universities' campuses. This finding agrees with the finding of Maalouf (2023) that ChatGPT has the potential to enhance business operations, customer satisfaction, and overall success in the increasingly digital and AI-integrated business landscape.

The current level of awareness regarding GPT technologies among entrepreneurs is notably increasing, significantly impacting their business decisions. This is because entrepreneurs now recognize the ability of GPT tools to improve operational efficiency, customer engagement, feedback and satisfaction, and strategic decision-making. This growing awareness is reshaping marketing strategies and overall business management practices toward success.

A hypothetical test based on the first finding also indicated a statistically significant relationship between awareness of GPT tools and the business start-up success of entrepreneurs in Rivers State Universities' campuses. The study concluded that there is a statistically significant relationship between awareness of GPT tools and the business start-up success of entrepreneurs in Rivers State Universities' campuses, as the calculated correlation coefficient (r) value was statistically greater than the table value at the $P > 0.05$ level of significance. Therefore, the null hypothesis was rejected at this level of significance. The strength of the relationship was confirmed with a p -value test, which supported the conclusion that a statistically significant relationship exists between awareness of GPT tools and the business start-up success of entrepreneurs in Rivers State Universities' campuses.

Relationship between entrepreneurs' utilization of GPT tools and business startup success on Rivers State Universities campuses: The second finding revealed a strong positive relationship between the utilization of GPT

tools and the business start-up success of entrepreneurs in Rivers State Universities' campuses. This finding is consistent with the findings of Cen (2024) that: (1) User entrepreneurs collect extensive user data through ChatGPT-like AI technology and intelligently analyze it to achieve optimal entrepreneurial judgments and decisions. (2) User entrepreneurs utilize ChatGPT-like AI technology to understand the latent needs of users and to acquire user demand information, such as product shortcomings and appeals. (3) ChatGPT-like AI technology enhances the entrepreneurial intention of user entrepreneurs, stimulates their creative thinking, and expands and deepens their social networks, thereby strengthening their identification with entrepreneurial opportunities. (4) ChatGPT-like AI technology drives and empowers the three-stage evolution of user entrepreneurship: idea generation, prototype development, and commercialization of innovative products. Furthermore, Otis et al., (2024) agrees that access to AI advice significantly impacts business decisions, with high performers benefiting by over 20 percent, while low performers experienced 10 percent decline. The current utilization of GPT tools among entrepreneurs is increasingly significant, especially in improving decision-making and marketing strategies. Entrepreneurs leverage GPT tools for several applications, including content creation, customer engagement, and data analysis, which collectively impacts their business decisions toward success and growth.

A hypothetical test conducted based on these findings indicated a statistically significant relationship between the utilization of GPT tools and the business start-up success of entrepreneurs in Rivers State Universities' campuses. The study concluded that there is indeed a statistically significant relationship between the utilization of GPT tools and the business start-up success of entrepreneurs in Rivers State Universities' Campuses as evidenced by the calculated correlation coefficient (r) value surpassing the table value at the $P > 0.05$ level of significance. Consequently, the null hypothesis was rejected at this level of significance. The strength of this relationship was confirmed through a p -value test, which supported the conclusion that a statistically significant relationship exists between the utilization of GPT tools and the business start-up success of entrepreneurs in Rivers State Universities' campuses.

CONCLUSION

This study examined the relationship between awareness and utilization of GPT tools for business start-up success in Rivers State Universities' campuses. Based on findings of the study, it was concluded that there are strong positive relationships between awareness of, and utilization of GPT tools and the business start-up success of entrepreneurs in Rivers State Universities' campuses.

RECOMMENDATIONS

Based on the results of the study, the following recommendations are made:

1. Budding entrepreneurs should embark on self-sponsored trainings to gain knowledge of GPT tools for business start-ups since it plays a crucial role in the growth and overall success of business startups especially in the current digital business landscape.
2. Budding entrepreneurs should acquire GPT tools infrastructure and utilize them to enhance the operational efficiency of their businesses, since it plays a crucial role in the growth and overall success of business startups especially in the current digital business landscape.

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EFFECT OF INTANGIBLE ASSETS ON THE PROFITABILITY OF LISTED HEALTHCARE FIRMS IN NIGERIA

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ABSTRACT

In today's knowledge-driven economy, intangible assets such as patents, goodwill, trademarks, and intellectual capital have emerged as critical drivers of firm value and competitive advantage. For healthcare firms, where innovation, brand reputation, and specialized knowledge are pivotal, the strategic role of intangible assets cannot be overstated. However, despite their growing importance, empirical studies examining the financial impact of intangible assets in developing economies, particularly within the Nigerian healthcare sector, remain limited. This study investigates the effect of intangible assets on the profitability of listed healthcare firms in Nigeria. The study was motivated by the inconsistency in prior findings and the underexplored role of intangible assets in influencing firm-level performance within emerging markets. The study utilized secondary data obtained from the annual financial statements of 4 healthcare firms listed on the Nigerian Exchange Group over a period of 9 years, from 2015 – 2023. The study employed multiple regression analysis to examine the relationship between intangible assets and profitability, measured by return on assets (ROA). Findings reveal that intangible assets have a statistically significant and positive effect on profitability, indicating that firms with higher investments in intangible resources tend to achieve superior financial performance. This underscores the need for healthcare firms to recognize and strategically manage their intangible assets as a means of enhancing long-term profitability and shareholder value. The study concludes that the success of listed healthcare firms in Nigeria depends not only on the use of tangible assets but also on the companies' ability to successfully manage their intangible assets. The study recommends that listed healthcare firms in Nigeria should invest in and effectively manage their knowledge-based resources, such as Research and Development, employee skills, and organizational processes in order to enhance their profitability.

Keywords: Intangible asset, profitability, healthcare firms, return on assets, Nigeria exchange group, emerging markets.

INTRODUCTION

The profitability of firms can be significantly influenced by the strategic utilization of intangible assets. These assets, which include intellectual property, human capital, and brand equity, have emerged as critical drivers of innovation, efficiency, and competitive advantage in knowledge-intensive industries. Onyekwelu and Okoh (2020) posit that intangible assets are critical to the wealth creation process of firms and have evolved into the primary competitive determinant for organizations in virtually all industries, especially service-oriented companies. Similarly, Buallay (2019) relates that intangible assets are now more than ever a critical strategic asset for corporate organizations. Hence, companies are constantly investing in intangible assets in order to remain competitive (Nawaz & Haniffa, 2017).

In Nigeria, where the healthcare sector faces significant challenges such as limited infrastructure and funding, intangible assets represent a potential pathway for achieving sustainable growth and improved financial performance. Thus, this study explores the relationship between intangible assets and the profitability of listed healthcare firms in Nigeria. The healthcare industry in

Nigeria is a dynamic and rapidly evolving sector that plays a vital role in the country's economic and social development. As healthcare organizations strive to improve their financial and clinical outcomes, it is essential to understand the role of intangible assets in driving profitability. Existing research (such as Awa et al., 2020; Gabriel et al., 2021; Abebe & Ali, 2022) highlight that intangible assets contribute to operational efficiency, enhance market value, and bolster financial performance in various industries. However, limited attention has been given to their specific role in the Nigerian healthcare sector. By addressing this gap, the study aims to provide valuable insights for managers, policymakers, and investors on leveraging intangible assets to improve firm profitability. Therefore, the objective of this study is to examine the effect of intangible assets on the profitability of listed healthcare firms in Nigeria. The paper is structured as follows: the literature review examines the conceptual as well as existing studies on intangible assets and financial performance, the methodology outlines the research approach, and the results discuss key findings. Finally, recommendations are provided to enhance the strategic

management of intangible assets in Nigeria's healthcare sector.

REVIEW OF RELATED LITERATURE

Conceptual Review

Intangible Assets: Intangible assets are assets that can neither be touched nor seen but are essential to the day-day running of corporations. According to International Accounting Standard (IAS) 38, intangible assets are identifiable, non-monetary assets without any physical substance. The Organization for Economic Cooperation and Development (OECD, 2011) defined intangible assets are those assets that do not have tangible or visible form and do not possess any physical or financial attributes yet they are important in business operations. Similarly, Beryerdof (2013) posits that intangible asset symbolize payment made by the acquirers for asset that will produce future economic benefits to firms but cannot be individually identified and recognized separately.

Blair and Wallman (2003) defined intangible assets are non-physical factors that contribute to, or are used in; the production of goods or the provision of services or that is expected to generate future productive benefits to the individuals or firms that control their use. Lev (2001) asserts that intangible assets are characterized by high risks, high uncertainty, firm-specificity, the absence of rivalry between uses as well as non-tradable, and these distinguished them from other types of assets.

Intangible assets are defined in this study as knowledge-based assets or intellectual capital of an organization from which firms generate future economic benefits, value, or wealth. These assets, which include goodwill, patents, trademarks, brand reputation, proprietary technologies, and human capital, are not physical in nature but possess the potential to enhance a firm's competitive advantage and long-term sustainability. In the healthcare sector—where innovation, research, and service quality are critical—intangible assets often determine the extent to which firms can deliver superior value to patients, improve operational efficiency, and differentiate themselves in the market. Profitability, which reflects a firm's ability to generate earnings relative to its costs and resources, is inherently linked to how well these intangible resources are leveraged. Firms that effectively manage and utilize their intellectual capital are more likely to achieve higher returns, as intangible assets

contribute to innovation, customer loyalty, cost efficiency, and improved decision-making. Thus, intangible assets serve not only as a source of future economic benefits but also as strategic inputs that drive profitability.

Profitability: Profitability is a critical concept in business and financial management, representing the ability of an organization to generate earnings relative to its revenue, assets, or equity over a given period. It serves as a key indicator of a firm's financial health, operational efficiency, and capacity for sustainable growth. The concept is fundamental to stakeholders, including investors, managers, and policymakers, as it influences decisions related to investment, resource allocation, and strategic planning (Kero & Bogale, 2023). Profitability has also been defined as a company's overall operational and market performance, which is the result of all of its corporate endeavours (Akinsulire, 2022). Several financial ratios are used to assess profitability, including return on assets, return on equity, net profit margin, and earnings per share (FINRA, 2025). This study defines profitability as the capacity of a business to generate a profit, which is the surplus remaining after deducting all expenses from revenue.

Theoretical Perspective: This study is underpinned by the Resource Based Theory (RBT) founded by Penrose (1959). The theory emphasizes the importance of internal resources for gaining a competitive advantage. It suggests that firms should leverage their unique structures, competencies, and resources, which are difficult for competitors to imitate, to achieve long-term success. RBT focuses on identifying the components that contribute to competitive advantage and organizational performance, promoting an internally-driven approach (Ahmed., et al, 2014).

Firms can develop sustainable advantages by creating unique combinations of resources that are valuable, rare, imperfectly imitable, and substitutable (Akter et al., 2016). While tangible assets are equally important, only intangible assets can lead to sustained competitive advantages, as they are harder to replicate by competitors (Appiahene., et al, 2018). The theory posits that organizations can improve long-term performance through effective utilization of intangible resources like human capital, goodwill and customer loyalty (Buallay et

al., 2017; Barney et al., 2022). Overall, RBT underscores the critical role of intangible assets in enhancing competitiveness and financial performance, making it particularly relevant for listed healthcare firms in Nigeria.

Empirical Review

Several studies have explored the relationship between intangible assets and financial performance across different industries and regions, among which are the following:

Abebe and Ali (2022) investigated the effect of intangible assets on the financial performance and policy of 17 Ethiopian commercial banks from 2017 to 2020. Their findings showed that intangible assets positively affect financial performance but negatively impact financial policy. However, their results may not be directly applicable to Nigeria due to differences in political, legal, and economic policies.

Akinsulire (2022) examined the effect of intellectual capital components on the financial and market performance of Nigerian Deposit Money Banks (DMBs) using data from 2011 to 2020. The study found that Human Capital Adequacy Ratio (HCAR), Relational Capital Adequacy Ratio (RCAR), and Capital Employed Adequacy Ratio (CEAR) significantly influenced return on assets (ROA), while Structural Capital Adequacy Ratio (SCAR) had an insignificant impact. The study recommended integrating intellectual capital investment into banks' reporting frameworks to enhance performance evaluation.

Altomonte et al. (2022) assessed intangible assets, industry performance, and finance during crises. They found that investment in intangible assets in advanced EU countries showed an upward trend before and after the global financial crisis (GFC), unlike tangible investments, which declined. Their findings suggest that intangible investment contributes to economic resilience and productivity growth post-crisis.

Duho (2022) explored the impact of intellectual capital and intangible value on non-financial firms' performance. Using the Value-Added Intellectual Coefficient (VAIC), the study found that intellectual capital positively affects firm performance, while asset tangibility negatively

impacts it. Investment in intangible assets showed a positive but insignificant effect on performance.

Akpeekon (2021) studied the moderating effect of ownership structure on the relationship between intangible assets and the financial performance of Nigerian Deposit Money Banks from 2012 to 2017. The study found that intangible assets negatively and significantly affected profitability, while managerial ownership had an insignificant moderating effect. This study differs from the current study by covering a more recent period (2017–2021) and incorporating more independent variables and a larger sample size.

Mozolea and Anton (2021) conducted a systematic literature review on the impact of intangible asset investments on SME performance. Their study identified research gaps in the literature and provided insights for scholars and practitioners on efficiently utilizing intangible assets in SMEs. Similarly, Gabriel et al. (2021) examined the relationship between intangible assets and economic performance in Brazilian public companies. They found that firms with intangible-intensive assets exhibited higher economic performance.

Al-Ani and Tawfik (2021) explored the value relevance of intangible assets in Gulf Cooperation Council (GCC) listed firms. Their results showed that intangible assets improve accounting information relevance in the UAE but have a negative effect in Kuwait. Additionally, their study identified a strong positive relationship between intangible assets and earnings quality in Saudi Arabia and Qatar.

Olaoye et al. (2020) found a positive but insignificant relationship between intangible assets and the profitability of DMBs. Awa et al. (2020) also found that goodwill and computer software had significant effects on return on assets (ROA) in Nigerian banks. They recommended optimizing intangible asset productivity to enhance performance.

Other studies, such as Khan et al. (2020), Ramos-Gonzalez et al. (2020) and Iriyanto et al. (2021) explored the role of intangible assets in SMEs, innovation, and productivity growth. Their findings highlighted the importance of managerial capabilities, socially responsible human resources, and financial frictions in shaping intangible asset utilization.

METHODOLOGY

The study used a quantitative research approach and panel data analysis to investigate the impact of intangible assets on the profitability of listed healthcare firms in Nigeria. The population of the study consist of the eight (8) listed healthcare firms on the Nigerian exchange group as at 31st December, 2023. The research utilized secondary data obtained from the annual reports and accounts of 4 healthcare firms listed on the Nigerian Exchange Group over a period of nine years, 2015 - 2023. The four firms were selected using purposive sampling technique and based on availability and accessibility of their annual reports. The independent variable in this study is intangible assets, which was measured by the natural logarithm of the book value of intangible assets, as used by Al-Ani and Tawfik (2021). As in Abebe and Ali (2022), the dependent variable is represented by return on assets (ROA). Thus, the study adapts the model of Abebe and Ali (2022), specified as follows:

$$\text{PROF}_{it} = \beta_0 + \beta_1 \text{INTA}_{it} + \beta_2 \text{FSZ}_{it} + \beta_3 \text{LEV}_{it} + \mu_{it}$$

Where:

PROF = Profitability, measured by return on assets (ROA).

INTA = Intangible Assets

FSZ = Firm size

LEV = Firm Leverage

β_0 = Constant

β_1 - β_63 = Coefficient of variables,

μ = Error term

RESULTS AND DISCUSSION

The results of the study are presented and discussed as follows:

Descriptive statistics: Table 1 presents the descriptive statistics which shows the key characteristics of the variables of the study.

Table 1: Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
PROF	36	0.0429	0.0888	-0.1775	0.2604
INTA	36	4.2684	0.7288	2.3873	4.9666
FSZ	36	6.8296	0.4369	6.3047	7.6442
LEV	36	0.4766	0.2246	0.1129	0.8783

Source: Output of descriptive statistics using Stata 14.2

The results of the descriptive statistics in Table 1 reveal that the mean value of profitability (PROF) of listed healthcare firms in Nigeria during the period of 2015-2023 was 4.29%, with standard deviation of 8.88%. The minimum and maximum values of profitability were -17.75% and 26.04% respectively. Intangible assets on the other has a mean of 4.2684, standard deviation of 0.7288, with minimum and maximum values of 2.3873 and 4.9666 respectively. The mean value of firm size for listed healthcare firms in Nigeria is 6.8296, with standard

deviation of 0.4369. The minimum and maximum values were 6.3047 and 7.6442 respectively. The average leverage of listed healthcare firms in Nigeria during the period of the study was 47.66% with standard deviation of 22.46%. The minimum and maximum of leverage was 11.20% and 87.83% respectively.

Correlation Analysis

Table 2 contains the results of the Pearson correlation coefficients of the variables of the study.

Table 2: Correlation Matrix

	PROF	INTA	FSZ	LEV	VIF
PROF	1.0000				
INTA	0.0176	1.0000			1.14
FSZ	0.3129	0.3240	1.0000		1.13
LEV	-0.2113	0.1323	-0.0349	1.0000	1.02

Source: Output of correlation analysis using Stata 14.2

The results of the correlation analysis in Table 2 indicate that there is positive correlation between profitability and intangible assets, as well as firm size. However, the table also reveals that there is a negative correlation between profitability and firm leverage. Overall, Table 2 indicates that there are no high correlations among the independent variables that may signal the existence of multicollinearity. In addition, the results of the variance inflation factor (VIF) also demonstrate the absence of multicollinearity since all the values are below the threshold of 10.

Diagnostic Test: In addition to pre-estimation tests, the study further conducts robustness tests to guarantee the credibility and reliability of the study outcomes. These tests include the Heteroskedasticity test and Hausman specification test. All the outputs are attached in Appendix I. The Heteroskedasticity test shows a chi value of 4.04 with a p-value of 0.0444. This indicates that there

is problem of Heteroskedasticity since the p-value is less than 0.05. The study therefore conducts robust regression which is known for removing Heteroskedasticity issues in linear regression.

In order to choose between the fixed and random effect models, the Hausman specification test was utilized. The result shows a chi value of 1.10 with a p-value 0.7776, which implies that the random effect model is a better for the study. This stems from the insignificant outcome of the Hausman specification test. Thereafter, the study conducts the Breusch and Pagan Lagrangian multiplier test for random effects as well the robust random effect test upon which the analysis and interpretations were based as follows:

Regression Analysis: The results of the GLS regression (robust random effects) are presented in table 3 as follows.

Table 3: Results of GLS Regression

Variable	Coefficient	Std. Error	t	p>(z)
INTA	0.0125	0.0112	1.12	0.003
FSZ	0.0691	0.0197	3.50	0.000
LEV	-0.0735	0.0369	-1.99	0.046
CONS.	0.3404	0.1133	-3.00	0.003
R-Squared:				
Within	0.0747			
Between	0.7631			
Overall	0.1474			
Wald chi(2)	213.01			
Prob. Chi(2)	0.0000			

Source: Output of Robust Random Effects Regression using Stata 14.2

The results of the generalized least square (GLS) regression in Table 3 show that the coefficient of determination, R-squared (R^2) has an overall value of 0.1474, which signifies that the independent variables of the study jointly explained about 14.74% of the total variations in the dependent variable. On the other hand, the table shows a Wald chi value of 213.01 which is significant at 1%, signifying the fitness of the estimated model.

Table 3 further reveals that the independent variable, intangible assets (INTA) have a coefficient of 0.0125 and

a p-value of 0.003. These indicate that intangible assets have a statistically significant and positive relationship with return on assets (ROA). Specifically, the results show that a 1% increase in intangible assets is associated with a 1.25% increase in return on assets, holding other factors constant. This finding suggests that healthcare firms in Nigeria can improve their profitability by investing in and effectively managing their intangible assets, such as intellectual property, brand value, R&D, employee skills, organizational processes, and human capital. The results are consistent with previous studies that have highlighted the importance of intangible assets

in driving financial performance, including Gabriel et al. (2021), Abebe and Ali (2022), Altomonte et al. (2022). The finding however contradicts Akpeekon (2021) who found that intangible assets negatively and significantly affect profitability.

Regarding the control variables, Table 3 displays both as statistically significant. While firm size is positively associated with profitability, leverage on the other hand has negative relationship with profitability. These show that larger firms are likely to be more profitable than their smaller counterparts while highly geared firms have lower profitability.

These findings have important implications for policymakers and healthcare firms in Nigeria. Policymakers should consider implementing policies and regulations that incentivize and support healthcare firms to invest in intangible assets, as this could contribute to the overall financial performance and competitiveness of the sector. For healthcare firms, the results highlight the need to prioritize the development and management of intangible assets as a key strategic priority. Firms should focus on building strong human capital, improving organizational structures and processes, and developing innovative products and services that can create long-term value for the business.

CONCLUSION AND RECOMMENDATIONS

This study has provided empirical evidence on the impact of intangible assets on the profitability of listed healthcare firms in Nigeria. The results suggest that healthcare firms can improve their financial performance by effectively managing and investing in their intangible assets, such as intellectual property, brand value, R&D, employee skills, organizational processes, and human capital.

The study hereby recommends that healthcare firms in Nigeria should prioritize the development and utilization of intangible assets as a strategic tool to enhance their profitability and competitiveness in the market. They should also focus on identifying, measuring, and effectively managing their intangible assets to enhance profitability and long-term sustainability. In addition, policymakers should consider implementing policies and regulations that incentivize healthcare firms to invest in and develop their intangible assets, as this can contribute

to the overall growth and development of the healthcare sector in Nigeria.

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Appendix I: Regression Outputs

```

_____ (R)
/_____/ /_____/ /_____/ /_____/
_____/ /_____/ /_____/ /_____/ 14.2
Statistics/Data Analysis

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Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
prof	36	.0429083	.0888914	-.1775689	.2604061
inta	36	4.268469	.7288545	2.38739	4.966062
fsz	36	6.829607	.4369578	6.304718	7.64425
lev	36	.4766976	.2246978	.1129418	.8783608

Normality Test

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
prof	36	0.95401	1.677	1.081	0.13979
inta	36	0.77765	8.108	4.376	0.00001
fsz	36	0.88442	4.215	3.008	0.00131
lev	36	0.96431	1.302	0.551	0.29076

Correlation Matrix

	prof	inta	fsz	lev
-----+				

```

prof |    1.0000
inta |    0.0176    1.0000
fsz  |    0.3129    0.3240    1.0000
lev  |   -0.2113    0.1323   -0.0349    1.0000

```

OLS Regression

Source	SS	df	MS	Number of obs	=	36
Model	.040763645	3	.013587882	F(3, 32)	=	1.84
Residual	.235795146	32	.007368598	Prob > F	=	0.1591
Total	.27655879	35	.00790168	R-squared	=	0.1474
				Adj R-squared	=	0.0675
				Root MSE	=	.08584

	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
prof	.0125754	.0212894	0.59	0.009	.0559406 .0307898
inta	.0691272	.0352206	1.96	0.058	.0026148 .1408693
fsz	-.0735077	.0653718	-1.12	0.269	-.2066657 .0596503
lev	.3404849	.2305984	1.48	0.150	.8101986 .1292287

. vif

Variable	VIF	1/VIF
inta	1.14	0.874392
fsz	1.13	0.888880
lev	1.02	0.975750
Mean VIF	1.10	

. hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance

Variables: fitted values of prof

chi2(1) = 4.04

Prob > chi2 = 0.0444

. regress prof inta fsz lev, robust

Linear regression	Number of obs	=	36
	F(3, 32)	=	2.18
	Prob > F	=	0.1097
	R-squared	=	0.1474
	Root MSE	=	.08584

	Robust				
	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
prof					

```

      inta |   .0125754   .0305472    0.41   0.003    .0747981   .0496473
      fsz |   .0691272   .0348851    1.98   0.056    .0019313   .1401858
      lev |  -.0735077   .0682759   -1.08   0.290   -.2125812   .0655658
      _cons |   .3404849   .2610272   -1.30   0.201    .87218    .1912102
-----+-----

```

```

. xtset id year
      panel variable:  id (strongly balanced)
      time variable:  year, 2015 to 2023
              delta:  1 unit

```

```

Fixed-effects (within) regression               Number of obs   =          36
Group variable: id                             Number of groups =           4

```

```

R-sq:                                           Obs per group:
      within = 0.0958                           min =           9
      between = 0.4909                          avg  =          9.0
      overall = 0.1154                          max  =           9

```

```

                                           F(3,29)          =          1.02
corr(u_i, Xb)  = -0.7067                    Prob > F          =          0.3965

```

```

-----+-----
      prof |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-----+-----
      inta |   .0134112   .0334874     0.40   0.692    .0550782   .0819006
      fsz |   .1080098   .1041321     1.04   0.308    .1049642   .3209838
      lev |  -.083814    .0716171    -1.17   0.251   -.2302874   .0626595
      _cons |   .7120473   .7489917     0.95   0.350    2.243907   .8198127
-----+-----

```

```

      sigma_u |   .03944902
      sigma_e |   .0878109
      rho     |   .16793227   (fraction of variance due to u_i)
-----+-----

```

```

F test that all u_i=0: F(3, 29) = 0.53                Prob > F = 0.6675

```

```

. xtreg prof inta fsz lev, re

```

```

Random-effects GLS regression               Number of obs   =          36
Group variable: id                             Number of groups =           4

```

```

R-sq:                                           Obs per group:
      within = 0.0747                           min =           9
      between = 0.7631                          avg  =          9.0
      overall = 0.1474                          max  =           9

```

```

                                           Wald chi2(3)     =          5.53
corr(u_i, X)   = 0 (assumed)                  Prob > chi2      =          0.1367

```

```

-----+-----
      prof |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-----+-----
      inta |   .0125754   .0212894     0.59   0.005    .0543019   .0291511

```

```

      fsz |   .0691272   .0352206    1.96   0.050   .0000961   .1381584
      lev |  -.0735077   .0653718   -1.12   0.261   -.201634   .0546187
      _cons |   .3404849   .2305984    1.48   0.140   .7924496   .1114797
-----+-----
      sigma_u |           0
      sigma_e |   .0878109
      rho |           0   (fraction of variance due to u_i)
-----+-----

```

```
. est store re
```

```
. hausman fe re
```

```

          ---- Coefficients ----
          |      (b)      (B)      (b-B)      sqrt(diag(V_b-V_B))
          |      fe      re      Difference      S.E.
-----+-----
      inta |   .0134112   -.0125754   .0259866   .0258489
      fsz |   .1080098   .0691272   .0388826   .0979949
      lev |  -.083814   -.0735077  -.0103063   .0292497
-----+-----

```

b = consistent under Ho and Ha; obtained from xtreg
 B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

```

      chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
              =      1.10
      Prob>chi2 =      0.7776

```

```
. xtreg prof inta fsz lev, re
```

```

Random-effects GLS regression              Number of obs   =          36
Group variable: id                        Number of groups  =           4

```

```

R-sq:                                     Obs per group:
      within = 0.0747                      min =           9
      between = 0.7631                     avg =          9.0
      overall = 0.1474                      max =           9

```

```

corr(u_i, X) = 0 (assumed)                Wald chi2(3)      =          5.53
                                           Prob > chi2       =          0.1367

```

```

-----+-----
      prof |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-----+-----
      inta |   .0125754   .0212894     0.59   0.055   .0543019   .0291511
      fsz |   .0691272   .0352206     1.96   0.050   .0000961   .1381584
      lev |   .0735077   .0653718     1.12   0.261   -.201634   .0546187
      _cons |  -.3404849   .2305984    -1.48   0.140   -.7924496   .1114797
-----+-----
      sigma_u |           0
      sigma_e |   .0878109
      rho |           0   (fraction of variance due to u_i)
-----+-----

```

```
. xttest0
```

Breusch and Pagan Lagrangian multiplier test for random effects

```
prof[id,t] = Xb + u[id] + e[id,t]
```

Estimated results:

	Var	sd = sqrt(Var)
prof	.0079017	.0888914
e	.0077108	.0878109
u	0	0

Test: Var(u) = 0

chibar2(01) = 10.00
Prob > chibar2 = 0.0027

```
. xtreg prof inta fsz lev, re robust
```

Random-effects GLS regression Number of obs = 36
Group variable: id Number of groups = 4

R-sq: Obs per group:
within = 0.0747 min = 9
between = 0.7631 avg = 9.0
overall = 0.1474 max = 9

corr(u_i, X) = 0 (assumed) Wald chi2(3) = 213.01
Prob > chi2 = 0.0000

(Std. Err. adjusted for 4 clusters in id)

	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
prof					
inta	.0125754	.011224	1.12	0.003	-.0345741 .0094233
fsz	.0691272	.0197449	3.50	0.000	.030428 .1078265
lev	-.0735077	.0369191	-1.99	0.046	-.1458678 -.0011476
_cons	.3404849	.113367	3.00	0.003	.5626802 -.1182896
sigma_u	0				
sigma_e	.0878109				
rho	0	(fraction of variance due to u_i)			



ENGINEERING AND SCIENCES



ON THE SPATIAL ANALYSIS OF THE RECORDED CASES OF MALARIA AND ITS IMPACTS ON THE POPULATION OF CHILDREN BELOW THE AGES OF FIVE YEARS IN NIGER STATE, NIGERIA FROM 2013 TO 2020.

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ABSTRACT

Geographically weighted regression method (GWR) is a local spatial regression technique that produces the predicted values for other points whose positions and properties are known. In this article, the application of GWR method was used to carry out the spatial analysis of recorded cases of malaria and its impact on the population of children below the ages of five in Niger State. The data used for the study were secondary data from Niger state Ministry for health, Minna, National Bureau of Statistics (NBS) and Nigeria Meteorological agency (NIMET), Headquarters, Abuja. The software used were Arc GIS version 10.8, R-studio version 10.6, excel and GWR version 4.09. The result revealed that, there are variations in the malaria risks across the local governments with a wide range of risks. Rijau local government has the highest malaria risk of 10,341 cases per 100,000 population while, Shiroro local government has the lowest risk of 942 cases per 100,000 population. The average risks across all local governments are relatively high at 2,470 cases per 100,000 population. The GWR results also showed that the AICc (461.902) of the geographically weighted regression based on fixed bandwidth (GWR-FB) model was smaller than that of the geographically weighted regression based on adaptive bandwidth (GWR-AB) models and is therefore, considered to be the best model. The research suggests that the treatment of malaria be made free for under five children at all government hospitals in Niger State to reduce the burden of malaria cases in the state. Community awareness and health education on the use of long-lasting insecticide treated nets (LLITNs) be step up by government at all levels to reduce the prevalence of malaria in the state especially among under five children.

Keywords: Malaria, Hotspots, population, Spatial Analysis, prevalence, World Health Organization, Under-five Children, ArcGIS.

INTRODUCTION.

Malaria as one of the leading cause of deaths worldwide has affected people, especially, children 0-59 months living in poverty prone areas of vulnerability, further exacerbating families and households, reducing productivity, discouraging investment and weakening national growth. An effective response requires multi-dimensional approach that integrates gender equality, human rights and health, vis-a-vis, action on social and environmental determinants of health. Health systems need to be improved to ensure high-quality interventions are available and acceptable for all, and the active participation of affected populations and communities are needed in decision-making processes at all levels especially, as it affects under five years children.

Globally, in 2024, the number of malaria cases was estimated at 273 million, with an incidence of 60.4 cases per 1000 population at risk. This was an increase of 11 million cases from the previous year and a rise in incidence from 58.6 cases per 1000 population at risk in 2024. The WHO African countries continue to records the heaviest burden of the disease, accounting for an estimated 94% of malaria cases worldwide in 2024.

The WHO Eastern Mediterranean Region has experienced a 57% increase in incidence since 2021, rising to 17.9 cases per 1000 population at risk in 2023. The top five countries carrying the heaviest estimated

burden of malaria cases in 2023 were Nigeria (26%), the Democratic Republic of the Congo (13%), Uganda (5%), Ethiopia (4%) and Mozambique (4%).

Globally, in 2024, the number of deaths was estimated at 597, 000 with a mortality rate of 13.7 per 100,000.

The number of malaria deaths and the mortality rate steadily decreased from 622,000 and 14.9 deaths per 100,000 respectively, in 2020. The WHO African Region continues to carry the heaviest burden of mortality with 95% of estimated malaria deaths worldwide.

Between 2000 and 2024, an estimated 2.3 billion malaria cases and 13.9 million malaria deaths were averted worldwide, with 1.9 billion cases and 13 million deaths prevented in the WHO African Region alone. In 2024, more than 189 million cases with more than 1 million deaths were averted globally. Children aged under-five years are the most vulnerable group affected by malaria; in 2019, they accounted for 67% (274000) of all malaria deaths worldwide. (WHO, 2020). However, malaria is declining in Africa, in some areas, the burden of malaria has remained unchanged or increased. In 2016, approximately 216 million clinical cases and about 450,000 deaths are reported worldwide. (WHO, 2017). Malaria is caused by five protozoan species, namely *Plasmodium falciparum*, *P. vivax*, *P. malariae*, *P. ovale*, and *P. knowlesi*.

Children under five years old are among the most vulnerable to malaria infection as they have not yet developed any immunity to the disease. Children who survive malaria may suffer long-term consequences of the infection. Repeated episodes of fever and illness reduce appetite and restrict play, social interaction, and educational opportunities, thereby contributing to poor development. Child mortality rates are known to be higher in poorer households and malaria is responsible for a substantial proportion of these deaths. (Mwageni et al., 2002).

Climatic factors, particularly rainfall, temperature and relative humidity have a strong influence on the biology of mosquitoes. In malaria endemic countries like Nigeria, climate factors reportedly contribute to the increased number of mosquitoes and thus make transmission favorable. Once adult mosquitoes have emerged, the ambient temperature, humidity, and rains will determine their chances of survival. Warmer ambient temperatures shorten the duration of the extrinsic cycle, thus increasing the chances of transmission. (Abeku et al, 2003).

Malaria is greatly influenced by rainfall in the tropics. (Arab et al., 2014). It creates an opportunity for anopheles mosquitoes to lay eggs, which can reach adulthood within nine to twelve (9-12) days that are necessary for the mosquito life cycle. Rainfall as one of the climatic variables that aid in the multiplication of mosquito breeding places and increasing humidity, which improves mosquito survival rates. The rainy season is a fertile period for the breeding sites, which are numerous. These species have the highest population density during the rainy season and these account for the high incidence of malaria at this period of the year (Reid, 2000). Malaria incidence is closely linked with temperature. (Feng et al., 2014). Temperature plays a fundamental role in the rate of multiplication of the parasite in mosquitoes and directly influences the mosquito development, gonotrophic cycle and longevity, as well as the duration of the extrinsic cycle of the Plasmodium parasite. In warmer temperatures, the mosquitoes develop more rapidly accelerating the mosquito life cycle and replicating rapidly the parasite growth (WHO, 2001). Mosquitoes survive better under conditions of high humidity. (Wu et al., 2016). They also become more affective when humidity rises. This is why they are more affective and prefer feeding during the night. The relative humidity of the environment is higher at night if the average monthly relative humidity is below 60%, it is believed that the life of the mosquitoes is so short that very little or no malaria transmission is possible. (Manas & Kwuntida, 2018).

LITERATURE REVIEWED.

Abossie et al., (2020); Explored the magnitude of malaria and associated factors among febrile children under 5 years old in Arba Minch “Zuria” District. Blood sample were collected from 271 systematically selected febrile children under-five years old. The data were analyzed using binomial and multinomial regression model. Children who slept under insecticide-treated nets (ITNs) were more likely to be protected from malaria infection than those did not sleep under an ITNs.

Ndiath et al., (2015); investigated malaria hotspots in Keur Soce sites by using geographically-weighted regression to explore the spatial variability of relationships between malaria incidence or persistence and the selected socio-economic and human predictors. A model comparison between ordinary least square and geographically-weighted regression was also used. The result showed that from June to December, a total of 408 confirmed cases were notified.

Hasyim et al., (2018); investigated the spatial association between malaria occurrence and environmental risks factors. Ordinary least square (OLS) method and geographically weighted regression (GWR) were used. The independent variables altitude distance from forest and rainfall in global OLS were significantly associated with malaria cases and GWR model, revealed the relationship between the malaria and environmental factors in south Sumatra strongly vary spatially in different regions.

Haque et al., (2010); investigated the spatial prediction of malaria prevalence in an endemic area of Bangladesh. The Bayesian geo-statistical model was developed from previously identified individual and environmental covariates (age, different forest types, elevation and economic status) for malaria prevalence. The findings represent an important strategy for targeting intervention and resources allocation. It can also be used as advocacy for directing funds to conduct more operational research in specific high-risk areas.

Muche et al., (2021); investigated the geographical heterogeneity and predictors of under-nutrition among under-five children in Ethiopia. ArcGIS Version 10.5 software was used for global, local and ordinary least square analysis and mapping. The findings can be generalized to all under-five children in Ethiopia. Moreover, the use of geographical information system (GIS) and sat scan statistical test helped to detect similar and statistically significant high-risk clusters/hot spots of under-nutrition.

Ehlkes et al., (2014); determined the vector of plasmodium falciparum transmission in the Ashanti region of Ghana. Semi-parametric geographically weighted Poisson regression (s-GWPR) model was used to determine the spatial associations of land use/land cover (LULC) and mosquito bone disease. Geographical information system (GIS) Plasmodium falciparum showed strong spatial variations within the study area.

Dawaki et al., (2016); investigated the prevalence and risk factors of malaria and to evaluate the knowledge, attitude and practices (KAP) regarding malaria among rural Hausa communities in Kano State, Nigeria. Chi-square test, Fisher's exact test and odd ratio (OR) to test the association between malaria prevalence and KAP items as the dependent variables with the demographic. The study reported high prevalence of malaria in Kano State as, where 60% of the participants were found positive for P. falciparum. This is consistent with previous studies conducted in Kano and other Nigerian States.

METHODOLOGY.

GWR model is an extended version of Ordinary Least Square (OLS) Method. The model can be written as:

$$y_i = \beta_0(u_i, v_i) + \sum_{k=1}^3 \beta_k(u_i, v_i) x_{ik} + \varepsilon_i \quad i = 1, 2, 3 \quad (1)$$

Where (u_i, v_i) represents the coordinates of the location of the i^{th} point in the space, y_i is the observed value of the dependent variable (in this study, malaria cases) at location i , x_{ik} ($k = 1, 2, 3$) is the observed value of the independent variable here, (relative humidity, temperature, and rainfall) at location i , β_k is the set of regression coefficients of the GWR model (in this article, the effects of relative humidity, temperature and rainfall, on malaria cases) while ε_i is the error of the i^{th} location, which is assumed to be independent and identically distributed normal random variable with mean zero and constant variance σ^2 .

The GWR equivalent is given by:

$$\mathbf{Y} = (\boldsymbol{\beta} \otimes \mathbf{X})\mathbf{1} + \boldsymbol{\varepsilon} \quad (2)$$

where $\otimes$ is a logical multiplication operator in which each element of the vector $\boldsymbol{\beta}$ is multiplied by the corresponding element of the matrix $\mathbf{X}$. Thus, if there are n data points and k input variables, then both $\boldsymbol{\beta}$ and $\mathbf{X}$ will have dimensions $n \times (k + 1)$ and is a $(k + 1) \times 1$ vector of 1s (Fotheringham *et al.*, 2002). The matrix $\boldsymbol{\beta}$ now consists of n sets of local parameters and has the following structure:

$$\boldsymbol{\beta} = \begin{bmatrix} \beta_0(u_1, v_1) & \beta_1(u_1, v_1) & \dots & \beta_k(u_1, v_1) \\ \beta_0(u_2, v_2) & \beta_1(u_2, v_2) & \dots & \beta_k(u_2, v_2) \\ \dots & \dots & \dots & \dots \\ \beta_0(u_3, v_3) & \beta_1(u_3, v_3) & \dots & \beta_k(u_3, v_3) \end{bmatrix} \quad (3)$$

The parameters in each row of the above matrix are then estimated by

$$\hat{\boldsymbol{\beta}}_{(i)} = (\mathbf{X}^T \mathbf{W}_{(i)} \mathbf{X})^{-1} \mathbf{X}^T \mathbf{W}_{(i)} \mathbf{Y} \quad (4)$$

where i represents a row of the matrix in (3.4); $\mathbf{X}$ is the matrix of independent variables and consists of $(k+1)$ columns; $\mathbf{Y} = (Y_1, Y_2, \dots, Y_n)^T$ is the dependent variable matrix and $\mathbf{W}_{(i)}$ is n by n spatial weighting matrix of the form:

$$\mathbf{w}(i) = \begin{bmatrix} w_{i1} & 0 & \dots & \dots & \dots & 0 \\ 0 & w_{i2} & \dots & \dots & \dots & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & \dots \\ 0 & 0 & \dots & \dots & \dots & w_{i3} \end{bmatrix} \quad (5)$$

The w_{ij} in (3.5) is the neighborhood ratio between the regression point and the reference point. This weight is calculated using any of the models like the global model, box-car, exponential, Gaussian, bi-square, and tricube models (Fotheringham, *et al.*, 2003). However, the Gaussian function is commonly used with Gaussian kernel function (Nakaya *et al.*, 2005 & Ndiath *et al.*, 2015) and w_{ij} is calculated as

$$w_{ij} = \exp \left[-\frac{1}{2} \left(\frac{d_{ij}}{bw} \right)^2 \right] \quad (6)$$

where d_{ij} is the distance between the regression point i and the reference point j , bw is the bandwidth value, d_{ij} is usually the Euclidean distance and is calculated as

$$d_{ij} = \sqrt{(u_i - u_j)^2 + (v_i - v_j)^2} \quad (7)$$

Where, u and v are the point coordinates (Longitude and Latitude).

The value of the bandwidth (BW) parameter can be constant for a whole model in the GWR model or it can be variable according to the point density in the location. The optimal value of bandwidth can be determined by cross validation (CV), generalized cross-validation (GCV), Akaike information criterion (AIC), and corrected Akaike information criterion (AICc) methods.

In this article, the cross-validation method is used and is given as

$$C.V. = \sum_{i=1}^n (y_i - \hat{y}_{\neq i}(BW))^2 \quad (8)$$

Where, $\hat{y}_{\neq i}(BW)$ is the fitted value of y_i by omitting the i th point from the process.

The weighting function can be written as:

$$W_{ij} = \begin{cases} 1 & \text{if } d_{ij} < b \\ 0, & \text{otherwise} \end{cases} \quad (9)$$

Spatial weighting has the problem of discontinuity, which results in a drastic change in estimated coefficients. One way of overcoming the problem of discontinuity is to express the weights (w_{ij}) as a continuous function of d_{ij} , the distance between i and j as:

$$w_{ij} = \exp \left[-\frac{1}{2} (d_{ij} / b)^2 \right] \quad (10)$$

Where b is referred as bandwidth. An alternative kernel utilizes the bi-square function as:

$$w_{ij} = \begin{cases} [1 - (d_{ij} / b)^2]^2 & \text{if } d_{ij} < b \\ 0, & \text{otherwise} \end{cases} \quad (11)$$

This will provide a continuous weighting function up to distance b and then zero weight for any data point outside b .

Study Area: Niger State was created on 3rd February, 1976. The State covered a total land mass of 76, 469.903 Square Kilometers (about 10% of the total land area of Nigeria) with a population growth of 3,954,772 as at march 2006 population and housing census, NPC/NBS web. However, the projected population growth of the state as at March, 2016 using an annual growth rate/change of 3.5% was 5,556,200. Similarly, the population is expected to grow to 27,202,843million and 27,734,993million by the year 2023 and 2024 respectively.

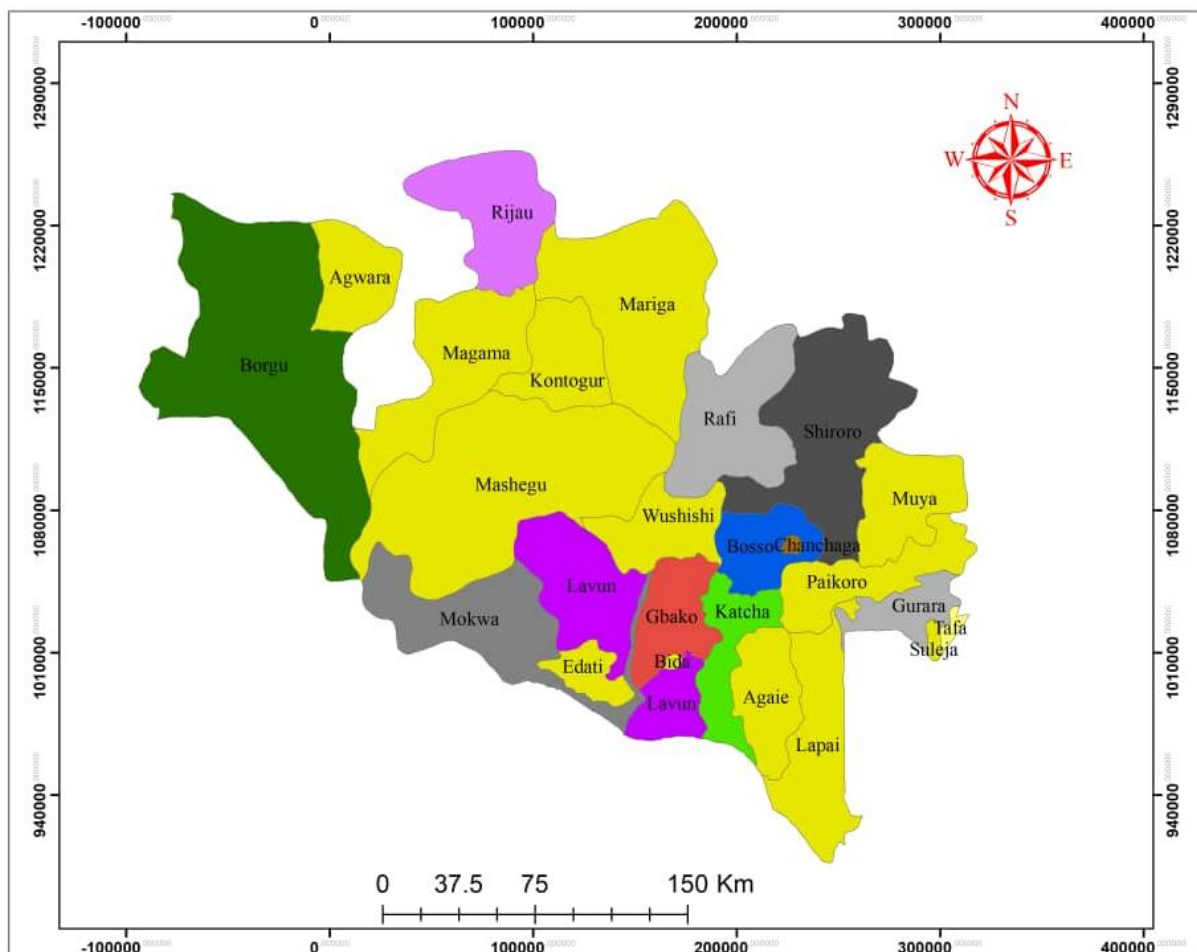


Figure 1: Map of Niger State showing the 25 LGA of the study area

Data Source and Software Packages used: The data were collected from Niger State Ministry of Health and Nigeria Meteorological Agency (NIMET).

Environmental factors used for the study are: Relative humidity, temperature and rainfall.

Software Packages used: R-Studio version 10.6 and ArcGIS version 10.8 respectively.

RESULTS AND DISCUSSIONS

Table 1 below is a summary of the number of reported malaria cases in Niger State, Nigeria. The data suggests that the minimum number of reported malaria cases was 1,601. The first quartile (25th percentile) of reported malaria cases was 2,599. This means that, 25% of the reported cases are below this number. The median number of reported malaria cases was 2,998. This is the middle value in the data set, where half of the reported cases are above this number and half are below.

The mean number of reported malaria cases is 3,675. This is the average of all the reported cases. The third quartile

(75th percentile) of reported malaria cases was 3,877. This means that, 75% of the reported cases are below this number. The maximum number of reported malaria cases is 18,220. This is the highest number of reported cases in the data set.

Table 1: Summary statistics of Malaria Cases

Statistic	Values
Minimum	1601
First Quarter	2599
Median	2998
Mean	3675
Third Quarter	3877
Maximum	18220

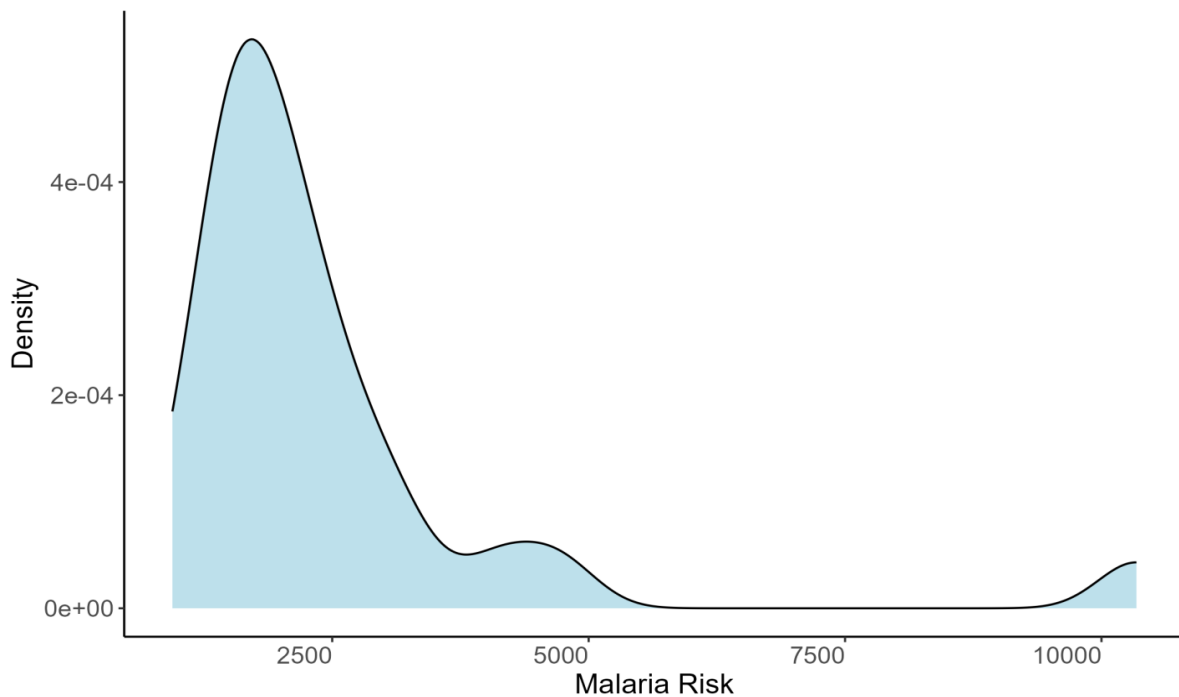


Figure 2: Plot of Density Graph of malaria cases

The above curve is highest near the right of the distribution where most values of malaria cases recorded in the state were located. The distribution is a unimodal because it had one peak. The density curve above

indicates that right skewed, then the mean is greater than the median which shows in the descriptive statistics table below.

Table 2: Result of Malaria Hotspots using Arc GIS Version 10.8

S/No	LGAs	Malaria Prevalence Rate ('000)	Relative Humidity (%)	Temperature (C°)	Rainfall (mm)
1	Rijau	10,341	67.0981	26.5490	3.3513
2	Agwara	4,709	67.0981	26.5490	3.3513
3	Lapai	4,111	71.1708	25.6950	3.9592
4	Wushishi	3,230	67.0981	26.5490	3.3513
5	Gurara	2,984	67.0981	26.5490	3.3513
6	Bosso	2,742	67.0981	26.5490	3.3513
7	Tafa	2,522	67.0981	26.5490	3.3513
8	Edati	2,426	60.1142	27.5958	2.5030
9	Paikoro	2,311	67.0981	26.5490	3.3513
10	Kontagora	2,180	67.0981	26.5490	3.3513
11	Lavun	2,130	70.2042	26.1458	3.5450
12	Muya	1,988	67.0981	26.5490	3.3513
13	Gbako	1,936	65.3650	27.0550	3.2983
14	Suleja	1,861	67.0981	26.5490	3.3513
15	Shiroro	1,775	67.0981	26.5490	3.3513

From table 2, the LGAs with the highest Malaria Prevalence rates are Rijau (10,341) and Agwara (4,709) while Shiroro local government has the lowest malaria risk in the state. These locations can be considered Malaria hotspots as they have a significantly higher risk of Malaria compared to other LGAs in the table. The high Malaria Risk values in Rijau and Agwara suggests that, the people living in these areas are at higher risk of contracting Malaria compared to other locations in the table. This may be due to several factors such as climatic factors, environmental conditions, and non-availability of healthcare facilities.

Malaria Prevalence rate in table 2, is calculated as shown below taking Rijau as an example:

$$\text{Rijau} = \frac{145762}{1409592} \times 100,000 = 10,341$$

Interpretation: This means that for every 100,000 population, the prevalence rate for Rijau is 10,341 under-five children.

Figure 3 above shows the rate of malaria infection per 100,000 populations of children of under five years. The bar chart is used to show malaria hotspot in Niger state. The local government with the highest malaria cases in

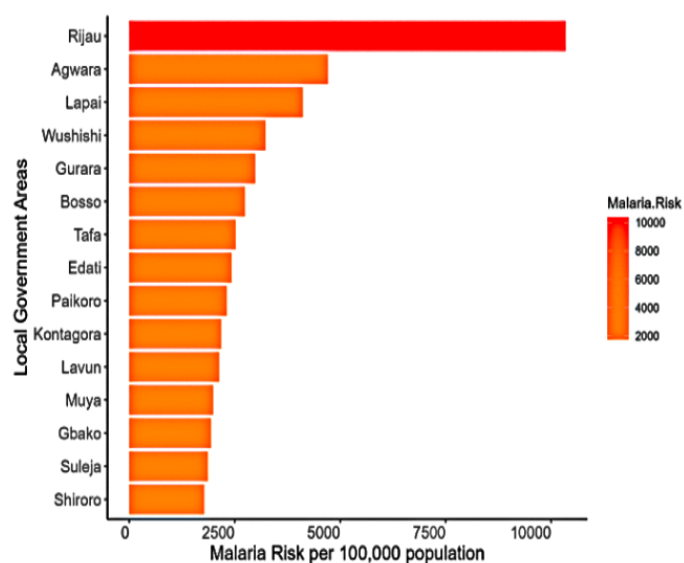


Figure 3: Bar chart of Malaria Hotspot in Niger State

Niger State was Rijau with 10340.723 which are shown in red on the chart. It was followed by Agwara with 4709.488, followed by Lapai with 4110.801 and Wushishi and Gurara with 3230.344 and 2984.188 respectively. The local government with the lowest malaria cases was Shiroro with 1775.083, which is shown in light red on the map and bar chart respectively.

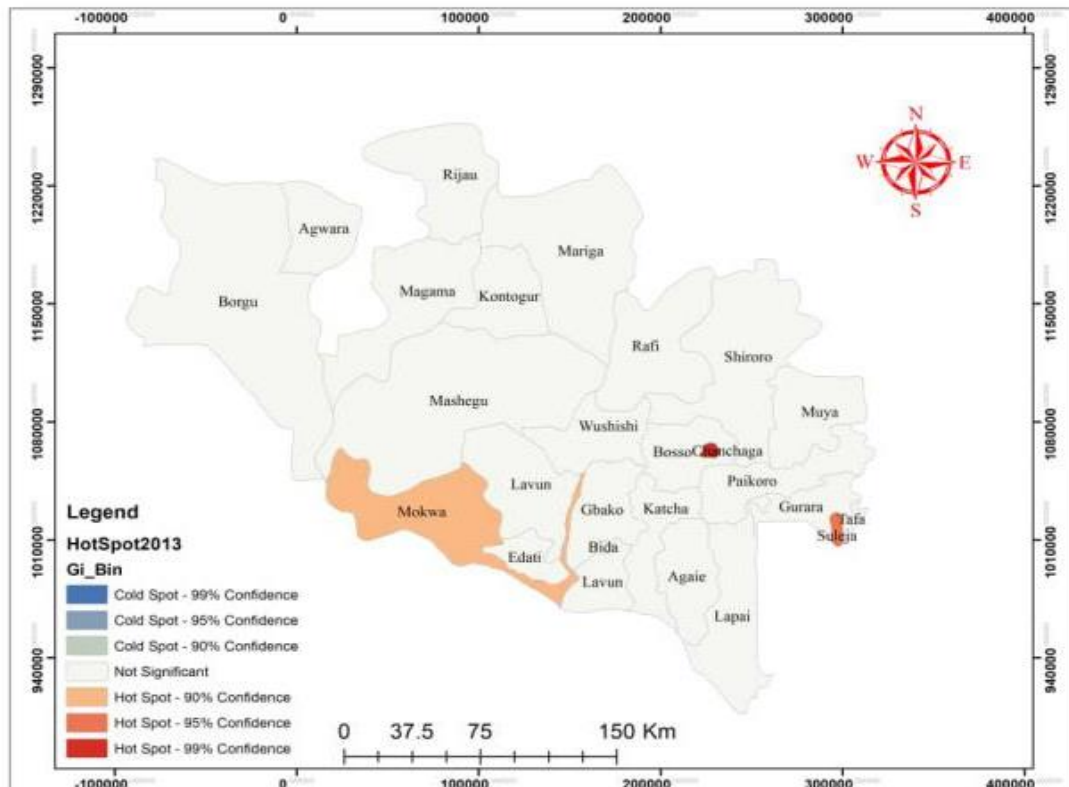


Figure 4: 2013 Malaria high risk map (hotspot). Mokwa LGA has the highest Malaria Risk. Source: Author's Lab work, 2023

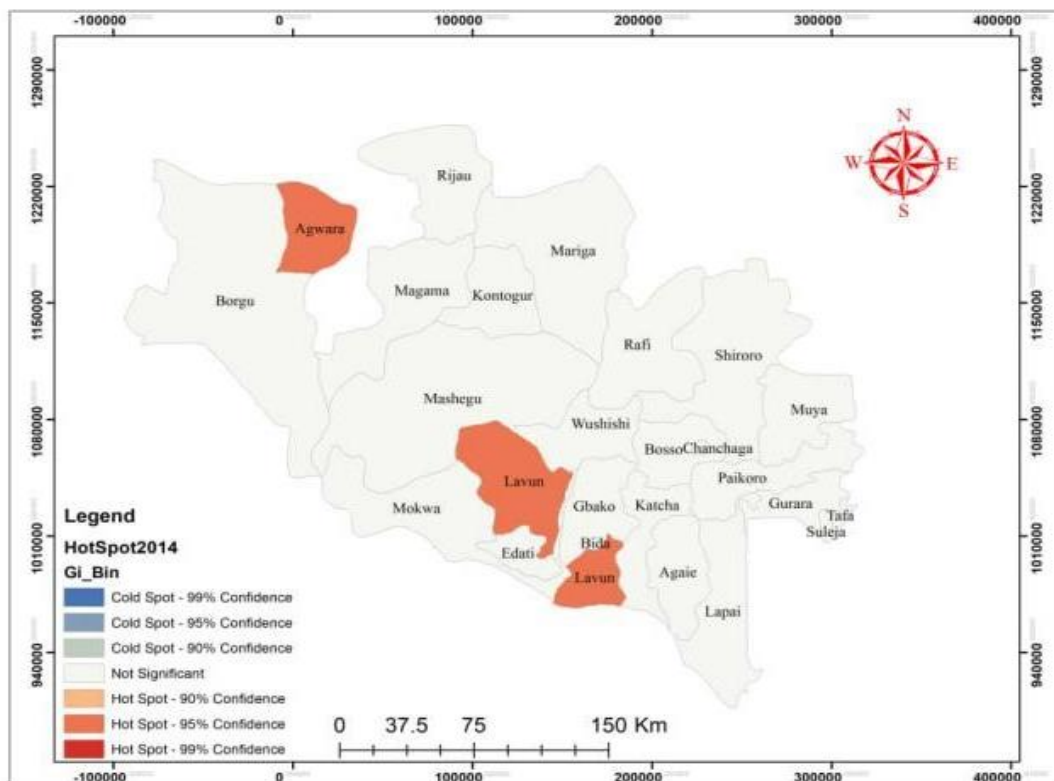


Figure 5: 2014 Malaria high risk map (hotspot). Lavun and Agwara LGA's has high concentrated malaria risk. Source: Author's Lab work, 2023

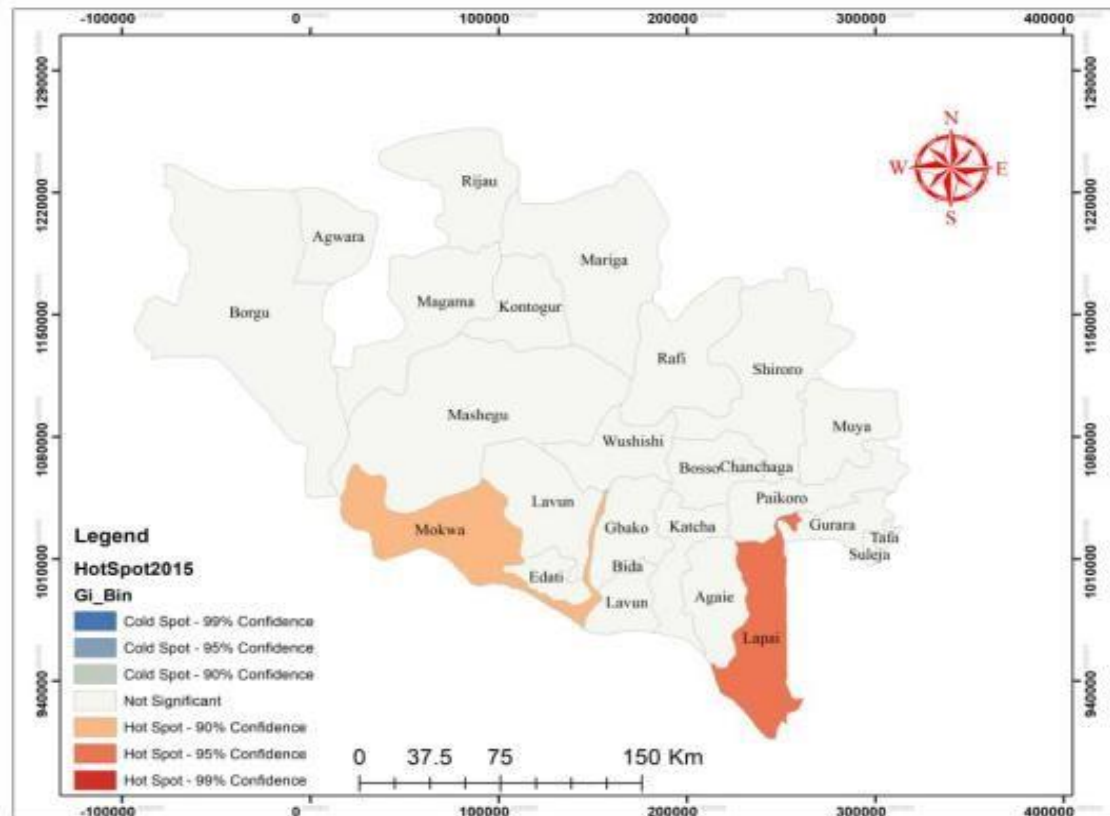


Figure 6: 2015 Malaria high risk map (hotspot). Lapai followed by Mokwa LGA recorded highest malaria risks. *Source: Author's Lab work, 2023*

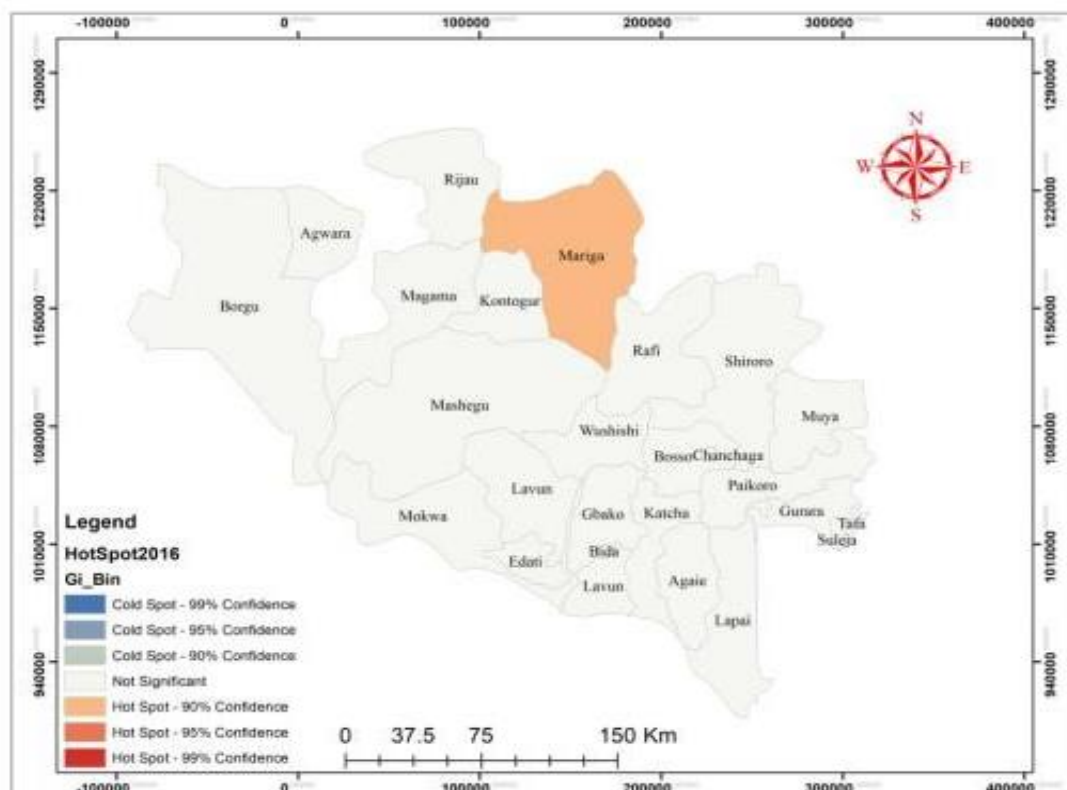


Figure 7: 2016 Malaria high risk map (hotspot). Mariga LGA shows highest concentration of malaria risk. *Source: Author's Lab work, 2023*

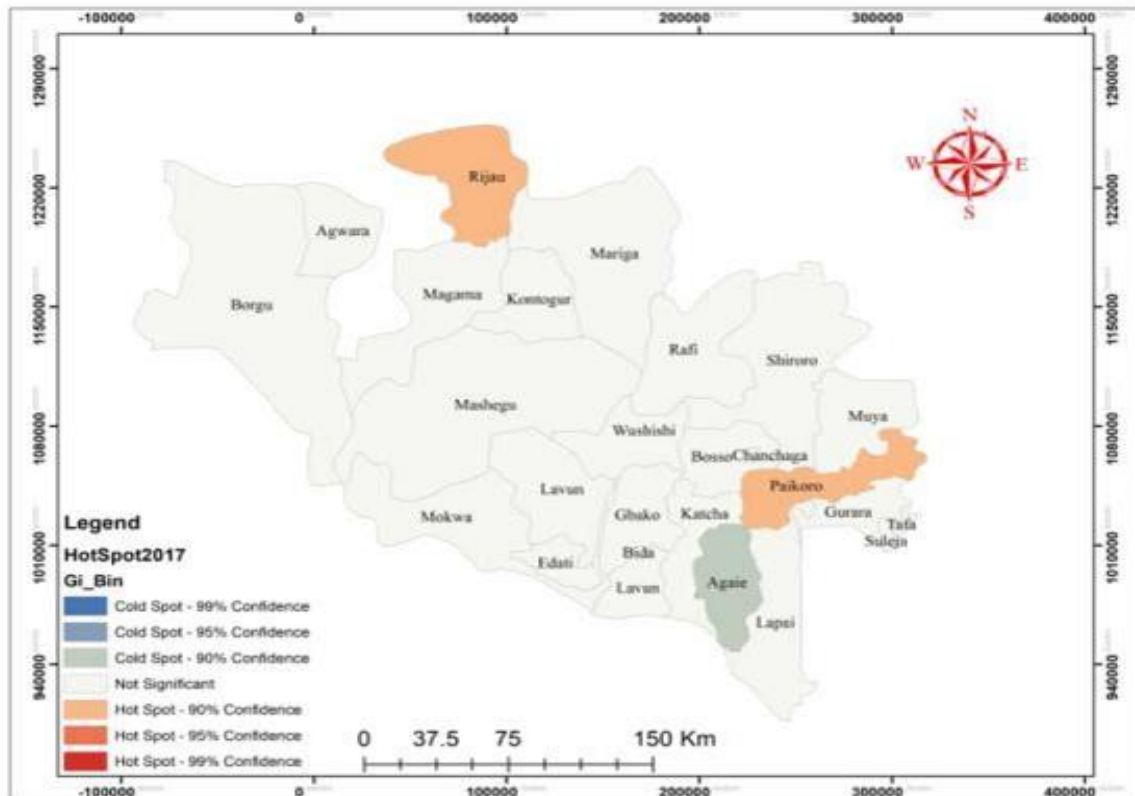


Figure 8: 2017 Malaria high risk map (hotspot). Rijau and Paikoro show highest concentration of malaria risks while Agaie has the lowest concentration. *Source: Author's Lab work, 2023*

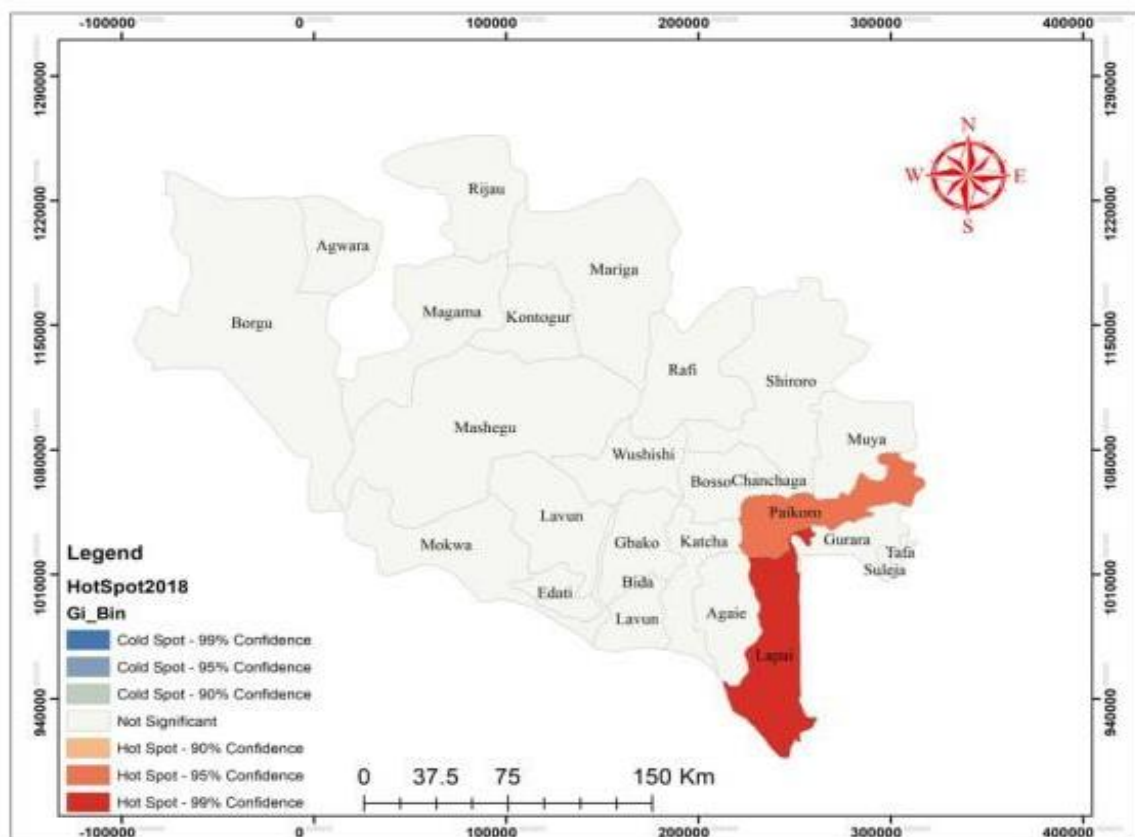


Figure 9: 2018 Malaria high risk map (hotspot). Lapai and Paikoro again revealed highest concentration of malaria risks. *Source: Author's Lab work, 2023*

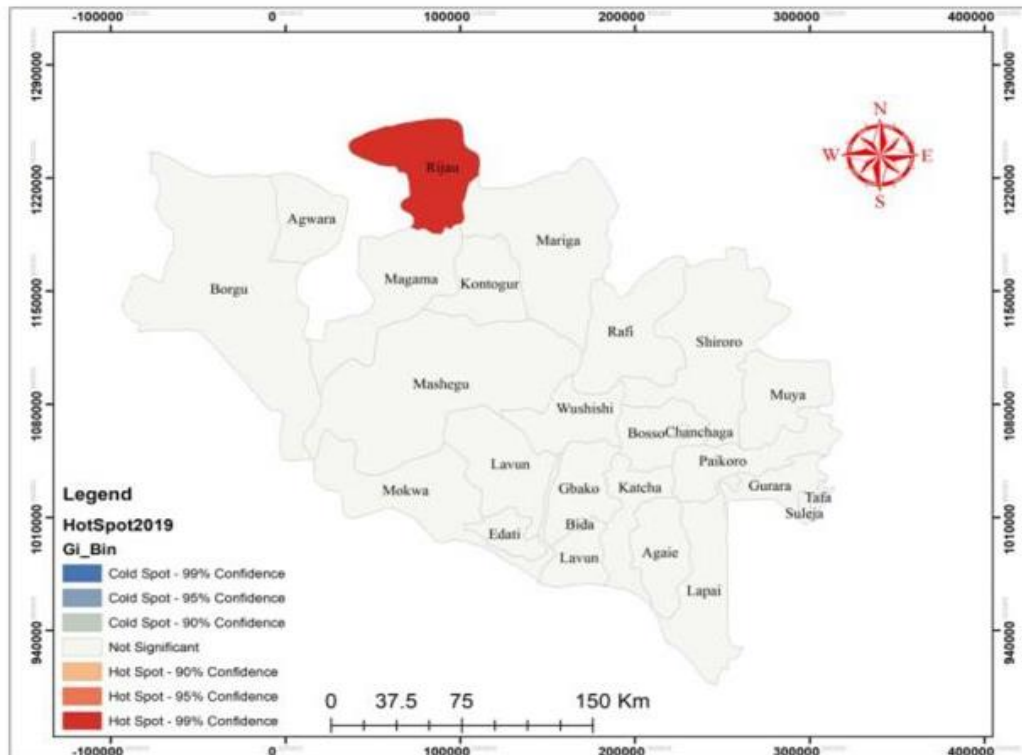


Figure 10: 2019 Malaria high risk map (hotspot). Rijau has again shows highest concentration of malaria risk. *Source: Author's Lab work, 2023*

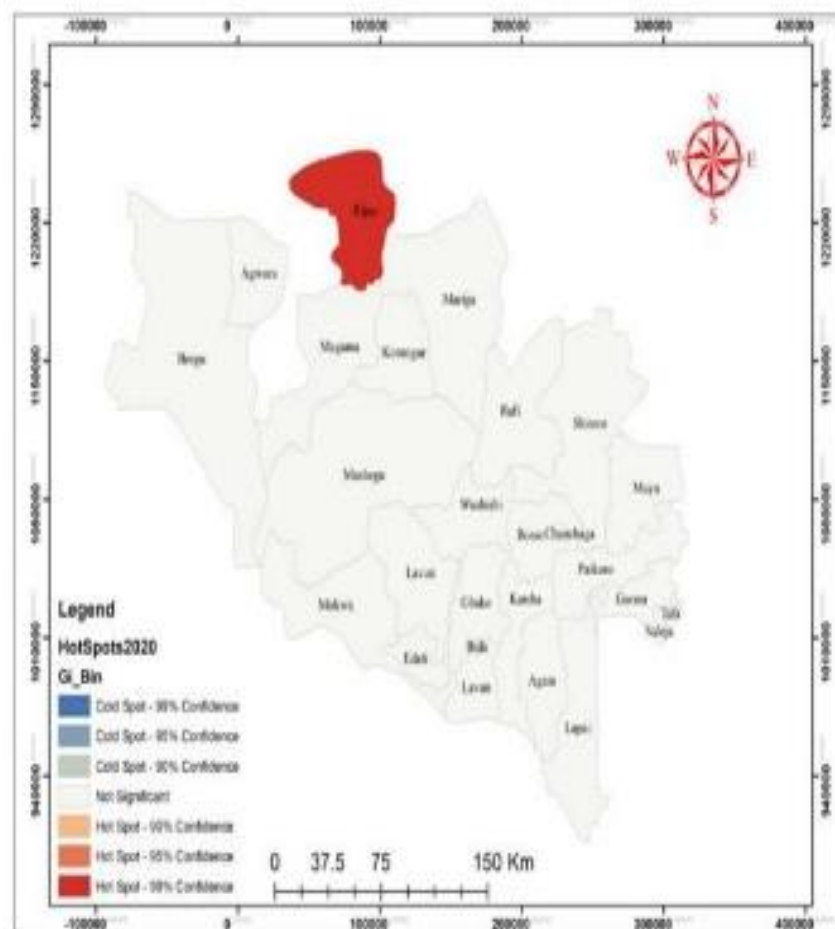


Figure 11: 2020 Malaria high risk map. Equally, Rijau maintained the lead.

Table 3: Model performance evaluation.

Model	Adj. R^2	AIC	AIC _c
GWR-FB	0.868	408.4376	461.902
GWR-AB	0.064	449.271	459.808

In table 3 above, it is seen that the GWR-FB model performed better with the highest Adj. R^2 value of **0.868** and the lowest information criterion AIC = 408.4376. The GWR-FB criterion, which has the lowest information criteria among the GWRs criteria, has chosen the optimal bandwidth.

FINDINGS

The study revealed that GWR based on fixed bandwidth performed better than GWR based on adaptive bandwidth having the highest R-square adjusted of 0.868 and lowest AIC_c of 461.902.

It was also discovered that Rijau and Shiroro LGs has the highest and lowest number of infected malaria cases in Niger State.

Areas of further Studies: This research work inherits some limitations which needs to be address in the future studies. We could not include some essential socio-economic variables such as age, gender, topography and water bodies in our analysis due to unavailability of data.

Application of Mixed geographically weighted regression (MGWR) model be applied in determining the performance and spatial variability of malaria cases in Niger State.

CONCLUSION AND RECOMMENDATIONS.

Malaria is still highly prevalent among under five children in Niger State, Nigeria despite series of interventions by government and donor agencies. In this study, significant gaps of malaria persist.

The research suggests that the control measures be put in place to reduce the burden of malaria in the state. Community awareness and health education on the use of long-lasting insecticide treated nets (LLITNs) be step up by government at all levels to reduce the prevalence of malaria in the state especially among under five children.

Government at all levels should prioritize and make the treatment of malaria for under five children free and compulsory in government owned hospitals. Children and pregnant women should always sleep inside long lasting insecticide treated nets. (LLITNs).

Government should provide LLITNs for under five children annually to reduce the prevalence of malaria cases.

Government should enforce the monthly environmental sanitation in order to reduce the spread and transmission of malaria in the state.

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IoT SECURITY UNRAVELED: A DEEP DIVE INTO CHALLENGES AND SOLUTIONS

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ABSTRACT

The Internet of Things (IoT) has revolutionized industries and our daily life activities, but this rapid expansion has also introduced significant security challenges. As IoT ecosystems grow, so do the risks associate with privacy breaches, unauthorized access, data integrity, and cyber-attacks. This paper explores the complex landscape of IoT security, examining the unique vulnerabilities inherent in IoT architectures, protocols, and devices. It delves into key security issues such as weak authentication, inadequate encryption, network vulnerabilities, and device lifecycle management. Additionally, the paper presents a range of strategies for mitigating these risks, including enhanced security frameworks, advanced encryption techniques, AI-driven anomaly detection, and the role of regulatory compliance in securing IoT networks. The study also explores the importance of collaborative efforts between manufacturers, security experts, and policymakers to build a more secure and resilient IoT ecosystem.

Keywords: Artificial Intelligence, Block-chain Technology, Cyber-security, Edge Computing, Encryption, Machine Learning, Security, Wireless Sensor Networks

INTRODUCTION

The rapid expansion of the Internet of Things (IoT) landscape has ushered in unparalleled opportunities for connectivity and innovation. This revolutionizes industries, enhances quality of life, and drives innovation. IoT technologies have been developed to facilitate task in different aspects of our life. It was one of the fast-growing technologies that proliferate in exponential manner in recent years (Thilakarathne et al., 2022). Recent researches revealed that there are over 30 billion interconnected IoT devices globally which is an undeniable achievement in the world of Information and Communication Technologies (ICT) (Hassija et al., 2019). More so, it has brought unprecedented convenience and efficiency to our lives (Thilakarathne et al., 2022). Internet-of-Things (IoT) notion is envisioned to improve the quality of modern life.

There is no doubt that the IoT Technology is surrounded with serious security flaws due to its inherent nature. IoT devices are more vulnerable because of several technical difficulties, which includes limited storage capability, power issues as well as computational strength (Hassija et al., 2019). These security issues led to the exposure of sensitive information to an unauthorized person that could be more dangerous to people's lives and well-being.

Although, there are so many efforts from expert to address these challenges, but still so many operational problems

remain unsolved. This research aims to provide empirical literature for exploring IoT-relevant empirical data, which can practically identify Internet-wide compromised IoT devices, if not in real-time.

The research frames its survey as follows:

1. Hoard and classify IoT-relevant literature
2. Set a taxonomy that helps readers understand various IoT security issues.
3. Draw inferences while discussing the set taxonomy in order to help future researchers.

REVIEW OF THE RELATED WORK

The research review related work in two phases, one is in the area of IoT architecture and the other is the IoT security issues.

IoT Architecture: Lubbers (2017) ascribed that the IoT architecture is often divided into layers, predominantly the four-layer architecture was reviled by so many researchers although few goes with proponents of a five-layer structure. The author also introduces an innovative way to connect small Internet of Things devices to high level Task Oriented Programming implementations languages such as Python and LUA (/ˈluːə/ LOO-ə; from Portuguese: lua [ˈlu(w)ɐ] meaning moon).

Pavithra et al. (2021) carried out a survey on the architecture of IoT systems, security parameters of IoT systems, as well as critical security applications in the areas of IoT. The authors reviewed application domains and some related technologies with a focus on their role in tackling IoT security issues, he further highlighted limited energy as well as computation power as constraints that restrain IoT devices from being adoptive to some of the powerful security frameworks.

In another work, Zhang et al. (2019) explained that IoT services can be provided using centralized architecture and distributed architecture, they also pinpointed that the IoT three-layer security approach has various challenges. In their research they proposed a high-level security management scheme using blockchain technology.

Furthermore, Malkawi et al., (2023) the description of new design of an IoT architecture that allows customizable data-driven operations, using the hybrid physical and virtual test-bed was given.

Another study in the context of IoT by Atzori et al. (2017) presented the evolutionary stages that have characterized the development of IoT, the research distinguished the three generations as (i) tagged things, (ii) a web of things, and (iii) age of social objects, cloud computing, and the future internet. The authors further described the emergence of technological trends as a booster to the realization of the next generation of IoT diffusion as providing new impetus to the IoT evolution.

IoT Security: Having reviewed noteworthy literature related to IoT architecture, the study now examines the researches on the security aspect of IoT.

In a related study by Zhao et al., (2022) revealed that so many IoT devices were seriously suffer by botnets, they perform a ten-month-long empirical study on the vulnerability of IoT devices and it further reveal that 12,740 (88%) MQTT (Message Queuing Telemetry Transport) servers have no password protection. More so, the authors proposed guidelines for IoT security analysis as well as guidelines for IoT ecosystem security.

Very recently, Dandotiya et al. (2023) presented a quantitative and qualitative analysis of the IoT ecosystem security which shows that the issues have to do with poor

authentication, data encryption, susceptible firmware and software, as well as lack of standardization, the authors further proposed security framework to examines security landscape and build effective countermeasures. They adopted an analysis-driven approach to address security issues to facilitate building secure and resilient IoT ecosystems.

Also, Pavithra (2021) presents a taxonomy to discuss IoT vulnerabilities and their attack vectors, the study identified Machine Learning (ML) as an inherent tool in IoT security, the study also suggested that trained mathematical expression can be used to keep the key of Software Defines Network (SDN) to protect IoT ecosystem security attacks and impacts on various security objectives.

Haseeb (2023) used deception systems to identify patterns of attack by the attackers, the research then conducted a large experiment for the period of two months where 15 honeypots server were deployed and collect attack data, the study discovers that, most of the attacks captured are automated and active attack campaigns on the Internet. The author highlighted advantages of increasing deception at various levels help in making the honeypot more appealing to lure IoT-specific attacks and convince attackers to maintain longer engagements.

In contrast, Ali et al. (2022) analyzed 260 articles and 54 reports using MAXQDA in which the nodes and themes were first identified. The research further proposed a model that works on a fog computing layer, the study concluded that data application is precious to be included in the security framework.

Neshenko et al. (2019) analyzed IoT security by reviewing existing security remedies and produce a unique taxonomy of current threats and vulnerabilities as they inter-relay with several dimension viz: Layers, Security Impact, Attacks, Countermeasures and Situational Awareness Capabilities.

METHODOLOGY

This research employed systematic methodology to generate a taxonomy for exploring recent IoT-related research works. The conceptual view of the inherent IoT

taxonomy is shown in figure 1. To identify the IoT vulnerability, the research began by searching for the relevant literature, where the research contributions were meticulously investigated to identify a holistic IoT paradigm, this was aimed at extracting relevant as well as impactful IoT vulnerabilities. Thereupon, the research categorizes IoT-security challenges in accordance with standard IoT architecture, it further examined and categorized IoT vulnerabilities by the means they manifest; whether they are specifically related to IoT devices sensing layer, network layer, data processing layer or related with Application Layer. Finally, the research pinpointed some of the techniques used by attackers as well as countermeasures to an IoT ecosystem.

PROPOSED TAXONOMY

In this section, the research focuses on elaborating on the proposed taxonomy as it manifests in different dimensions.

IoT Vulnerabilities: From the reviewed literatures, it was discovered that the following are genesis of IoT ecosystem vulnerabilities.

- (i) **Inadequate Security Measures:** Many IoT devices lack robust security features due to cost constraints or rushed development. Weak passwords, lack of encryption, and insufficient authentication mechanisms make them easy targets for hackers (Hassija et al., 2019).
- (ii) **Outdated Firmware and Software:** Manufacturers may not provide regular updates or patches for IoT devices, leaving them susceptible to known vulnerabilities that attackers can exploit Pavithra (2021).
- (iii) **Poorly Implemented Authentication:** Weak or non-existent authentication mechanisms can allow unauthorized access to IoT devices, enabling attackers to control them remotely (Thilakarathne et al., 2022).
- (iv) **Data Privacy Concerns:** IoT devices often collect sensitive data about users and their environments. If this data is not properly protected, it can be intercepted or accessed by unauthorized parties (Neshenko et al., 2019).
- (v) **Physical Vulnerabilities:** IoT devices deployed in public spaces or accessible areas can be physically tampered with, allowing attackers to

gain control or extract sensitive information (Zhang et al., 2019).

- (vi) **Interoperability Issues:** IoT devices from different manufacturers may use different communication protocols or standards, leading to interoperability issues that can be exploited by attackers to compromise the entire system (Zhao et al., 2022).
- (vii) **Lack of User Awareness:** Users may not be aware of the security risks associated with IoT devices or may not take necessary precautions such as changing default passwords or updating firmware (Atzori et al., 2017; Malkawi et al., 2023).
- (viii) **Supply Chain Vulnerabilities:** Components used in IoT devices may come from untrusted sources, introducing potential vulnerabilities into the devices during manufacturing or assembly (Zhao et al., 2022).
- (ix) **Denial-of-Service (DoS) Attacks:** IoT devices connected to the internet can be targeted in large-scale DoS attacks, overwhelming their resources and rendering them unusable (Zhao et al., 2022).
- (x) **Physical Access to Devices:** If physical access to an IoT device is compromised, attackers can directly manipulate the device's hardware or software to gain control or extract sensitive information Pavithra (2021).

Proposed Taxonomy Overview: The proposed taxonomy was properly illustrated conceptually in Figure 1. Here IoT vulnerabilities were frames in to sensing layer, network layer, data processing layer and Application Layer. Where the last frame pinpointed some of the countermeasure's techniques.

(A) Sensing layer: The sensing layer in an IoT ecosystem consists of sensors and other actuators that usually collect data from the surroundings. As such, it is crucial to be secured. Some of the vulnerabilities that could be identified with this layer are as follows.

- (i) **Malicious code injection Attack:** In this form of attack, IoT devices are compromised by injecting malicious code into the firmware, software, or memory of IoT devices where an attacker could be able to steal data as well as

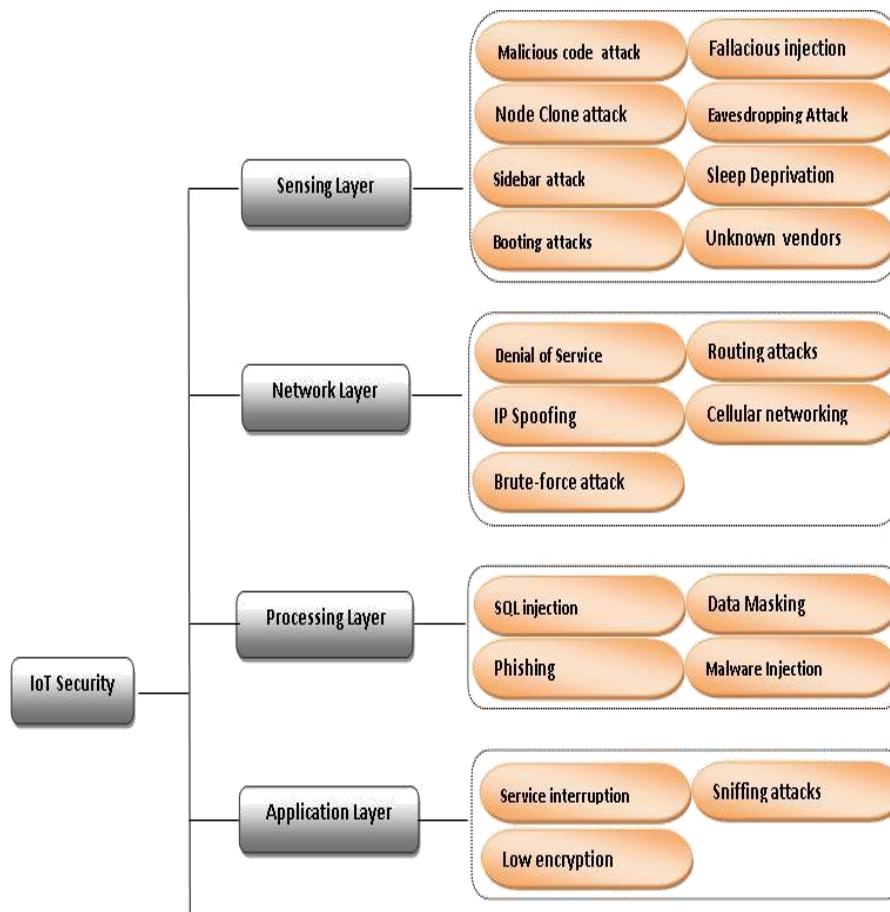


Figure 1: Proposed Taxonomy

misleading some nodes which result into system malfunction (Thilakarathne et al., 2022).

attackers get access to the IoT device (Neshenko et al., 2019).

(ii) **Node Clone Injection Attack:** In the context of IoT this has to do with cloning or impersonating legitimate IoT nodes within a network. Where an attacker usually performs reconnaissance to identify the structure and communication patterns within the IoT networks and create malicious replicas or clones of legitimate IoT nodes within the network. These clones mimic the behavior and characteristics of genuine nodes, making it difficult to distinguish them from the authentic ones (Malkawi et al., 2023).

(iv) **Sleep Deprivation Attack:** In this type of attack, an attacker aims at draining the battery of IoT devices or deplete their computational resources by keeping them active and preventing them from entering low-power (sleep modes). By forcing devices to remain active, attackers can analyze the traffic patterns and responses of the IoT network, gaining insights into how the system operates. This information can be used for planning more sophisticated attacks in the future.

(iii) **Sidebar Attacks:** This is another dangerous security issue on IoT ecosystems where information from IoT devices is exposed. This information can include timing data, power consumption and electromagnetics, which help

(B) **Network Layer:** Security at the network layer in IoT architecture is critical due to an inherent nature of IoT ecosystem which featured with a diverse deployment of IoT devices that operates in hostile environments and seldomly exposes to various attacks such as

eavesdropping, spoofing, and data interception. Below are the security challenges being faced by this layer.

- (i) **Denial of Service (DoS):** In the context of the Internet of Things (IoT) Denial of Service (DoS) has to do with disrupting normal functioning of IoT devices and systems, rendering them unavailable to their intended users. These attacks exploit the connectivity and computational constraints of IoT devices to cause widespread disruption (Rehman et al., 2023).
- (ii) **Routing Attacks:** Routing attacks on IoT ecosystem usually is aiming to disrupting routing protocols used by IoT devices to communicate. These target network topologies weaken the security mechanism of the IoT ecosystem (Malkawi et al., 2023).
- (iii) **IP Spoofing:** In an IoT ecosystems IP (Internet Protocol) spoofing involves the manipulation of IP packet headers to conceal the identity of the sender, allowing attackers to impersonate legitimate devices or to disguise the origin of malicious traffic (Alazab et al., 2023).
- (iv) **Brute-Force Attack:** The brute-force attack in IoT networks involves an attacker systematically attempting all possible combinations of passwords or keys to gain unauthorized access to IoT devices or networks. Given the typically limited computational resources and often weak security measures in IoT devices, brute-force attacks can be particularly effective and damaging (Otoom et al., 2023).

(C) Processing Layer: Processing layer in an IoT ecosystem plays a critical role in managing, analyzing, and acting upon the data collected from various IoT devices. This layer is responsible for transforming raw data into information for decision-making processes (Hassan et al., 2020). Below are some of the security challenges usually faced by processing layer.

- (i) **SQL Injection:** SQL Structured Query Language injection is traditionally a web application attack but is now becoming increasingly significant as IoT devices where an attacker injection malicious SQL statements into a query which mislead the interface

and reads as normal input data. These allow the attacker to read, modify, or delete data, and sometimes even execute administrative operations on the database (Crespo-Martínez et al., 2023).

- (ii) **Data Masking:** Data masking attack is a method by which an attacker attempts to reverse or bypass data masking techniques to reveal the original, sensitive data. This type of attack targets the vulnerabilities in the data masking process, potentially exposing private information that was intended to be protected (Mangkoenegoro & Djajadiningrat, 2023).
- (iii) **Phishing:** Phishing in the context of the Internet of Things (IoT) involves cyber attackers leveraging IoT devices by applying some of the phishing techniques to deceive individuals into providing sensitive information about the devices. Such as usernames, passwords, credit card numbers, or other personal data (Abbas et al., 2021).
- (iv) **Malware Injection:** Malware injection is one of the malicious acts where an attacker embeds malware into IoT devices or their communication channels to gain unauthorized access, disrupt operations, or steal sensitive data Arshad et al. (2024).

(D) Application Layer: The application layer in IoT ecosystem is one of the most important layers it interacts with both the user interfaces and the underlying network layers. This enables communication among IoT devices, applications, and users. This layer provides the protocols and services that facilitate device interoperability, data exchange, and the user-facing functionalities of IoT systems (Quincozes et al., 2024). Some of the security threats to this layer are explained below.

- (i) **Service Interruption:** This is a security risk that disrupts the normal functioning of IoT devices, preventing them from operating as intended by prolonging the unavailability of IoT services. This can have significant consequences due to the interconnected nature of devices and the critical applications they often support (Ibor et al., 2018).
- (ii) **Sniffing Attacks:** Sniffing attacks on IoT devices create significant security threat which involves data theft, financial loss, identity theft, and unauthorized access to sensitive information. In this

type of cyber-attack, an actor usually uses packet sniffing tools to intercept and analyzes network traffic in order to identify communication protocols and network configurations for the target device (Lamba & Chinchawade, 2023).

- (iii) **Flooding attack:** Flooding attack is a type of cyber-attack where the attacker deliberately overwhelms a cloud-based service or infrastructure, which has significant impact on Quality of Service (QoS). The goal was to disrupt normal operation of the cloud service, causing Denial of Service (DoS) or Distributed Denial of Service (DDoS) conditions (Thilakarathne et al., 2022).

Countermeasures: Absolutely, it is essential to set countermeasures for IoT ecosystems due to the unique security and privacy challenges they present. IoT devices often have limited computational resources, making traditional security measures difficult to implement (Ibor et al., 2018). They are also frequently deployed in environments where they are susceptible to physical tampering and cyber-attacks (Malkawi et al., 2023). These necessitate the needs for comprehensive countermeasures to enhance the security, privacy, and reliability of IoT ecosystems. In this paper, the countermeasures were identified as follows;

- (a) **Device security:** In securing the IoT ecosystem, device security in the IoT structure is a critical concern due to the interconnected nature of IoT devices, which often collect, transmit, and process sensitive data. Williams et al. (2022) suggested Strong Authentication as well as Authorization Protocols as a remedy.
- (b) **Monitoring an incident response:** Monitoring an incident response facilitates early detection of potential threats and anomalies in IoT ecosystem (Potter et al., 2023). Below are the key aspects for monitoring an incident response in IoT ecosystem. Real-Time Monitoring, Automated Alerts, Deep Packet Inspection (DPI), Status Checks, Quarantine Measures and Threat Intelligence.
- (c) **Physical security:** This has to do with putting physical protection to IoT devices which protect them from physical threats that could compromise their functionality, integrity, and data. It also prevents unauthorized physical access, tampering,

theft, and environmental damage (Iqbal & Wajid, 2024). Here are key strategies and practices for physical security in IoT devices: Device Placement and Protection, Access Control, Tamper Detection and Response, Redundancy and Resilience, Environment Monitoring.

- (d) **Technological Facilitated Countermeasures:** There are several IoT technologies that address security issues at various layers of the IoT ecosystem, from devices and networks to data management and user interactions. According to Tillakaratne et al. (2022), Fog computing, Machine Learning, Encryption Technology as well as Edge computing are the emerging technologies that significantly enhance security, privacy, and data integrity.

CONCLUSION AND RECOMMENDATION

In this paper, many literatures in the context of IoT and IoT security had been reviewed, from the study some of the IoT security challenges and countermeasures were being highlighted. Different security challenges in respect to diverse layers of IoT architecture that persists at the different layers of the IoT architecture viz: application layer, data processing layer, network layer, and physical layer were also summarized. Likewise, the research pinpointed some of the emerging technologies that could be a worthwhile resource to enhancing security features in IoT ecosystem.

This paper thereby recommends the adoption of the highlighted countermeasures of mitigating the series of securities issues that are associated with each layer of the IoT architecture, where a secured IoT devices are assured and guaranteed.

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NUTRITIONAL COMPOSITIONS OF DRIED LEAF SAMPLES OF *Jatropha tanjorensis*, *Telfairia occidentalis* and *Amaranthus hybridus* AS INDICATORS OF THEIR IMPORTANCE IN FOOD SECURITY

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ABSTRACT

Vegetables are widely designated as protective foods in human diet due to their varied health benefits attributable to their richness in vitamins, minerals, amino acids and dietary fibres. They are rich and very available sources of nutrients. This study aimed at determining and revealing the nutritional compositions of three dried leafy vegetables namely *Jatropha tanjorensis*, *Telfairia occidentalis* and *Amaranthus hybridus*; thereby indicating their importance in food security. The leaf samples were washed, air dried and pulverized. The moisture, ash, crude fat, crude protein, crude fibre, and carbohydrate contents of the vegetables were assessed using standard methods of the Association of Official Analytical Chemists. The data obtained subjected to analysis of variance using IBM SPSS statistics (v 20) revealed significant differences between the percentage nutrient compositions of the vegetables. *J. tanjorensis* had significantly higher contents for moisture ($1.50 \times 10^1 \pm 0.25$ %), carbohydrate ($3.39 \times 10^1 \pm 0.47$ %) and energy ($3.32 \times 10^2 \pm 0.98$ %); *T. occidentalis* showed significant content advantage over others in protein ($4.36 \times 10^1 \pm 0.15$ %), while *A. hybridus* had significantly higher values in ash ($1.26 \times 10^1 \pm 0.24$ %), fat ($1.06 \times 10^1 \pm 0.059$ %) and fibre ($9.73 \times 10^0 \pm 0.002$ %). Dry matter contents were not significantly different in *A. hybridus* and *T. occidentalis* but were significantly higher than was present in *J. tanjorensis*. Combination of the three vegetables for cooking where possible is recommended as that makes all the nutrient available to the consumer.

Keywords: Nutrient composition, *Jatropha tanjorensis*, *Telfairia occidentalis*, *Amaranthus hybridus*, Food security.

INTRODUCTION

Vegetables are increasingly recognized as essential for food and nutrition security. They are widely designated as "protective foods" in human diet due to their varied health benefits attributable to their richness in vitamins, essential fatty acids, minerals, amino acids, dietary fibres (Shukla et al., 2016) and various essential bioactive compounds (Da Silva et al., 2017). They are those herbaceous plants whose part or parts are eaten as supporting food or main dishes and they may be aromatic, bitter or tasteless (Mensah et al., 2008). The consumption of leafy vegetable is part of Africans cultural heritage and they play important roles in the tradition and food culture of African household. Mensah et al., (2008), reported that vegetables are the cheapest and most available sources of important proteins, vitamins, minerals and essential amino acids.

Globally crop diversity and nutritional value of vegetable crops are of special significance for improving food and nutrition security (Fresco et al., 2014). Food security was long associated with abundance of staple crops but the situation is different today, encompassing nutrient security in food security (Schreinemachers et al. 2018). Imamura et al.'s (2015) report covering 187 countries indicated a shift

toward unhealthy and junk food items such as processed meat, red meat, diets rich in trans-fat, saturated fat, sodium, and free sugar, which may further increase the risk of diet-related non-communicable diseases. Langyan et al. (2021 a, b) indicated the need to diversify the global agriculture and food system to nourish people and address hunger and hidden hunger. WHO (2016) indicated that 2 billion people are affected by insufficient intakes of micronutrients.

Vegetables are known to be important sources of protective foods (Nnamani et al., 2009; Sheela et al., 2004). Vegetables have also been reported to be good sources of oil, carbohydrates, minerals as well as vitamins (Adenipenkun & Oyetunji, 2010). They contribute significantly to dietary diversity and food security while playing an important role in the prevention of malnutrition and micronutrient deficiencies (Afolabi et al, 2021). *Jatropha tanjorensis*, *Telfairia occidentalis* and *Amaranthus hybridus* are locally available and consumed leafy vegetables.

Jatropha tanjorensis (family Euphorbiaceae) is commonly known as hospital too far and Catholic vegetable. It is locally called Asibitishin in Nupe, iyana-ipaja in Yoruba,

Asibitikusa in Hausa and Ugu Oyibo in Igbo language (Gbile 1984; Blench and Dendo, 2008). It is primarily used for fencing while its secondary uses are as sources of edible leafy vegetables and medicine. It can also be used as alternative to lettuce in salad preparation amongst other very vital usages (Igbinaduwa et al., 2011). It is used as food. Virtually every part of the plant is beneficial and nutritional in various ways. The leaves are commonly cooked and eaten like vegetables such as fluted pumpkin and African Spinach (Anwar, 2007).

Ethno-botanical survey showed that, *J. tanjorensis* was used in study areas as a remedy to diseases such as: measles, scabies, malaria, high blood pressure, stomach ache, diabetes mellitus, eczema and anaemia with 74 % of the interviewees mentioning the leaves as part mostly used (Comfort et al., 2021). The juice of the plant and the pounded leaves are applied to wounds and refractory ulcers. The juice is very successfully used to treat scabies, eczema and ringworm (Kirtikar & Basu, 2001).

Telfairia occidentalis (family Cucurbitaceae) has the common names of 'Fluted pumpkin', 'fluted gourd' and locally called Agboroko in Yoruba, kabewa in Hausa and Ugu in Igbo language (Gbile, 1984; Blench & Dendo, 2008). It is a tropical vine grown in West Africa as a leaf vegetable and for its edible seeds. It is mainly cultivated in southeastern Nigeria and it is used primarily in soups and herbal medicines (Nwanna et al., 2008). The leaf extract alone is useful in the management of hypercholesterolaemia, liver problems, and impaired immune system (Eseyin et al., 2014; Adaramoye et al., 2007) but the oil from the seed could result in hyperlipidemia and hyperglycaemia if consumed excessively. Protein Energy Malnutrition (PEM) is rarely seen among dwellers where *Telfairia* is consumed in large proportion daily (Dike, 2010). Nwangwa et al. (2007) showed that it has potential to regenerate testicular damage and increase spermatogenesis. In Nigeria the fresh juice from the leaves is used as tonic by women that have just given birth; its high iron content assists in the replenishment of lost blood. It is also used for treatment of anaemia, chronic fatigue and diabetes (Alada, 2010; Dina et al., 2006).

Amaranthus hybridus (family Amaranthaceae) is commonly called African Spinach with local names as Alayefa in Nupe, Efo-tete in Yoruba, Allayahu in Hausa and Inine in Igbo Language (Gbile, 1984; Blench & Dendo, 2008). It is mostly consumed in the rural areas or in the communities where they are being planted (Olaposi & Adunni, 2010). It is underutilized when compared to the introduced varieties due to the flavor and unfamiliar taste impacted on the food (Smith & Eyzaguirre, 2007). In Nigeria, *A. hybridus* leaves combined with condiments are used to prepare soup (Mepha et al., 2007). In Congo, their leaves are eaten as spinach or green vegetables (Dhellot et al., 2006). These leaves boiled and mixed with a groundnut sauce are eaten as salad in Mozambique and in West Africa.

Proximate and nutrient analysis of edible fruit and vegetables play a crucial role in assessing their nutritional significance (Pandey et al., 2006). This therefore necessitated this study with a view to determine and compare the nutrients contained in these locally available leafy vegetables; to indicate areas where any has nutritional advantage over others, while also promoting behavioral change towards dried leafy vegetables for nutrition security and economic development.

METHODOLOGY

Preparation of samples: Freshly harvested vegetable samples of *Jatropha tanjorensis*, *Telfairia occidentalis* and *Amaranthus hybridus* were separately rinsed in water to free them of contaminations e.g. soil; air dried at room temperature of 26°C for 27 days, pulverised using a blender, sieved through a 1.5 mm sieve size, and stored in labelled sealed containers for the determination of their proximate compositions.

Proximate Analysis: The analysis of the Proximate Compositions of *Jatropha tanjorensis*, *Telfairia Occidentalis* and *Amaranthus hybridus* was carried out using the official methods of the Association of Official Analytical Chemists (AOAC, 2010).

Data analysis

The data obtained were subjected to analysis of variance (ANOVA) using IBM SPSS statistics (v 20). Where

significant values were obtained, Duncan multiple range test was used to separate the means.

The results of the proximate compositions of *Jatropha tanjorensis*, *Telfairia occidentalis* and *Amaranthus hybridus* are shown in Table 1.

RESULTS AND DISCUSSION

Table 1. Proximate Compositions of *Telfairia occidentalis*, *Amaranthus hybridus* and *Jatropha tanjorensis*

Proximate components	Vegetable type/Proximate values (%)		
	<i>T. occidentalis</i>	<i>A. hybridus</i>	<i>J. tanjorensis</i>
Dry matter	$8.67 \times 10^1 \pm 0.64^b$	$8.73 \times 10^1 \pm 0.23^b$	$8.49 \times 10^1 \pm 0.33^a$
Moisture content	$1.36 \times 10^1 \pm 0.61^b$	$1.26 \times 10^1 \pm 0.24^a$	$1.50 \times 10^1 \pm 0.25^c$
Ash content	$1.19 \times 10^1 \pm 0.031^b$	$1.47 \times 10^1 \pm 0.021^c$	$9.04 \times 10^0 \pm 0.061^a$
Crude fat	$1.05 \times 10^1 \pm 0.035^b$	$1.06 \times 10^1 \pm 0.059^c$	$1.05 \times 10^1 \pm 0.025^a$
Crude protein	$4.36 \times 10^1 \pm 0.015^c$	$2.28 \times 10^1 \pm 0.002^a$	$2.56 \times 10^1 \pm 0.200^b$
Crude fibre	$7.84 \times 10^0 \pm 0.010^b$	$9.73 \times 10^0 \pm 0.002^c$	$5.97 \times 10^0 \pm 0.002^a$
Carbohydrate	$1.23 \times 10^1 \pm 0.79^a$	$2.94 \times 10^1 \pm 0.24^b$	$3.39 \times 10^1 \pm 0.47^c$
Energy content	$3.20 \times 10^2 \pm 0.03^a$	$3.04 \times 10^2 \pm 0.98^a$	$3.32 \times 10^2 \pm 0.98^c$

Rows with different superscripts are significantly different ($P \leq 0.05$), $n = 2$

The vegetables showed significant differences in their percentage proximate nutrient compositions. This emphasizes their uniqueness as different species.

Amaranthus hybridus had the least moisture content of $1.26 \times 10^1 \pm 0.24$ %. This therefore indicates it might have a longer shelf life than the other vegetable types. Achanta and Okos (2000) and Chou and Chua (2001) noted that any food prepared from dried leafy vegetables has more keeping quality than the fresh one.

The higher ash content of $1.47 \times 10^1 \pm 0.021$ % in *Amaranthus hybridus* shows it to be richer in mineral elements such as Na, Mg, Ca, Fe etc. than *Telfairia occidentalis* ($1.19 \times 10^1 \pm 0.031$ %) and *Jatropha tanjorensis* ($9.04 \times 10^0 \pm 0.061$ %).

Telfairia occidentalis had the highest protein value of $4.36 \times 10^1 \pm 0.015$ % while *A. hybridus* had the least protein value of $2.28 \times 10^1 \pm 0.002$ %. Akubugwo et al., (2007) reported that plant food that provides more than 12 % of its calorific value from protein is considered good source of protein, thus, all the leafy vegetables investigated are good sources of protein. Protein serves for the growth and maintenance of body tissues. Its deficiency causes poor growth and muscle wasting in children (Edem et al, 2009).

Thus, the addition of *Telfairia occidentalis* to meals would significantly increase protein intake.

Crude fibre was significantly higher in *A. hybridus* ($9.73 \times 10^0 \pm 0.010$ %) than in *T. occidentalis* ($7.84 \times 10^0 \pm 0.10$ %) with the least value present in *J. tanjorensis* ($1.05 \times 10^0 \pm 0.025$ %). Fibre is known to cleanse the digestive tract, remove potential carcinogens from the body, as well as keep blood sugar levels under control (Emebu & Anyika, 2011). Dietary fibres play useful roles in providing roughages that aid digestion (Ladel et al., 2009) and bowel movement. Leaves with high crude fibre content may contribute to a reduction in certain diseases like diabetes, high blood pressure, obesity and other digestive disorders (Wan et al., 2008). Harshman and Aldoori, (2004) reported lowered incidence of duodenal ulcer recurrence with the intake of fibre content of 28.2g/day for 6 months. The crude fibre content of *Telfairia occidentalis* is higher than was reported (4.35 ± 0.13 %) by Okibe et al., (2016). This may be a result of locational differences. The fibre content of *Amaranthus hybridus* ($9.73 \times 10^0 \pm 0.002$ %) in this study is in close range with the value of 10.44 ± 0.01 % reported by Akinwunmi and Omotayo, (2016).

The carbohydrate content of $1.23 \times 10^1 \pm 0.79$ % in *Telfairia occidentalis* is low compared to the value of 80.99 reported

by Elizabeth *et al.*, (2012) from fresh samples. This indicates that drying has effect on carbohydrate content.

That the air-dried samples of the leafy vegetables studied retained valuable amounts of nutrients indicate that drying can be a valuable means of their preservation especially when they are abundantly available. This can help to negate postharvest losses. Engaging in this could serve for self-sufficiency and a viable source of income when properly handled as other forms of vegetables (tomatoes, pepper, okra) are being dried, preserved and marketed acceptably. This is particularly important for farmers and traders, especially women who dominate the vegetable trade in Nigeria (Lawal *et al.*, 2023). Air drying vegetables makes them handy, and using them would address micronutrient deficiencies (hidden hunger) and significantly improve nutritional status when incorporated regularly into meals.

CONCLUSION

The results of this study showed *T. occidentalis* had the highest content of crude protein ($4.36 \times 10^1 \pm 0.015$ %); *A. hybridus* had the highest value for ash ($1.47 \times 10^1 \pm 0.021$ %) and fibre ($9.73 \times 10^0 \pm 0.002$ %) content while *J. tanjorensis* had the highest carbohydrate ($1.23 \times 10^1 \pm 0.79$ %) and energy contents ($3.32 \times 10^2 \pm 0.98$ %). These indicate that each of the vegetables have advantages in some of their components than others confirming the saying 'No one has it all'. Availability and preference may influence one's choice at any given time. The findings also noted retention of nutrients in air dried vegetables indicative of their contributions to nutrient/food security and health maintenance, particularly in areas where animal proteins are expensive.

RECOMMENDATIONS

Where possible, the combination of these vegetables should often be eaten as they will contribute greatly to the daily requirements of body nutrients.

The establishment of home gardens for the cultivation of vegetables should be promoted to aid easy access to vegetables without the limiting consideration of the cost/convenience of buying.

Further studies should be carried out on the effect of storage on nutrient contents of dried vegetables, which could be explored for economic benefits as other vegetables.

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IMPACT OF MULTIMEDIA INSTRUCTIONAL RESOURCES ON USER EDUCATION AMONG POLYTECHNIC STUDENTS IN NIGER STATE

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ABSTRACT

This study examines the impact of multimedia instructional resources on user education among polytechnic students in Niger State, Nigeria. The study employed a survey research design using a questionnaire as an instrument for data collection. The population of this study comprised of National Diploma (ND I) students enrolled during the 2022/2023 academic session at Federal Polytechnic Bida (1,098 students) and Niger State Polytechnic, Zungeru (455 students). A multi-stage sampling technique was employed to ensure adequate representation of the population. The study found that although multimedia instructional resources are used in library user education programmes among polytechnic students in Niger State, their usage remains inadequate. However, students taught using multimedia resources performed significantly better than those exposed to traditional instructional methods. The study also identified several challenges affecting the effective use of multimedia resources, including inadequate power supply, poor library funding, high cost of multimedia facilities, lack of ICT infrastructure and limited competence in multimedia technology usage. The study therefore recommends the integration of multimedia instructional resources into polytechnic education to enhance user education and improve academic performance.

Keywords: Multimedia, Influence, Information and Communication Technology, Instructional Resources, User Education.

INTRODUCTION

A polytechnic is an institution of higher learning that primarily focuses on teaching, learning, and research across a broad range of academic and technical disciplines. It awards National Diplomas (ND) and Higher National Diplomas (HND) to students upon successful completion of their academic programs. In the Nigerian context, polytechnics play a vital role in fostering socio-economic development and national capacity building by producing skilled manpower across various sectors (Omisore, 2021; Adebayo & Sanni, 2022). As centers of applied knowledge and vocational excellence, polytechnics are committed not only to theoretical learning but also to practical and innovative problem-solving approaches.

Likewise, Peretomode (2018) emphasized that polytechnic education equips students with the capacity to engage with core personal and societal issues. It also instills ethical values and critical thinking, enabling students to distinguish between right and wrong in the face of complex human challenges. Central to achieving these educational goals is the polytechnic library. The library serves as a crucial intellectual hub, providing access to vast information resources necessary for research, teaching, and lifelong learning. According to Anyim (2017), the polytechnic library functions as a strategic academic resource center that enhances the intellectual capabilities of students and staff alike. Hence,

to facilitate the effective utilisation of library resources, many institutions have adopted library user education programmes. These programs aim to equip users with essential skills for locating, evaluating and retrieving information in both traditional and digital library environments. User education has been described under various terms such as library orientation, reader instruction, bibliographic instruction, and information literacy (Harrod's Librarians' Glossary, 2000). Regardless of the terminology, the objective remains to empower users with the competence to independently access and use library resources efficiently.

Initially, traditional face-to-face teaching methods were predominant in the delivery of user education. While effective in earlier times, the rise of Information and Communication Technologies (ICTs) has transformed teaching and learning processes globally (Onuoha & Olarongbe, 2020). In this digital age, multimedia instructional resources have emerged as a more dynamic and interactive approach to user education. Multimedia instructional resources refer to the integration of multiple media elements such as text, audio, video, animation, and graphics to facilitate instructional delivery. These resources enhance comprehension, engagement, and retention among learners. Recent studies further confirm the value of multimedia-based instruction in promoting digital literacy, especially within higher education

contexts (Alhassan & Garba, 2023; Aina & Omotayo, 2021). this paper aims to investigate the influence of multimedia instructional resources on user-on-user education among polytechnic students in Niger state.

Statement of the Problem: In the digital era, multimedia instructional resources have become essential tools for disseminating information and improving library user education across tertiary institutions. The rapid advancement of ICT has redefined how libraries operate, transforming the processes of storing, searching, accessing, and retrieving information (Obasi & Okoro, 2022). For polytechnic students, especially, proficiency in using digital resources is crucial to maximising the benefits of modern library services. However, preliminary observations in selected polytechnics across Niger State reveal a significant underutilisation of available library resources by students, which may be attributed to several factors such as; the limited presence of ICT-based search tools in library environments, low levels of digital literacy among students, and inadequate instructor capacity in deploying multimedia resources for teaching user education (Yusuf & Lawal, 2022). Also, multimedia-based instructional resources on user education with particular reference to students of Polytechnic Libraries in Niger State has not been investigated. Therefore, the study seeks to examine the impact of multimedia instructional resources on user education among students of Polytechnic in Niger State.

Objectives of the Study: The main objective of the study is to assess the impact of multimedia instructional resources on user education among Polytechnic students in Bida, Niger State, Nigeria. However, the specific objectives are to:

1. Examine the extent to which multimedia instructional resources are used in user education among polytechnic students in Bida Niger State
2. Determine the effect of multimedia instructional resources on user education among polytechnic students in BidaNiger State.
3. Identify the challenges associated with the use of multimedia instructional resources in user education among polytechnic students in BidaNiger State.

Research Questions: This study is guided by the following research questions:

1. . To what extent are multimedia instructional resources used in user education among polytechnic students in Niger State?
2. What is the impact of multimedia instructional resources on user education among polytechnic students in Niger State?
3. What challenges are associated with the use of multimedia instructional resources in user education among polytechnic students in Niger State?

LITERATURE REVIEW

Multimedia instructional resources integrating videos, animations, simulations, and interactive media are increasingly recognized for their capacity to enrich user education programs in higher education. Schroeder & Cenkci (2018), a 2018 study of four universities in North-Central Nigeria (including institutions in Niger State) revealed that while usage was limited, multimedia significantly enhanced student comprehension during library induction sessions. Complementing this, a 2023 study on academic information literacy confirmed that multimedia-enhanced instruction strengthens students' ability to search, evaluate, and synthesize information. Bello & Musa(2023).

Zheng, Wang & Lin (2022) on recent global meta-analyses in higher education have found positive effects of multimedia approaches: they improve engagement, promote active learning, and support better retention compared to text-only instruction. These findings support the theoretical basis for incorporating multimedia into library user education. Anyim (2018). in their Studies of Nigerian polytechnic and university libraries (e.g., Federal Polytechnic Idah, universities in North-Central Nigeria) show that multimedia resources such as projector-led orientations and recorded tutorials are being introduced but remain underutilized, often due to infrastructure limitations. The 2018 North-Central study reported multimedia use at "low extent," even though its benefits were widely acknowledged.

User education or library instruction has become a central theme in library and information science discourse as well as in research generally (Nwokocha, 2018). The rationale was addressed by experts such as Akibode (2014), Adeniyi (2016) and Onalapo-Akinbode (2019), who expressed disappointment over the inability of users to conveniently make use of libraries without staff

assistance. They expressed the fear that this situation may go out of hand with the introduction of advanced information technology in library operations. There is therefore the need to educate clientele on how to use Information and Communication Technology (ICT) tools for the location and retrieval of information in the library.

Nwokocha (2018) opines that library skills are not inherent but acquired through a process of teaching and learning often known as user education. In the world that is saturated with advances in Information Communication Technologies, effective teaching and learning is almost impossible without application of various ICT based instructional resources. In the modern-day educational environment efforts are made in the application various ICTs in teaching and learning in order to meet the demands of the information age. The first consideration has been domiciled on which instructional materials can create effective teaching impression and effect on the students. Multimedia has the potential and would prove to be one of the powerful tools that could assist library user educators to enhancing their professional capacity and also enable the student and users achieve their educational and information goals. In addition, the dynamic nature of the library user education precipitated the need for the instructors to remain flexible and adaptable to change in

the way in which teaching is delivered. However, despite these insights, there remains a notable research gap: no empirical studies have yet examined the comprehensive effect of multimedia instructional resources on user education across Niger State's polytechnics. Addressing this can provide vital evidence for policy and practice enhancements in the region.

METHODOLOGY

In this study, survey research design was be adopted. Hence, the population of this study comprises the National Diploma (ND) students in the Federal and State Polytechnics under study in 2022/2023 academic session. They are: Federal Polytechnic Bida (1098) .and Niger State Polytechnic, Zungeru (455) both in Niger State. furthermore, 10% was extracted using random sampling techniques giving the population of 110aprox. For federal polytechnic Bida, and 45 approx. For N/State polytechnic as depicted in Table 1. A four-point Likert scale questionnaire was used EXAMPLE Very Great Extent (VGE) Great Extent (GE) Low Extent (LE) Not at All (NAA). The latter aspect of the Likert scale was used for table 5 and 6 on the frequency of challenges and strategies for enhancing the use of multimedia resources in user education programme in polytechnic in Niger State.

Table1: Population of the Study

S/N	Institution	Department					Total	10%
		Public Admin.	Business Admin	Electrical/Electronic Engineering	Building Technology	Computer Science		
1	The Federal Poly Bida	347	254	139	108	250	1098	110aprox
2	Niger State Poly Zungeru	93	108	95	25	134	455	45aprox
Total		440	362	234	133	384	1553	

Source: Field Survey, 2023

The data presented in Table 2 shows that most of the library user education students are from the department of Public Administration 44(28.4%) computer Science 38(24.5%), Business Administration 36(23.2%)

electrical/electronic Engineering 23 (14.8%) and Building Technology14 (9.1%) respectively

Research Question 1: What Extent Is the Impact of Use of Multimedia Instructional Resources on User Education Programme Among Polytechnic Students in Niger State?

Table 2: Distribution of students

S/no	Department	Frequency	Percentage
1	Public Administration	44	28.4
2	Business Administration	36	23.2
3	Electrical/electronic Engineering	23	14.8
4	Building Technology	14	9.1
6	Computer Science	38	24.5
TOTAL		155	100

Table 3: Extent of Use of Multimedia Resources

S/NO	Responses	Frequency	Percentage
1	Very Great Extent	4	2.6
2	Great Extent	8	5.2
3	Low Extent	48	31
4	Very Low Extent	60	38.7
5	Not at All	35	22.5
Total		155	100

Source: field Survey 2023

The data presented in Table 3, shows the extent of use of multimedia instructional resources in library user education programme in polytechnics in Niger state. Total number of Respondents, 155; Very Great Extent 4(2.6%); Great Extent 8(5.2%); Low Extent 48 (31%); Very Low Extent 60 (38.7%) while Not at All 35 (22.5%).

Research Question 2: What Is the Extent of Use of Multimedia Instructional Resources on User Education Among Polytechnic Students in Niger State?

Table 4: Extent of Use of Multimedia Instructional Equipment

S/NO	ITEMS	VHE		HE		LE		VLE		NA	
		F	%	F	%	F	%	F	%	F	%
1.	Projector	12	7.7	28	18.1	55	35.5	24	15.5	36	23.2
2.	Camera	10	6.5	26	16.8	33	21.3	45	29.0	41	26.4
3.	Camcorder	16	10.3	32	20.6	40	25.8	17	11.0	50	32.3
4.	Scanner	18	11.6	44	28.4	46	29.7	32	20.6	15	9.7
5.	Computer	34	22.0	53	34.2	12	7.7	29	18.7	27	17.4
6.	Audio-visual	30	19.4	21	13.5	48	31.0	20	12.9	36	23.2

Table 4 data highlight the Extent of use of Multimedia Instructional Resources on User Education among Polytechnic Students in Niger State projector very high extent 12(7.7%) high extent 28(18.1%) low extent 55(35.5%) very low extent 24(15.5%) Not available 36(23.2%), for camera very high extent 10(6.5%) high

extent 26 (16.8%) low extent 33 (21.3%) very low extent 45(29.0%) Not available 41(26.4%). Camcorder very high extent 16(10.3%) high extent 32(20.6%) low extent 40 (25.8%) very low extent 17(11.0%) Not available 50(32.3%), Scanner very high extent 18 (11.6%) high extent 44 (28.4%) low extent 46 (29.7%) very low extent

32(20.6%) Not available 15(9.7%) while for computer very high extent 34(22.0%) high extent 53(34.2%) low extent 12 (7.7%) very low extent 29(18.7%) Not available 27(17.4%) and Audio-visual very high extent 30 (19.4%) high extent 21 (13.5%) low extent 48 (31.0%) very low extent 20(12.9%) Not available 36(23.2%),

Research question 3: What are the challenges associated with the use of multimedia on user education among Polytechnic in Niger State?

Table 5: Challenges

S/NO	ITEMS	FREQ	%
1	Inadequate Power Supply	44	28.3
2	Poor funding of Library	38	24.5
3	Lack of competence in the use of multimedia Technology	14	9.0
4	High cost of multimedia facilities	29	18.7
5	Lack of ICT infrastructure	20	13.0
6	Lack of maintenance policy	10	6.5
Total		155	100

Source: Field Survey 2023

The data presented in Table 5 shows the challenges associated with the use of multimedia in user education among polytechnic student in Niger State. These include: Inadequate Power Supply 44 (28.3%) Poor funding of Library 38 (24.5%) Lack of competence in the use of multimedia Technology 14 (9.0%) High cost of multimedia facilities 29 (18.7%) Lack of ICT infrastructure 20 (13.0%) Lack of maintenance culture 10 (6.5%)

CONCLUSION

Based on the findings of this study, it was concluded that multimedia instructional resources are not effectively utilized in library user education programme in polytechnics in Niger State; however, the students admitted that multimedia instructional resources are very resourceful in their learning other than the conventional instructional mode. This could be attributed to the fact that multimedia instructional resources improve teaching effect, facilitate teaching content, make the best of class time, break the “teacher centered” teaching pattern and fundamentally improve class efficiency; promotes communication skill; improves teachers and student’s relationship or interaction and bridges the gap between the teacher and students; make teaching and learning

flexible and creates a lively and interesting learning environment.

It has been found that teaching in Nigeria tertiary institutions is inadequate in the application of multimedia technologies due to several challenges discussed earlier. However, teaching of library user education in Nigerian universities is generally lacking in the application of multimedia technologies (Oparah, 2016).

Multimedia instructional technologies are indispensable tools that should not be divorced from the 21st century library and information literacy instruction. With the present National Policy on Education, it becomes imperative for Library in Nigeria to take a lead in the use of Information communication Technologies for effective instruction. ICT application is a key factor to relevance in the scheme of things in the 21st century.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations were made:

1. Multimedia instructional technologies should be adopted by the polytechnics in Nigeria as a common mode of instruction in library user education programme such as the use of library, library orientation, information literacy, library instruction and other aspects of user

education programme. This will help to enhance students' understanding of various library concepts, resources and services and make them independent proficient users of library.

2. Librarians should continuously review the library user education programme and information literacy skills of users/students as this evaluation will ultimately reveal the exact multimedia instructional resources that would be employed in user education programme at any point in time. Librarians must keep in mind that multimedia instructional technologies are meant to assist them and not to totally replace them or render them useless. In other words, the center of attention should still remain on the students/users and not the technology.

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EFFECT OF RICE HUSK ASH WITH GROUNDNUT HUSK ASH IN SELF-COMPACTING CONCRETE

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ABSTRACT

This research work is centered on investigation into the suitability of rice husk ash (RHA) and groundnut husk ash GHA as partial replacement of cement in self-compacting concrete (SCC). The rapid increase and the renewal of interest in wide range of concrete performance has created more challenges in the construction industry. These challenges are associated basically with conventional materials like cement and aggregates, which are becoming increasingly expensive due to high cost incurred in their processing, production and transportation. The shortcoming associated with conventional concrete such as poor flow and segregation leading to poor finishing and delayed construction time led to the initiation of Self-compacting concrete (SCC). In this research, an eco-friendly and cost-effective material like rice husk and groundnut husk which are agricultural waste was used to partially replace cement by weight of cement. This paper presents the findings of a strength analysis of SCC containing GHA and using 10% RHA as an admixture at 0, 5, 10, 15 and 20% of GHA. A total of 60 cubes were moulded and cured in water for 7, 14, 21 and 28 days after which they were subjected to compressive strength tests. The compressive strength of rice husk ash and groundnut husk ash as a partial replacement of cement in SCC increases with age (days) but decreases with increase in the proportion of GHA and RHA to cement. However, 5% GHA and 10% RHA replacement was considered as optimum for structural concrete.

Keywords: Rice Husk Ash, Groundnut Husk Ash, Compressive Strength, Self-compacting Concrete, super plasticizer

INTRODUCTION

Self-compacting concrete (SCC) is a special kind of concrete that can flow and fill the gaps of reinforcement and the corners of molds without any kind of vibration and compaction during the placing process (Brouwers and Radix, 2005). The highly fluid nature of SCC makes it suitable for placing in difficult conditions and in sections with congested reinforcement. Self-compacted concrete was developed to give a desirable achievement in the construction industry to resolve the issues associated with casting the concrete in place.

The use of supplementary cementitious materials significantly improves the microstructure of concrete and helps to produce less permeable concrete. Pore in structure and interfacial transition zone of concrete influence the mechanical and durability properties of concrete (Alexander, et al., 2008). When pozzolanic materials are used, reactive silica that's present in these materials react with calcium hydroxide and produce additional C-S-H gel, with this, the permeability of concrete is considerably reduced because of pore refinement as well as additional C-S-H formation, (Ekaputri, et al., 2009).

Groundnuts are one of Nigeria's most widely produced agricultural natural resources, where the shells have not been utilized and become waste. Groundnuts husk ash

(GHA) contains chemicals, namely calcium oxide (CaO) 13.19%, aluminum oxide (Al₂O₃) 2.01%, silica (SiO₂) 21.73%, magnesium oxide (MgO) 1.82%, and ferrous oxide (Fe₂O₃) 5.03% as cement-forming element. Groundnut shell ash (GSA) is one of the waste materials to be used as partial replacement of cement (Alabadan, et al., 2006).

Rice is one of the most profitable types of farming in Nigeria, though, rice is classified as cash crop for farmers, it is one of the most consumed staple foods and important cereal in Nigeria. Nearly 7 million tonnes of rice is consumed per year in the country. Nigeria is one of the larger producers of rice in Africa, producing approximately 8.2 million tonnes yearly, same as Egypt, Madagascar, Tanzania and Mali, as contained in the Food and Agriculture Organization of the United Nation (FAO) (Adedotun, 2024)

The rice husk (RH) is produced from the milling process of paddy. The paddy grain is surrounded by the by-product known as husk. In the milling process of paddy, about 78% of weight is received as rice and 22% of weight is received as husk. In the firing process of rice husk, this husk has approximately 75% organic volatile substance and remaining 25% weight of husk is transformed into ash and this ash is known as rice husk ash (RHA). The RHA contains about 80-90% amorphous silica. In every 1000

kg of paddy, approximate 22% (220 kg) of husk is produced, and around 78% (780 kg) of rice is produce. In the milling process when this husk is burnt in the boiler approximate 25% (55 kg) of rice husk ash is produced, (Muhammad et al., 2010).

According to Mahmud et al., (2009) reported that, Nigeria is a major rice producing country, and the husk generated during milling is mostly used as a fuel in the boilers for processing paddy, producing energy through direct combustion and / or by gasification.

MATERIALS AND METHODS

The materials used for this research work are Portland cement (Dangote brand 3X), groundnut husk ash as partial replacement of cement and rice husk ash as an admixture respectively. Groundnut husk was sourced from various groundnut husk disposal sites in Gbako Local Government Area, Niger, Nigeria. It was collected in bags and air-dried for 48 hours to remove moisture. Rice husks were obtained from rice milling plants in Bida and its environs.

The materials were burned for two (2) hours at a controlled temperature of 600°C, allowed to cool, and then sieved through a 75µm British Standard sieve to generate fine ash. The chemical composition of cement, GHA and RHA as determined by X-Ray Fluorescence (XRF) test using XRF Nitron 300 machine. The river sand (fine aggregate) with a specific gravity of 2.62 sourced from River Umar in Bida, Nigeria was used. Sieve analysis was conducted on the fine aggregate, and it was classed as Zone 1 using BS EN 882 (1992) grading limitation.

Coarse aggregate of 20 mm sized machine crushed gravel stone was used. The aggregate's specific gravity and crushing value are 2.71 and 22.5% respectively. Drinking water that meets the ASTM C1602-12 (2012) was used for the SCC's batching and curing. A chloride-free liquid super-plasticizer was added to the SCC's mix at 1.4% weight of binder as described by the manufacturer to improve its workability.

Mix design of the self-compacting concrete was done in accordance with procedures laid out in BS EN 206 (2013) and ACI (2002) which involved the preparation of

constituents' materials. The specifications and guidelines give in EFNARC (2005) was used to achieve a mix design for the targeted SCC strength. The manufacturer recommendation of 1.4% of weight of the binder's weight was used as the quantity of the superplasticizer. The proportions for varied GHA and RHA substitutions are as shown in Tables 1.

Strength Test: The mix design for the control AA-00 (SCC without GHA and RHA) was obtained via trial mixes using AA-00 as the control mix and AA-01 to AA-05. A 60 No. samples of SCC made with GHA and RHA blends were used for the mix proportions. Cement, GHA, and RHA were carefully dry mixed and added to aggregates and mixed thoroughly with water and super plasticizer, the water and super plasticizer were manually added while mixing, and the material was moulded using a 150 x 150 x 150mm moulds. It was allowed to set for 24 hours at room temperature and demoulded before curing in water for 7, 14, 21 and 28 days, in accordance with BS EN 12390-2 (2019).

Water absorption: The guideline in BS EN 1881-122 (2020) was used to conduct the water absorption test. 21No. of 100 mm x 100 mm x 100 mm cubes made at 0, 5, 10, 15, 20, and 25% GHA blended with RHA was immersed in water for 28 days. The samples were air-dried for 24 hours after removing from mould, weighed and recorded. The samples were then transfer to curing tank to be cured in water for 7 days before being air-dried and re-weighed to compute the amount of water absorbed. Equation 1 was used.

$$\text{Water absorption} = \frac{W_2 - W_1}{W_1} \quad (1)$$

Where,

W_1 = weight of dried cube (g),

W_2 = weight of saturated cube (g)

Chloride and sulfate attack: 5% solution of Sodium Chloride (NaCl) was prepared, and 21 No. of concrete samples were weighed and immersed in the salt solution after curing in water for 28 days. The samples were then cured in the solution for 3, 7, and 28 days, respectively. The samples were air dried and reweighed after the curing intervals to evaluate the weight loss of SCC containing GHA+RHA at 0, 5, 10, 15, 20, and 25%, and the

procedure was repeated for 5% Hydrogen Tetraoxosulphate (VI) acid (H_2SO_4). The specimens were evaluated for weight loss, after subjecting to salt and acidic aggression using Equation 2.

$$\% \text{ weight loss} = \frac{\text{Loss in weight}}{\text{Initial weight}} \times 100\% \quad (2)$$

RESULT AND DISCUSSION

Result of Physical Properties

The results of particles size distribution of fine aggregate are presented in Figure 3. The fine aggregate used was

found to be sharp sand with tested specific gravity of 2.64 and bulk density of 1521 kg/m^3 . The coarse aggregate used are crushed granite of nominal size 20mm with tested specific gravity of 2.69 and average impact value of 27.87%. The ratio of loose bulk density to the compacted bulk density for fine aggregate is 0.91 which lies within the range of 0.87 to 0.96, limit for good sand for concrete work, while the ratio of the loose bulk density to the compacted bulk density for coarse aggregate is 0.93 which lies within the usual range of 0.87 to 0.96 (Neville, 2011).

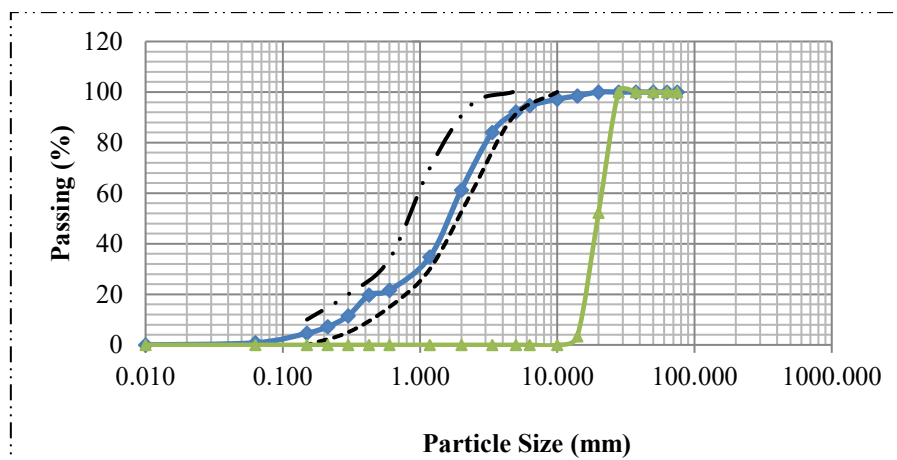


Fig 3: Sieve Analysis on Coarse Aggregate and Fine Aggregate

Compressive Strength Test Result: The result of compressive strength is shown in figure 4. It was observed that the compressive strength is increased with the curing age, while reducing as the percentage replacement was increasing. Though the strength increases up to 5% of the control, with the addition of 10% RHA as an admixture. The 28 days compressive strength at 5% was 39.1 N/mm^2 ,

which is the optimum replacement. This increase in strength above control could be attributed to the pozzolanic reaction of RHA content, as well as a superior filler effect by GHA. This trend is similar to the work of Auta *et al.*, (2015) on MHA in normal weight concrete and Ogork and Uche (2014) while dealing with groundnut husk waste.

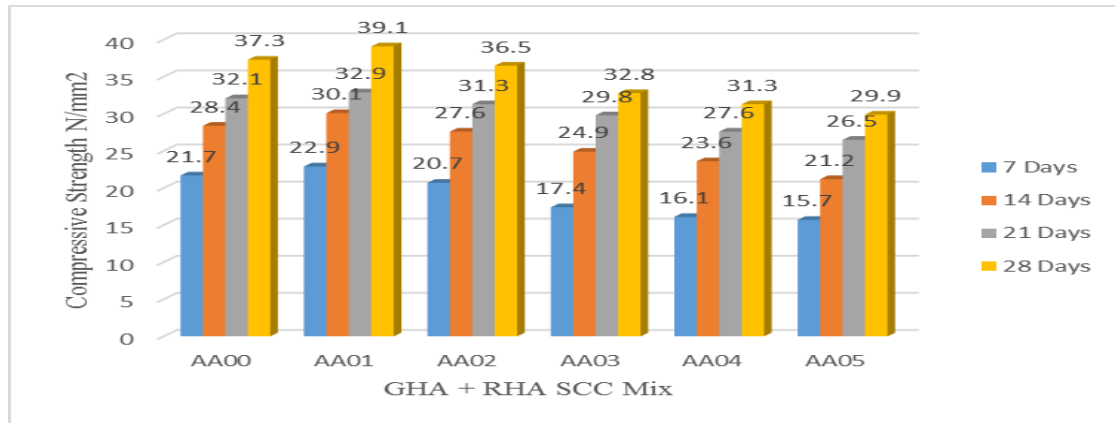


Figure 4: Compressive Strength Test Result

Water absorption: The water absorption of GHA-RHA SCC result is shown in Figure 5. it was observed that the water absorption capacity reduced as the percentage of cement replaced with GHA increased. With the addition of RHA in to GHA SCC, a slight decrease in water absorption

of the concrete was notice. This reduction in water absorption could be attributed to further lowering of porosity of GHA SCC as RHA with smaller particles is blended to fill more voids (Safiuddin *et al.*, 2011).

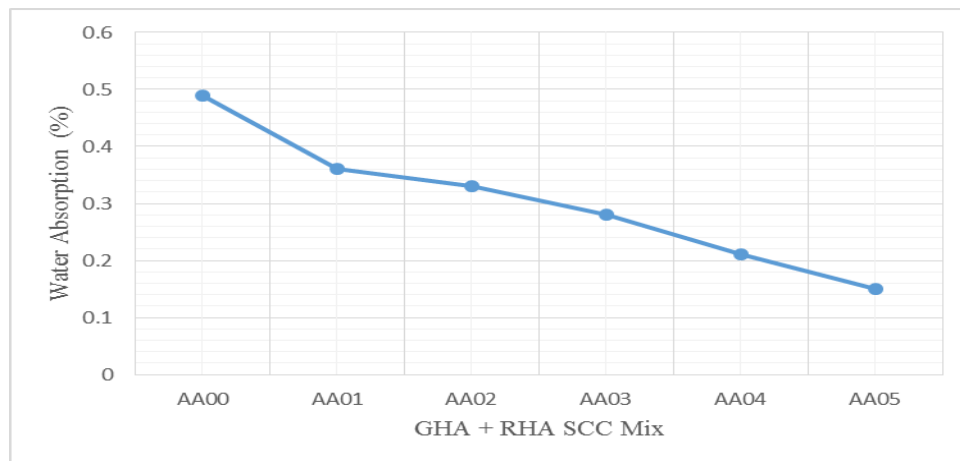


Figure 5: Water Absorption of GHA+RHA SCC

Sodium Chloride Resistance of GHA – RHA SCC: The result of immersion of SCC in to sodium chloride solution is shown in Figure 6. The GHA-RHA significantly affected the compressive strength of concrete at the ages of 7, 14, 21 and 28 days when cure in normal water but the decrease in compressive strength of concrete severe when cured in NaCl solution. Concrete cured in NaCl solution shows little reduction in compressive strength for all days of curing. The improvement in compressive strength is

mostly due to the smaller particle size GHA which can fill the micro-voids within the cement particles, and the pozzolanic activity of GHA which reacts with calcium hydroxide, a by-product of cement hydration and produces additional calcium silicate hydrate (C-S-H). The additional C-S-H reduces the porosity of concrete by filling the capillary pores, and thus improves the resistance to NaCl attack. This is because dense impermeable concrete mass increase resistance against salt attacks (Sahoo *et al.*, 2015).

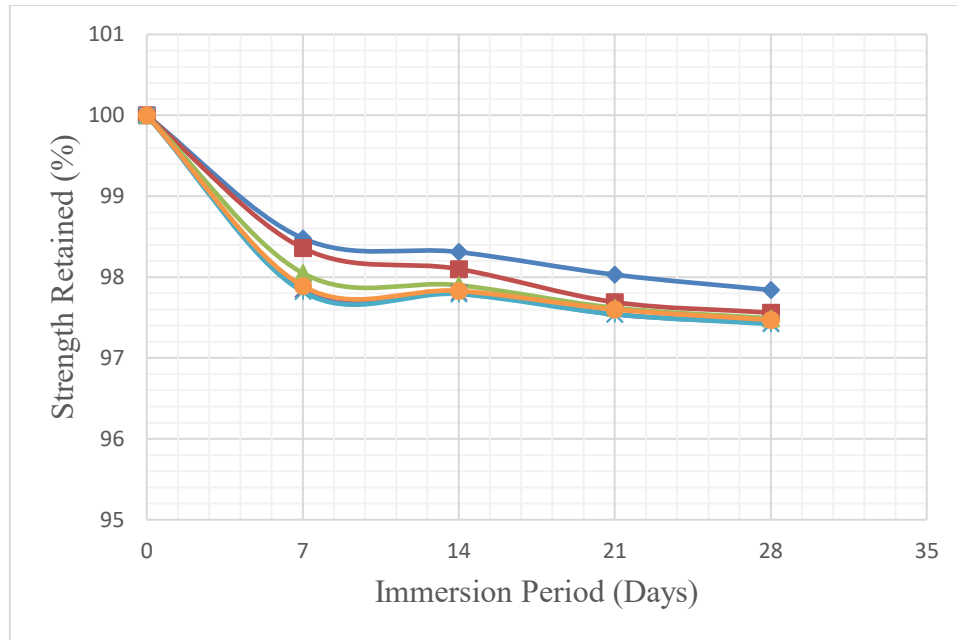


Figure 6: Strength retention of GHA-RHA SCC from Sodium Chloride attack (NaCl medium)

Sulphuric Acid Resistance of CPA – Concrete: The result of immersion of SCC in to sulphuric acid solution is shown in Figure 7. It was observed that, during sulphate attack, the sulphate ions react with cement hydration products, resulting in an alteration of the C-S-H structure and a decrease in SCC strength. However, at 28 days curing all GHA-RHA replacement, SCC shows decrease in resistance by acid attack, which is due to delay in the pozzolanic reaction by a GHA. Though, the resistance at

the later age is due to pozzolanic reaction and formation of C-S-H gel. As C-S-H gel component in GHA and RHA concrete increase and this in turn improve the strength of concrete. According to Sahoo et al (2015), the free lime of concrete hydration reacts with either sulphate or aluminate to form gypsum and ettringite respectively, which both causes expansion internally and result in crack propagation, thereby reducing the strength of the concrete.

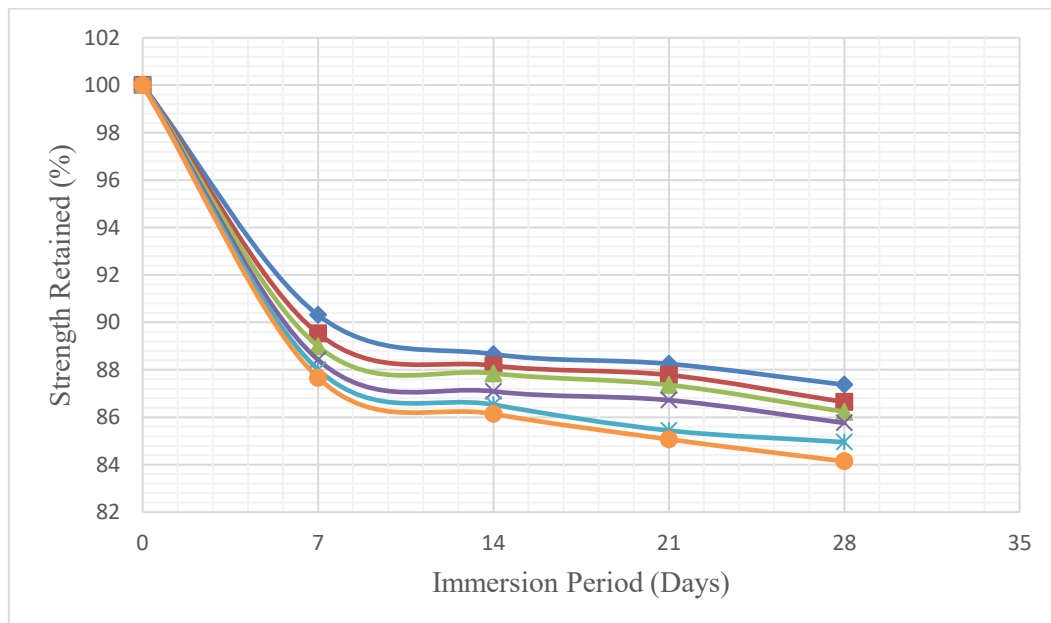


Figure 7: Strength retention of GHA-RHA SCC from acid attack (H₂SO₄ medium)

CONCLUSION

Based on the research findings, the following conclusion can be made

- i. The compressive strength of SCC was more than the targeted design strength of 35N/mm² as GHA and RHA proportions rise was not more than 5% CPA+RHA substitution.
- ii. Grade 35 SCC can be satisfactorily produced using 5% GHA+10% RHA replacement of cement by weight.
- iii. GHA and RHA in SCC reduces the SCC's water absorption.
- iv. Resistance to NaCl and H₂SO₄ degradation decreased with addition of RHA to the GHA SCC.

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MICROBIOLOGICAL ASSESSMENT OF SELECTED ICE CREAMS SOLD IN BIDA AND MINNA NIGER STATE, NIGERIA

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ABSTRACT

The overall quality of ice cream depends upon the storage period of ice cream, packaging microbial and handlings. This work was aimed at assessing the microbiological quality of the different ice creams produced in Niger State. The microbial load (total plate count, coliform count, staphylococcal count, psychrotrophic and fungi count) of four kinds of ice creams; banana, vanilla, chocolate and strawberry ice creams were evaluated as well as possible microorganisms associated with their spoilage. The analysis of variance performed on the result obtained from this present study revealed that bacterial count varied quite considerably ($p < 0.05$). The average bacterial count $\log_{10}\text{cfu/ml}$ of total plate count, coliform count, staphylococcal count of the samples was 4.86, 2.04, 3.85 for samples obtained from Minna while that of Bida were 6.95, 2.02 and 3.08 respectively. There was no coliform in strawberries ice cream obtained from Minna. The psychrotrophic count $\log_{10}\text{cfu/ml}$ ranged from 4.24 to 5.09 for ice cream sampled from Minna and Bida. There was significant difference ($p < 0.05$) between the mean fungi count of vanilla and banana ice cream sampled from Minna and Bida, however the staphylococcal count of vanilla ice cream did not differ $p > 0.05$. The different types of bacteria isolated from these ice creams were *Bacillus* sp, *S. aureus*, *Salmonella* sp, *Shigella dysenteriae* and *Pseudomonas fluorescens*, *Asperigillus fumigatus*, *mucor* sp. Inadequate electricity supply might have led to the proliferation of microorganisms in the ice creams as well as the distribution processes.

Keywords: Ice creams, microbiological assessment, inadequate electricity, Bicycle supply

INTRODUCTION

Ice cream is the main dairy product that attracts the interest of large segment of populace. As a result, its production and consumption are rapidly increasing (Nalbone *et al.*, (2022); Abdullahi, 2023). A lot of people package ice cream in different containers such as cones and cartons. Some in 'open' containers at retail outlets or ice cream parlors, which is distributed manually in scoops, cones or sundaes (Sura *et al.*, 2020). Ice cream is a good medium for microbial growth due to its nutrient content, neutral pH (6–7) and long storage duration (Mohammed *et al.*, 2021). Consumers do think that production process such as pasteurization, freezing and hardening does eliminate most of harmful microbes in ice creams. During the processing after a pasteurization step, there is a potential hazard by an addition of contaminated ingredients or an improper handling of the final product including an abuse of the storage temperature (Mohammed *et al.*, 2021).

The overall quality of ice cream depends upon the storage period of ice cream during which many undesirable changes might occur in the ice cream that leads to deterioration in the physicochemical, sensory quality and

microbial quality. Generally, the industry standard for ice cream storage is -28.9°C . According to the International Dairy Foods Association and NAFDAC, (2021) any ice cream product stored at higher than -28.9°C has incurred heat-shock damage and should not be sold via retail.

In Nigeria, electricity is one of the major challenges as such, the storage temperature of ice cream produced are compromised, retailers may just end up distributing refrozen ice creams to consumers, some of these ice creams are without expiry date, no packaging and the scissors used by bicycle retailers are used and re-used in cutting the ice cream cartoons without washing or disinfecting it at intervals. According to Sung *et al.* (2015), the microbiological quality of ice cream during retail marketing mainly depends on the contamination during the product handling as well as efficiency and sanitary conditions during frozen storage.

Many food poisoning cases associated with the consumption of ice creams have been reported (Ojo-Omoniyi, and Babatunde, 2019). Some diseases associated with food poisoning resulting from ice cream

ingestion are tuberculosis, brucellosis, diphtheria, scarlet fever, Q-fever and mostly gastroenteritis. Majority of these ice cream consumers are children including those of vulnerable age (Mokbul *et al.*, 2016). The present investigation was, therefore, planned to study the microbiological quality of varieties of ice cream sold in Niger state.

MATERIALS AND METHODS

Sources/Sampling of ice cream: The research was carried out from May 2016 to October 2016 in two cities of Niger State. (Minna and Bida). Samples were collected from Chanchanga area, Bosso, Mobile round about (Minna), Federal Polytechnic area, Old Market and New Market (Bida). A total of 120 samples of ice creams were used for this present study. Four varieties of ice cream consisting banana, vanilla, strawberries and chocolate ice creams were purchased from ice cream vendors which included ice cream from bicycle retailers in cartoons, polyethene bags and cones were collected in sterile containers, which were kept in iceboxes and transported to Centre for Genetic Engineering and Biotechnology (Step B) of Federal University of Technology, Minna for analysis.

Microbiological Analysis: Serial Dilution: The frozen ice creams were allowed to thaw or melt after which 10ml of the ice cream samples was added to 90ml of sterile 0.1% peptone water and 1ml of stock sample added to 9ml of peptone water (1:10w/v). This was further diluted up to 10^6 for bacterial count and 10^4 for molds and yeast count

Isolation and Enumeration of Microorganisms: One milliliter from each selected dilution (10^6 for bacteria and 10^4 for fungi) after thorough mixing, were inoculated in nutrient agar and Eosin Methylene Blue agar (EMBA) using pour plate technique and plates were incubated at 37°C for 48hr, for psychrotrophic count, the 1ml diluents was inoculated on nutrient agar and incubated at 7°C for 10days. Fungi and yeast count were determined by adding 4mg of chloramphenicol to 100ml of Sabround Dextrose agar, SDA and yeast extract agar plates prior to autoclaving. And the plates were incubated at ambient temperature (37°C) for 6days. Developed colonies were further subculture to obtain pure colony (Mokbul *et al.*, 2016). Results obtained were subjected to one-way ANOVA and Student t-test using SPSS.

Identification of Isolates: Identification was by conventional method (colonial morphology and biochemical test) as described by Mokbul *et al.* (2016). The bacteria isolate from different samples were grouped on the basis of colonial morphology such as size of the colony, color, surface, edge, slope and elevation. Microscopic Examination of the isolates were determined by making smears of each of the different bacterial isolates in a clean- grease free slide and air dried. These were directly observed under the microscope using the oil immersion objective (x100).

The bacterial isolates were stained using Gram's Method of staining to study the morphological appearance of the cell as well as their Gram reactions (Whether they are Gram positive or Gram negative) and cell arrangement. Gram positive cells retained the purple color of the initial dye while the Gram-negative cells retained the pinkish-red color of the counter stains. Biochemical tests were performed to confirm the identity of the isolated bacteria using 24 hours old cultures, biochemical tests such as oxidative/fermentative (O/F) utilization of sugars and carbohydrates, catalase, coagulase amongst others in accordance with the methods of Mokbul *et al.* (2016). Characterization method employed for fungal isolates was by wet mount of fungi hyphae in lacto-phenol cotton blue. examination of the culture and morphological features.

RESULTS AND DISCUSSION

The analysis of variance performed on the result obtained from this present study revealed that bacterial count varied quite considerably ($p < 0.05$). The average bacterial count $\log_{10}\text{cfu/ml}$ of total plate count, coliform count, staphylococcal count of the samples was 4.86, 2.04, 3.85 for samples obtained from Minna while 6.95, 2.02 and 3.08 were recorded for Bida samples respectively. The mean staphylococcal count and coliform count did not differ $p > 0.05$ between ice cream sampled in both metropolises. The psychrotrophic count $\log_{10}\text{cfu/ml}$ ranged from 4.24 to 5.09 for ice cream sampled from Minna and Bida (Table 1). There was significant difference ($p < 0.05$) between the mean fungi count of vanilla and banana ice cream sampled from Minna and Bida, however the staphylococcal count of vanilla ice cream did not differ $p > 0.05$. As presented in Table 2, vanilla ice cream had more microbial load followed by chocolate ice cream and then others.

However, the fungi count observed from this study among vanilla, strawberries and chocolate ice cream did not differ $p>0.05$. A similar trend also occurred between coliform count and staphylococcal count of vanilla and chocolate ice cream. Table 3 revealed that there was no coliform in strawberries ice cream obtained from Minna. The staphylococcal count of reported in flavored ice cream samples obtained from Minna did not varied $p>0.05$.

In this study all the ice cream samples exceeded the standard limits (10^5 for TBC and 10^2 for coliform) in terms of total plate count, coliform count, staphylococcal count and fungi count. Due to the fact that ice cream mix has to undergo pasteurization, the microbial count is expected to be low or less than 100 bacterial cells per ml. However, the slightly high microbial load reported in this study might be due to inadequate electricity supply and distribution processes. The quality attributes of ice cream depend on various factors, including ice crystal size, overrun, initial freezing temperature, and storage temperature. Among these, storage temperature is of particular interest to ice cream manufacturers and retail stores, because the physical characteristics of ice cream associated with mouth feel are greatly influenced by storage temperature (Choi and Shin, 2014). Despite the stipulated temperature period by International Dairy Foods Association, retailers still hawk refrozen ice cream. Of great concern is the packaging of ice cream by local vendors. The total plate count $4.86 \text{ Log}_{10}\text{Cfu/ml}$ observed in this present study did not vary from 1.4×10^4 to 3.0×10^4 reported by Moshood *et al.* (2013) from locally produced ice cream in Bauchi State. Ojo-Omoniye *et al.* (2018)

documented range of 1.14×10^3 to 6.0×10^4 in ice cream retailed in Lagos Metropolis, South West Nigeria, this was similar to the microbial load presented in Table 1. Notably, the coliform count observed from this present study was similar to 2.4×10^3 reported by Mohamed *et al.* (2021).

The different types of bacteria isolated from these ice creams were *Bacillus sp.*, *S. aureus*, *Salmonella sp.*, *Shigella dysenteriae* and *Pseudomonas fluorescens*, *Asperigillus fumigatus*, *mucor sp.* These pathogens are of public health significance as they are capable of causing various ailments to man. The presence of *Staphylococcus aureus* in both locally produced and industrially produced ice-cream could be from nose where it is commonly found, hands, skin and clothing of handlers (Mansura *et al.*, 2016). *Staphylococcus aureus* has been known to cause Staphylococcal food poisoning due to ingestion of improperly stored food in which *S. aureus* has grown. Coughing, talking, sneezing produces droplets which could settle on ice-cream during transportation, storage and retailing. Some researchers in Kaduna also assessed ice cream in Kaduna. Similar organisms such as *Salmonella sp.*, *S. aureus* were isolated (Mohammed *et al.*, 2019). However, Abdullahi (2023), did not isolate *Salmonella sp.* from samples of ice investigated from both local and imported ice cream in Iraq. The presence of possible pathogenic organisms in the analyzed ice-cream should be viewed with concern by the consumers, producing company and the Government since food poisoning by *Bacillus sp.* and *Salmonella sp.* is possible through consumption of contaminated ice- cream.

Table 1: Microbial Quality of Ice Cream Samples from Niger State

Microbial Parameters ($\text{Log}_{10}\text{cfu/ml}$)	Minna	Bida
Total Plate Count	4.86 ± 0.02^b	6.95 ± 1.00^a
Coliform Count	2.04 ± 0.00^a	2.02 ± 0.01^a
Psychrotrophic Count	4.24 ± 0.10^b	5.09 ± 1.00^a
Staphylococcal Count	3.46 ± 0.12^a	3.52 ± 0.44^a
Fungi Count	3.85 ± 0.21^a	3.08 ± 0.20^b

Values are mean $\pm$ S.E of 60 determinants, different letters of superscript are significantly different along the row

Table 2: Mean Microbial Quality of Flavoured Ice Cream (Log₁₀cfu/ml)

Microbial Parameters (Log ₁₀ Cfu/ml)	Ice cream Samples			
	Banana	Chocolate	Strawberries	Vanilla
Total Plate Count	5.00±1.20 ^b	5.16±0.38 ^b	4.89±0.34 ^c	5.60±1.22 ^a
Coliform Count	1.95±0.00 ^b	2.16±0.10 ^a	1.78±0.00 ^b	2.15±0.02 ^a
Psychrotrophic Count	3.36±0.16 ^c	3.73±0.14 ^c	5.80±1.12 ^a	4.85±0.32 ^b
Staphylococcal Count	2.95±0.03 ^b	3.83±0.30 ^a	3.02±0.04 ^b	4.17±0.45 ^a
Fungi Count	3.17±0.10 ^{ab}	3.22±0.21 ^a	3.46±0.10 ^a	3.44±0.18 ^a

Values are mean ±S.E of 60 determinants, different letters of superscript are significantly different along the row

Table 3: Mean Microbial Quality of Flavoured Ice Cream (Log₁₀cfu/ml)

	Minna				Bida			
	Banana	Chocolate	Strawberry	Vanilla	Banana	Chocolate	Strawberry	Vanilla
TPC	5.00±1.28 ^c	4.85±1.00 ^d	5.00±0.22 ^c	4.60±0.02 ^d	7.00±1.48 ^a	5.47±1.00 ^c	4.69±0.42 ^d	6.62±2.00 ^b
C.C	1.17±0.00 ^d	2.30±0.04 ^b	Nil	2.63±0.19 ^a	2.74±0.02 ^a	2.00±0.01 ^b	1.68±0.00 ^c	1.66±0.00 ^c
P.C	6.60±1.40 ^a	5.45±1.47 ^b	3.50±0.38 ^d	1.39±0.01 ^f	6.83±1.30 ^a	2.00±0.02 ^c	4.60±0.33 ^c	6.92±1.38 ^a
S.C	3.41±0.25 ^c	3.47±0.56 ^c	3.39±0.49 ^c	3.55±0.20 ^c	2.47±0.41 ^d	4.17±0.24 ^b	4.40±0.40 ^b	6.00±1.37 ^a
F.C	3.74±0.22 ^b	3.81±0.43 ^b	3.48±0.12 ^b	4.34±1.00 ^a	2.40±0.12 ^c	3.67±0.32 ^b	3.23±0.34 ^b	2.54±0.24 ^c

Values are mean ±S. E of 60 determinants, different letters of superscript are significantly different along the row
ML=Microbial Load (Log₁₀cf/ml), TPC=Total plate count, C.C=coliform count, P.C=psychrotrophic count
S.C=staphylococcal count F.C=fungi count

Table 4: Colonial Morphology of Bacteria Isolates

Sample code	Form/shape	Elevation	Margin/Edge	surface	Colonial colour	Structure	Haemolysis Blood agar plate	Spore formation	Motility	Gram reaction	Shape	Description
S1	circular	convex	entire	smooth	golden yellow	shiny	+	-	-	+	C	Cocci in cluster
B7	circular	umbonate	undulate	rough	dull white	opaque	-	+	+	+	R	Rod in chain
B8	circular	convex	smooth	smooth	pink	translucent	+	-	-	-	+	Rod in single in pair
PS	circular	umbonate	Wavy/lobate	mucoid	Green yellow	translucent	-	-	+	-	R	Rod
SA	circular	convex	smooth	smooth	Pale, Colourless/ black center	transparent	-	-	+	-	R	Slender rod in chain/clusters

Table 5: Cultural and Microscopic Characteristics of Identified Fungi

Samples Code	Macroculture	Microscopy				Isolates
		Blastospores/nature of hyphae	Pseudomycelium	Conidiospores/spores shape	Arthrospores	
AK2	Long-fibred, rough woolly hyphae, white colony	Thick hyphae, no septate	—	Elliptical oconidia, sporangiophores contain spores	Absent	<i>Mucor spp</i>
AK4	Green velvety colony	Septate hyphae	—	Conidiophore rise laterally on hyphae	—	<i>Aspergillus fumigatus</i>

Table 6: Characterization and Identification of Isolates

Sample code	Gram reaction	Cell shape	Presence of spore	Motility	Catalase	Coagulase	Oxidase	Methyl red	Voges proskauer	Gelatin hydrolysis	Starch hydrolysis	Urease	Nitrate reduction	Citrate simmon	Hydrogen sulphide	Indole test	Glucose	Sucrose	Manitol	Fructose	Lactose	Maltose	Probable organism
B 7	+	R	+	+	+	N	-	-	+	-	+	-	-	-	-	-	+	+	+	-	+	-	<i>Bacillus sp</i>
S1	+	C	-	-	+	+	-	+	+	+	-	-	+	-	-	-	+	+	+	+	+	+	<i>Staphylococcus aureus</i>
S	-	R	-	+	+	N	-	+	+	+	+	-	-	-	-	-	+	-	+	+	-	+	<i>Salmonella sp</i>
B 8	-	R	-	-	-	N	-	+	+	-	N	-	+	-	-	-	+	-	-	N	+	N	<i>Shigella dysenteriae</i>
P S	-	R	+	+	+	N	N	+	-	+	+	-	N	-	-	-	+	-	+	+	-	-	<i>Pseudomonas</i>

R=rod, N=not applicable, -negative, +positive

CONCLUSION

In this study all the ice cream samples exceeded the standard limits in terms of total plate count, coliform count, staphylococcal count and fungi count. The presence of coliforms and staph in this ice cream showed the possibility of acquiring food borne disease.

This is of public health concern and calls for proper education of hawkers and the government should produce light in area for ice production.

Conflict of Interest: The authors have no conflict of interest to declare

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NUTRITIONAL AND MICROBIAL QUALITY OF SELECTED BRANDED AND UNBRANDED PASTA IN BIDA, NIGER STATE

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ABSTRACT

Pasta and wheat grains related products represent food stuffs that are daily present in nutrition. Their production can take place in industrial and artisanal conditions. Among many advantages in industrial production, significantly greater microbiological safety of the finished product is one of the most important. The aim of this research work was to investigate the nutritional and microbiological safety of pasta and related products produced in industrial plants that are fully automated and in handicraft establishments that are not fully automated. Fifty samples of different branded and unbranded pasta (locally produced pasta) were purchased randomly from Old and Modern Markets in Bida. These were analyzed for nutritional (proximate, mineral and vitamins) and microbiological status. The results revealed significant difference ($p < 0.05$) among the various samples in terms of fat, protein and moisture content. Calcium and potassium content (100 mg/g) ranged 0.39-0.98 and 0.40-0.70 while vitamin C ranged 0.19-0.74 mg/ml. The coliform count of the samples ranged 0.00-4.78 log₁₀cfu/g while yeast counts (log₁₀ cfu/ml) for both branded and unbranded pasta ranged 3.29-4.14. Producers of unbranded pasta are advised to make a packaging for the product as this will help reduce the high microbial contamination observed in this study.

Key words: Pasta, unbranded pasta, branded pasta, Microbial quality

INTRODUCTION

Pasta is the most popular corn foodstuff; its consumption has been observed to rise in Nigeria and other countries (Amoo *et al.*, 2024). Worldwide consumption of pasta has increase due to ease of cooking, convenience and relatively low cost and long shelf life. According to Lasabi *et al.*, 2022, Nigeria is rated 12th globally for instant noodles with annual consumption of 1.76 billion noodles. Pasta demand especially indomie is very high in Nigeria market today. At present Nigeria is experiencing greater growth in production of noodles, spaghetti and macaroni (Rifai *et al.*, 2022).

The word pasta and noodles are occasional used interchangeably due to the fact that the products are basically same type and produced from wheat semolina or fine flour and water, and intermittently produced from other cereals like rice, corn, mixed with eggs and spices (Dagem *et al.*, 2016). Pasta is often criticized as unhealthy or junk food according to Muller *et al.* (2022). However, Nayyar and Imdadul (2024) reported pasta as a sustainable product that improves the nutritional quality of food pyramid when fortified (Pasquale *et al.*, 2023)

There are different notions of quality of pasta because they are made by using different raw materials,

production technics and quality control methods (Bresciani *et al.*, 2022; Schmid *et al.*, 2023). The different processes involved in pasta production does not really eliminate all the pathogens that are inherent in the flour. Some of them survive those processes and in deed continue their proliferation. Other microorganism gets in contact with the products while on shelf or in the hands of the retailers. Pathogenic organisms such as *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* and wild fungi have reported to colonize pasta. Pastas are often subjected to infection with various fungi, many of which synthesize mycotoxins (Akhigbemidu *et al.*, 2025). This improperly controlled drying with possible proliferation of organisms could result in a potential hazard to public health (Oyewole *et al.*, 2024). Some mycotoxins have been implicated in liver cancer, aflatoxicosis and food intoxication (Onyema *et al.*, 2014). However, the production of pasta can be industrial and handicraft (locally made). The quality of pasta product is very important factor in terms of proper nutrition and placement on demanding markets, both domestic and foreign. Pasta, when not properly managed in the market in the hand of the Vendors can be contaminated (Motaleb *et al.*, 2022; Amoo *et al.*, 2025). The manufacturing of pasta product involves controlled drying step at room temperature which, if not properly controlled, enable the

extensive growth of microorganisms and can cause food borne diseases. Food borne illness is a major international health problem with consequent economic reduction (Akher *et al.*, 2021). Again, the homemade pasta is sundried exposing the products to mineral denaturation. In Nigeria, among many of the food poisoning reported in the recent past, is the contamination of indomie noodles (a brand of pasta foods) with poisonous substances believed to be pesticide residues (Muendo *et al.*, 2022). Hence this study aimed at assessing the nutritional status and microbial level of branded and unbranded pasta sold in Bida metropolis.

MATERIALS AND METHODS

Sources / Collection of Samples: A total of fifty pastas which comprises of 25 branded pastas and 25 unbranded pastas were purchased randomly from Old and Modern Market, Bida in sterile polyethylene bag. These pastas were labelled as sample A (Golden penny macaroni), sample B (Golden penny spaghetti), sample C (chicken flavor indomie), sample D (Honey well indomie), sample E (Onion chicken) and sample F (Locally made spaghetti) respectively. These samples were immediately transported to STEP-B Laboratory (Centre for Genetic Engineering and Biotechnology) in Federal University of Technology, Minna for analysis.

Proximate Analysis of Brand and Unbranded Pastas:

The moisture content, protein, fat, ash, crude fibre, carbohydrate and Energy analysis were carried out using standard procedures of the AOAC, (1990).

Determination of Mineral and Vitamin of Brand and Unbranded Pastas:

The micronutrient determined were N, Ca, Mg, P and Na while vitamin A, C and D were determined using Anandakumar *et al.*, 2025; Lasabi *et al.*, 2025) method.

Microbiological Analysis Pasta: Ten grams of the pasta product (locally made pasta, Indomie, spaghetti and macaroni) were added to 90ml of sterile 0.1% peptone water and homogenize (1:10w/v) in sterile laboratory blender. 1ml of the homogenate was added to 9ml of 0.1% peptone water (1:10w/v). This was further diluted up 10^{-6} for bacterial count and 10^{-4} for fungal count. Tryptose soy agar, Eosin methylene blue agar and malt extract agar for

viable count, coliform and fungi count using a pour plate method in triplicate. These were incubated for $30 \pm 2^\circ\text{C}$ for 48 hrs for bacterial and 5 days for fungi. Colony that developed were counted and recorded as Log_{10} cfu/g (Azounwu *et al.*, 2018; Lambil *et al.*, 2022; Ajiboye *et al.*, 2023).

RESULTS AND DISCUSSION

The present evaluation of the organoleptic properties of the various pasta sold in Bida metropolis is a pointer to the fact that pasta need dietary modification, supplementation and food fortification. The findings revealed in Table1-3, shows that there were significant differences ($p < 0.05$) among the means of the various pasta samples in terms of organoleptic, micronutrient and vitamin contents. The local made pasta revealed highest moisture content 11.07% with lowest energy compared to other pasta sampled. On the other hand, sample, A and B had the highest crude proteins content 8.57% and 8.94% respectively. The moisture content of indomie Onion chicken (sample E) had the lowest moisture content 3.29% followed by indomie chicken flavour (5.23%). This may be attributed to the proper oven drying of the products and discontinuous or batch drying method employed during production of the commercial pasta. The moisture content as observed in this study revealed that indomie onion chicken has the potential of extended shelf life without been damaged by microbial spoilage or mycotoxins (Oppong *et al.*, 2015). Veena *et al.*, 2019 reported moisture content lower than that observed in this present study. With respect to the fat, crude protein, ash and carbohydrate contents of the samples, there were no significant difference ($p > 0.05$) between sample A and B. This could be attributed to the fact that the products were from the same company perhaps a mandatory/statutory standard was observed across board. The crude fibre content of spaghetti samples, ranged from 4.75 to 5.55% and was quite higher than 0.08%, 0.68-2.59 and 0.8-1.3 reported by Dagem *et al.* (2016); Bolarinwa and Oyesiji (2021; Lasabi *et al.*, (2022). The protein content reported (6.7-12.1/11.1-17.7) by the same authors were higher than 8.94% documented in this present work but was in conformity with the value (9.89%) observed by Oppong *et al.* (2015). The reason for this discrepancy might be the fact that the later researchers work on fortified pasta.

Table 1: Proximate Content of Pasta

proximate (%)	Sample ^{1,2}					
	A	B	C	D	E	F
Moisture	9.26 ± 0.15 ^b	10.89 ± 0.14 ^{ab}	5.23 ± 0.16 ^c	4.66 ± 0.69 ^{cd}	3.29 ± 0.63 ^d	11.07 ± 0.01 ^a
Fat	9.75 ± 0.14 ^c	9.75 ± 0.14 ^c	10.18 ± 0.16 ^b	10.75 ± 0.14 ^a	9.25 ± 0.14 ^d	7.80 ± 0.56 ^e
Crude protein	8.37 ± 0.00 ^a	8.94 ± 0.17 ^a	6.47 ± 0.00 ^b	4.36 ± 0.67 ^d	4.48 ± 0.15 ^c	6.49 ± 0.05 ^b
Ash	0.98 ± 0.01 ^b	0.93 ± 0.01 ^b	0.98 ± 0.00 ^b	0.09 ± 0.00 ^b	1.18 ± 0.01 ^a	0.63 ± 0.42 ^c
Crude fibre	5.25 ± 0.14 ^{bc}	4.75 ± 0.14 ^{bd}	5.55 ± 0.29 ^b	5.85 ± 0.00 ^a	4.96 ± 0.3 ^{cd}	5.25 ± 0.42 ^{bc}
Carbohydrate	56.09 ± 0.62 ^d	54.87 ± 0.13 ^d	61.72 ± 0.22 ^b	61.62 ± 1.06 ^b	66.85 ± 0.8 ^a	59.76 ± 0.19 ^c
Energy	4.30E ± 0.79 ^a	4.28E ± 0.53 ^{ab}	4.36E ± 0.39 ^a	4.36E ± 4.29 ^a	4.29E ± 5.83 ^{ab}	4.19E ± 0.49 ^b

¹Each value is Mean ± S.E of 10 determinants; ²Different letters on the row show significant differences (p < 0.05)

Key: Sample A (Golden penny macaroni), sample B (Golden penny spaghetti), sample C (chicken flavor indomie), sample D (Honeywell indomie), sample E (Onion chicken indomie) and sample F (Locally made spaghetti).

Table 2: Vitamin content of pasta

Parameters (Mg/mg)	Sample ^{1,2}					
	A	B	C	D	E	F
Vitamin A	11.40 ± 0.58 ^c	10.52 ± 0.00 ^d	11.39 ± 0.00 ^c	12.56 ± 0.00 ^a	11.64 ± 0.00 ^b	8.29 ± 0.00 ^a
Vitamin B	0.13 ± 0.00 ^b	0.47 ± 0.33 ^a	0.12 ± 0.00 ^b	0.13 ± 0.00 ^b	0.17 ± 0.00 ^b	0.32 ± 0.00 ^b
Vitamin C	0.74 ± 0.19 ^a	0.67 ± 0.00 ^b	0.69 ± 0.00 ^b	0.19 ± 0.00 ^c	0.63 ± 0.00 ^b	0.79 ± 0.00 ^a
Vitamin D	0.01 ± 0.00 ^d	0.03 ± 0.00 ^b	0.01 ± 0.00 ^d	0.01 ± 0.00 ^d	0.02 ± 0.00 ^c	0.04 ± 0.00 ^a

¹Each value is Mean ± S.E of 10 determinants; ²Different letters on the row show significant differences (p < 0.05)

Key: Sample A (Golden penny macaroni), sample B (Golden penny spaghetti), sample C (chicken flavour indomie), sample D (Honey well indomie), sample E (Onion chicken indomie) and sample F (Locally made spaghetti).

Table 3: Mineral Content of Pasta

Minerals (100 mg/g)	Sample ^{1,2}					
	A	B	C	D	E	F
Nitrogen	2.98 ± 0.00 ^a	3.03 ± 0.00 ^a	2.64 ± 0.00 ^c	2.56 ± 0.00 ^c	2.31 ± 0.00 ^d	2.73 ± 0.00 ^b
Phosphorus	0.40 ± 0.00 ^b	0.47 ± 0.00 ^a	0.39 ± 0.00 ^b	0.49 ± 0.00 ^a	0.40 ± 0.00 ^b	0.49 ± 0.00 ^c
Potassium	0.57 ± 0.00 ^b	0.70 ± 0.00 ^a	0.40 ± 0.00 ^c	0.70 ± 0.00 ^a	0.40 ± 0.00 ^c	0.50 ± 0.00 ^{bc}
Calcium	0.93 ± 0.15 ^a	0.87 ± 0.00 ^b	0.98 ± 0.94 ^a	0.77 ± 0.18 ^c	0.87 ± 0.29 ^b	0.39 ± 0.00 ^d
Magnesium	0.70 ± 0.00 ^a	0.20 ± 0.00 ^b	0.47 ± 0.00 ^a	0.70 ± 0.00 ^a	0.77 ± 0.00 ^a	0.21 ± 0.00 ^b
Sodium	0.85 ± 0.00 ^a	0.83 ± 0.00 ^a	0.67 ± 0.12 ^c	0.88 ± 0.18 ^a	0.69 ± 0.00 ^b	0.57 ± 0.00 ^d

¹Each value is Mean ± S.E of 10 determinants; ²Different letters on the row show significant differences (p < 0.05)

Key: Sample A (Golden penny macaroni), sample B (Golden penny spaghetti), sample C (chicken flavor indomie), sample D (Honey well indomie), sample E (Onion chicken) and sample F (Locally made spaghetti).

As revealed in Table 3 the mineral composition of the different pasta showed significant differences (p < 0.05). There was variation in the levels of mineral available in different pasta. The locally made pasta was observed to be higher in N and K than that of sample C, D and E. High sodium is known to increase the blood pressure of the body especially in patient with hypertension disease (Veena et

al., 2025). High phosphorus content was noticed in Golden penny spaghetti and indomie. Phosphorus has been reported to improve cellular repair, optimized chemical reaction and proper nutrient utilization (Veena et al., 2025). The low mineral content observed in unbranded pasta is not surprising as the products are exposed in

market without packaging. This may lead to evaporation and nutrient denaturation.

The vitamin quality of the various pasta differed significantly ($p < 0.05$) as well. This may be attributed to the various method of processing by the company.

Table 4: Microbial load of pasta

Parameters (Logcfu/g)	Sample ^{1,2}					
	A	B	C	D	E	F
Total viable Count	3.24 ± 0.07^c	3.25 ± 0.04^c	3.93 ± 0.02^b	3.88 ± 0.00^b	3.92 ± 0.06^b	6.08 ± 0.00^a
Coliform count	0.00 ± 0.00^c	0.00 ± 0.00^c	1.80 ± 0.05^b	0.00 ± 0.00^c	1.81 ± 0.02^b	4.78 ± 0.00^a
Staphylococcal count	1.00 ± 0.00^d	1.01 ± 0.00^d	0.50 ± 0.25^c	2.40 ± 0.28^b	0.00 ± 0.00^c	6.13 ± 0.25^a
Fungi count	6.08 ± 0.03^b	6.56 ± 0.06^b	3.83 ± 0.02^d	3.00 ± 0.04^c	4.75 ± 0.06^c	7.32 ± 0.00^a
Yeast count	4.10 ± 0.00^a	4.10 ± 0.02^a	4.09 ± 0.00^a	3.29 ± 0.03^b	4.14 ± 0.00^a	4.07 ± 0.04^a

¹Each value is Mean $\pm$ S.E of 10 determinants, Different letters on the row show significant differences ($p < 0.05$)

Key: Sample A (Golden penny macaroni), sample B (Golden penny spaghetti), sample C (chicken flavor indomie), sample D (Honey well indomie), sample E (Onion chicken) and sample F (Locally made spaghetti)

The locally (unbranded) made pasta had more vitamin content as compared with branded pasta. Locally made pasta had higher vitamin A and C as compared to branded pasta. This may be attributed to the slightly high moisture content of the home-made pasta (Table1). Again, most local producers use dried fresh cereals in producing pasta.

The microbiological result of the various pastas sampled in Bida markets revealed low microbial count except sampled F. Notably, there were no coliforms in most of the commercial pasta and their microbial count was quite moderate. In all microbial parameters the locally made pasta had higher microbial compared to the commercial pastas. The TPC, TCC, TSC, TFC and TYC ($\log_{10}\text{cfu/g}$), exceeded the microbial standard for pasta which includes; $< 10^5\text{CFU/g}$ total mesophilic Aerobic Bacteria, $< 10^2\text{CFU/g}$ enterobacteriaceae, $< 10^2\text{CFU/g}$ staphylococcus, $< 10^2\text{CFU/g}$ mold, and $< 10^3\text{CFU/g}$ yeast (Scioscia *et al.*, 2016). The TPC range ($\log \text{Cfu/g}$ 3.27-6.08) observed from this present study was similar to the submission (3.20×10^5 - $4.3 \times 10^6\text{Cfu/g}$) of Akhgbemudu *et al.* (2025) in Nigeria, but slightly higher than the values 6.6×10^4 - 2.2×10^5 reported by Mounmouny *et al.* (2025) from spaghetti investigated in Cote d'Ivoire. The Staphylococcal count in locally produced spaghetti which exceeded the standard limit, was also lower than 1.13×10^5 published by Amoo *et. al.* (2025) in Bauchi. There was no significant difference ($p > 0.05$) in the yeast count of all the pasta except that of Honey well indomie. Yeast is known to survive drought due to their spore's production hence during storage and preservation they tend to retain their viability. According to Ajiboye *et al.*, 2025, neglects of

proper production and hygienic standard might contribute to the high microbial load. Amoo *et al.* (2025) was of the opinion the bacterial load in food at any given time is influenced by handling practices and storage conditions. The high count observed in sample F might be a reflection of unhygienic practice of the producer. The high fungi count might have also increased due to the exposure of the products in the market without packaging as well as sun drying methods used during processing. According to Azounwa *et al.*, (2018), many food vendors often lack formal education and operate without licenses and are untrained.

CONCLUSION

The findings from this research, revealed variations in the proximate, micronutrients and microbial contents of locally produced and commercial pastas. The locally produced pasta had more vitamins however were highly contaminated with different microorganisms and at levels which exceeded standard limit for pastas. We hereby recommend mandatory health certification, regular renewal of production licenses and training of vendors as well as packaging/fortification of locally made pastas.

Conflict of Interest

The authors have no conflict of interest to declare.

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