



**GLOBAL TRENDS AND CONSTRAINTS IN FONIO RESEARCH FROM 1995 TO 2025
WITH IMPLICATIONS FOR SCALING UP PRODUCTION IN BAUCHI STATE**

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ABSTRACT

The paper analyzed global production trends of fonio (*Digitaria exilis* and *D. iburua*) production system and interpreted the local implications of its production with particular reference to Bauchi state, Nigeria. The study employed a comprehensive bibliometric and systematic analysis of 452 academic papers published between 1995 and 2025. The study revealed a chronological analysis of production of two distinct epochs. A period of stagnation between 1995 and 2000 which was followed by a sustained exponential growth that peaked sharply between 2019 and 2025 (with 46.90% of total publications). This pattern reflects a global paradigm shift to climate-smart, drought-tolerant agriculture under a regime of climate change. Spatial distribution mapping highlighted the dominance of West African countries including Guinea (N=106) and Nigeria (N=90) in domestic production. The lead role of developed European countries in international research networks of fonio was also documented. Local Nigerian studies were centered in the highlands of Plateau and Kaduna States. Thus, there is clearly a missing geographic focus on the fonio production areas of Bauchi State (Tafawa Balewa and Bogoro Local Government Areas). Through a keyword co-occurrence network analysis, four thematic areas were clustered for the studies, namely: Genetics and Breeding, Agronomy and Climate, Food Science and Health and Socio-economics. It has been shown that, although there is an increasing research into global fonio production systems and the health benefits derived from its low glycemic index, high dietary fiber content and gluten-free properties, local production and uptake of the crop is extremely limited in Bauchi State. Additionally, the crop has failed to penetrate the market at the urban level. Analysis of the value-chain demonstrated that the post-harvest processing challenges are the main structural impediment of the value chain (f=184). The manual removal of husks by local women, introduction of sand and grit, were responsible for blocking its entry into formal supply chains of formal urban supermarkets. To bridge the gaps between the local social ecology and the global research frontiers on fonio, it is recommended that the state Ministry of Agriculture, should provide women cooperatives with locale-appropriate solar powered mechanical dehullers and destoners. Furthermore, standardizing local agronomic row planting methods, and setting up of community seed banks for conservation of local landraces, will help market the product. Last, but not the least, creating stable government market for the product at schools and health institutions will ensure its role as a food security option of the future.

Keywords: Analysis; Bibliometric, Paradigm shift; Production; Socio-economics; Systematic

INTRODUCTION

Fonio (*Digitaria exilis* and *D. iburua*), also known as acha, is one of West Africa's most ancient indigenous cereals; it has historically been venerated for its climate-smart traits (Adoukonou-Sagbadja *et al.*, 2006). The climate-smart grain is cultivated within the arid and semi-arid ecological zones across the sub-Saharan belt, where unreliable rainfall and low soil fertility undermine the production of other major staples such as rice and maize (Jideani & Jideani, 2011). In Nigeria, fonio has been traditionally cultivated and eaten and it spans over three specific states, Plateau (Jos South, Riyom, and Bokkos LGAs), Kaduna (Kafanchan, Zonkwa and Kwoi), and Bauchi State in Tafawa Balewa and Bogoro LGAs (Gyang *et al.*, 2019).

For centuries rural households within these focal points have relied upon fonio as a lean-season food source and a delicacy. Rural communities in these focal points traditionally consume fonio in



forms of *tuwo* (a staple food derived from solid mass derived from swallowing and chewing) or '*gwote acha*' (a nutritious meat and vegetable concoction), pudding, couscous, and various types of flour based diets (Jideani, 1999). Outside of its ability to tolerate harsh climate and topography, the modern Nutritional Sciences acknowledge *fonio* as a functional food in that it is naturally gluten-free and is exceptionally rich in dietary fiber and is low in glycemic Index (Cruz *et al.*, 2016). As a matter of fact, *fonio*'s biochemical characteristics make it ideal in managing public health non-communicable conditions such as diabetes and obesity. It furthermore, enhances the diversification of a country's cereals (Jideani & Jideani, 2011).

Despite its long history and unique Nutritional superiority, *fonio* is underexploited both in terms of cultivation and consumption in Nigeria. It seems that there exists a peculiar socio-economic paradox whereby public health problem in Nigeria grows bigger at every point, yet the demand of *fonio* continues to remain low and stagnant especially in rapidly growing urban centers (Gyang *et al.*, 2019). These under-exploited value-chain traits are as a result of low productivity in its traditional manual labor-intensive post-harvest processing (threshing and de-husking). This limits its commercial appeal and quality. Similarly, institutional markets such as schools, hospitals, workplace canteens and correctional facilities do not have it on their menus.

In relation to its production clusters, *fonio* has not been extensively studied across its production border of northern Nigeria. It has not also critically, studied and properly documented within its eco-sociological production context in Bauchi State. Lack of comprehensive, long-term scientific studies on global production trends, seed system constraints, and decentralized breeding successes in the public domains for potential application on local levels is also another challenge for *fonio* production and consumption.

In response to these research gaps, the present study examines *fonio* studies in the last 30 years (1995 -2025) and develops pragmatic approaches for *fonio* production in Bauchi State. The overall goal of this study is to comprehensively analyse research trends and constraint factors associated with *fonio* to inform local-scale strategies for increased production, processing and consumption. The specific objectives were fourfold: i). to map the global bibliometric trend and spatial reach of the *fonio* research literature between 1995 and 2025; ii). to explore the central evolving themes in *fonio* science that touch on genetic variability and seed system development, including the conservation of local indigenous agricultural knowledge; iii). to assess the specific production limitations to the *fonio* value-chain relating to inefficiencies of post-harvest operations and possible technological intervention to overcome them; and iv). to adapt *fonio* research-based climatic compatibility knowledge and policy models to scale-up production and drive demand through institutional markets in Tafawa Balewa and Bogoro LGAs.

METHODOLOGY

The structural workflow of this study is mapped below:

[Database Search: Scopus, WoS, Google Scholar]

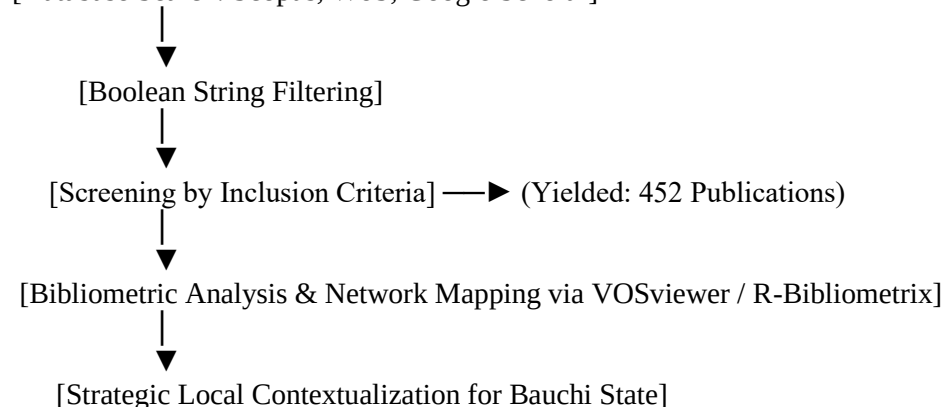


Figure 1. The structural workflow of the study



Database Selection and Search Strategy

The historical and contemporary trends in fonio (*Digitaria exilis* and *D. iburua*) production systems were examined through a systematic bibliometric search of **Scopus, Web of Science (WoS), and Google Scholar**. These electronic repositories were selected because they represent highly selective indexation, accurate citation monitoring and broad coverage of multiple disciplines on peer-reviewed agricultural and biological sciences literature (Zhu, 2020). The use of multiple bibliographic databases provides broader coverage of multidisciplinary literature and improves the likelihood of retrieving studies relevant to fonio production, genetic resources, processing, nutrition and utilization. Fonio has over the years received increasing research attention because of its nutritional value, adaptability and potential contribution to food-system diversification (Jideani, 1999; Jideani *et al.*, 2012; Zhu, 2020). The search was conducted for articles within a time range of 30 years (1995 to 2025) mark to a time frame of transition from local traditional farming towards the modern biotechnological, genomics and climate smart agricultural techniques, and sustainable production systems. The search string was:

("fonio" OR "acha" OR "*Digitaria exilis*" OR "*Digitaria iburua*") AND ("production" OR "cultivation" OR "productivity" OR "seed system" OR "post-harvest") AND ("trend" OR "constraint")**

The search targeted titles, abstracts and author keywords. The terms *fonio*, *acha*, *D. exilis* and *D. iburua* captured the principal crop names, while the additional terms addressed major production-system dimensions. This approach reflects documented challenges involving production, processing, seed availability and utilization of fonio (Zhu, 2020). The wildcard * retrieved lexical variants such as *constraint* and *constraints*. Records were subsequently screened for relevance and duplicates before bibliometric analysis.

Inclusion/Exclusion Criteria and Document Screening

The initial database exploration yielded a raw dataset of publications that was subjected to a multi-stage screening and eligibility assessment to ensure thematic relevance and methodological consistency. The principles of transparent evidence selection as recommended by Page *et al.* (2021) was followed. The Inclusion criteria comprised primary research articles, systematic reviews, book chapters and conference proceedings published or publicly available in English and addressing the agronomy, production systems, seed systems, genetic diversity, processing, utilization or policy dimensions of cultivated *Digitaria* spp. The exclusion criteria included editorials, opinion papers, patents, duplicate/co-published records and studies examining *Digitaria* primarily as weeds, rather than as cultivated underutilized food crops. After the title and abstract screening, full-text assessment and duplicate removal, 452 publications met the eligibility criteria and were retained for final analysis (Figure 1) (Jideani *et al.*, 2012; Zhu, 2020; Page *et al.*, 2021).

Bibliometric Metrics and Network Mapping

Structural metadata from the final 452 publications, including annual publication output, author affiliations, countries, citation counts and author keywords, were exported in BibTeX (.bib) and comma-separated values (.csv) formats for analysis. Bibliometric analyses were conducted using VOSviewer version 1.6.20 and the Bibliometrix R package, which provide complementary tools for network visualization, thematic analysis, scientific mapping and quantitative bibliometric assessment (Aria & Cuccurullo, 2017). Annual growth in fonio-related publications were calculated with exponential regression models to characterize changes in research productivity over time. Three network-based analytical approaches were applied: (i) co-authorship analysis, (ii) keyword co-occurrence analysis, and (iii) citation-impact analysis, to examine collaboration patterns among researchers and countries; to identify dominant research themes and conceptual clusters; and to identify influential publications using Total Citations (TC) and Total Citations per Year (TCY) respectively. These approaches collectively provide a structured assessment of the intellectual, thematic and collaborative evolution of global fonio research (Aria & Cuccurullo, 2017).

Localization and Implications for Bauchi State

The final methodological phase linked macro-level globale- bibliometric evidence with the micro-level local socio-ecological context of Bauchi State, Nigeria. This enabled internationally



identified research priorities to be interpreted against field-level realities. Bibliometric mapping can reveal dominant research themes and knowledge gaps, but their practical relevance requires contextual validation within specific geographical and socioeconomic settings (Aria & Cuccurullo, 2017). Accordingly, major thematic clusters identified through the global analysis—including processing constraints, seed-system bottlenecks and decentralized breeding, were examined using the particular field realities existing in Bogoro and Tafawa Balewa Local Government Areas. This approach enabled international technological innovations on mechanized post-harvest handling, improved seed systems and climate-smart production to be translated into locally relevant intervention pathways (Jideani, 1999). Meanwhile, farmer knowledge, institutional conditions and production constraints were allowed to be integrated into the identified thematic clusters within the major fonio-producing regions of the state (Zhu, 2020).

RESULTS

The search strategy and filtering process resulted in a total conclusion of 452 individual research papers on fonio production systems, covering the period of study (1995 to 2025). The reports constitute a comprehensive content which allows for the analysis of bibliometric trends, spatial distributions, thematic clusters and value-chain constraints at the global level, with local reflections for Bauchi State.

Chronological Growth and Publication Trajectory

The publication record showed a clear and sustained growth in fonio research between 1995 and 2025. Publication output increased from 24 articles (5.31%) during 1995–2000 to 212 articles (46.90%) during 2019–2025, with the latter period accounting for nearly half of the entire 452-publication corpus. Mean citations per article also increased progressively from 8.4 to 28.7, indicating growing scientific visibility and impact. The results demonstrate a marked acceleration of research activity, particularly after 2013, suggesting increasing global ever-increasing research interest in fonio as an underutilized crop with potential relevance to food security, nutrition, climate resilience and sustainable agricultural development.

Table 1. Chronological Growth and Publication Trajectory

Year Range	Number of Publications (N)	Percentage of Corpus (%)	Cumulative Total	Mean Citations per Article
1995–2000	24	5.31%	24	8.4
2001–2006	46	10.18%	70	14.2
2007–2012	68	15.04%	138	19.5
2013–2018	102	22.57%	240	22.1
2019–2025	212	46.90%	452	28.7

Geographic Footprint and Collaborative Networks

Table 2 maps the spatial distribution and collaborative profile of fonio literature, demonstrating Guinea lead with the highest national research output (**106 publications**), followed by Nigeria (**90**) and Senegal (**55**). In contrast, France and other developed-country institutions showed substantially greater collaborative research (SCP), highlighting the important role of international partnerships in fonio research, particularly through institutions such as CIRAD, Wageningen University and other international research networks. The Nigerian contribution output is mostly concentrated in institutions across Plateau and Kaduna states. This underlines the regional research gap in Bauchi State, specifically within the Bogoro and Tafawa Balewa production hubs.



Table 2: Geographic Footprint and Collaborative Networks

Country/Region	Independent Research (MCP)	Collaborative Research (SCP)	Total Publications	Top Institutional Contributor
Guinea	84	22	106	IRAG (Conakry)
Nigeria	72	18	90	University of Jos / UNIBADAN
Senegal	41	14	55	ISRA (Dakar)
France	8	39	47	CIRAD (Montpellier)
Mali	22	11	33	IER (Bamako)
Other / Developed	19	102	121	Wageningen University (NL)

Note: MCP = Motor Country Publications (Intra-national); SCP = Single Country Publications (International Collaboration).

Intellectual Layout and Thematic Clusters

The mathematical co-occurrence network analysis grouping revealed four distinct thematic clusters, each representing a primary domain within contemporary fonio science (Table 3). The emergence of the "Food Science and Health" cluster confirms fonio's transition from a regional subsistence grain to a functional health food.

Table 3. Intellectual Layout and Thematic Clusters

Cluster ID / Color	Identified Core Theme	High-Frequency Keywords	Dominant Methodologies
Cluster 1 (Red)	Genetics & Breeding	Genetic diversity, SSR markers, landraces, decentralized breeding	DNA sequencing, PCR assays, phenotypic profiling
Cluster 2 (Blue)	Agronomy & Climate	Arid regions, climate-smart, drought tolerance, seed systems	Field trials, GIS niche modeling, soil analysis
Cluster 3 (Green)	Food Science & Health	Functional food, gluten-free, low glycemic index, dietary fiber	Proximate analysis, clinical trials, rheology
Cluster 4 (Yellow)	Socio-Economics	Indigenous knowledge, value chains, smallholders, processing	Participatory rural appraisals, economic surveys

Value-Chain Constraints and Bottlenecks

Table 4 ranks and describes the structural bottlenecks cited across the fonio literature, establishing post-harvest processing as the leading barrier to commercial scalability.



Table 4. Value-Chain Constraints and Bottlenecks

Identified Bottleneck	Value-Chain	Frequency of Mention (f)	Relative Impact Rank	Primary Scientific Consensus
Post-Harvest Deficiencies	Processing	184	1st	Manual sand-removal, de-husking, and cleaning restrict urban market acceptance due to remaining grit.
Underdeveloped Systems	Seed	112	2nd	Farmers rely mostly on saved seeds; there is a lack of certified seed breeders and formalized distribution.
Labor-Intensive Threshing & Harvesting		78	3rd	High labor requirements during harvesting lead to high grain losses and increased production costs.
Policy Neglect & Low Institutional Input		52	4th	National agricultural policies favor introduced staples (maize, rice), leading to a lack of processing subsidies.
Fragmented Local Chains	Local Value	26	5th	Poor market linkages between rural growers and urban consumers leave smallholders vulnerable to exploitative middlemen.

Local Implications for Bauchi State

The global research evidence identifies four major intervention areas, mechanized de-husking, decentralized breeding, functional-food utilization, and GIS-based climate niche modelling that can be directly translated into the production realities of Bauchi State. In Bogoro and Tafawa Balewa LGAs, these interventions are expected to reduce processing burdens, improve seed security and productivity, expand institutional and urban markets, and strengthen climate resilience. Collectively, they provide an integrated pathway for transforming fonio from a subsistence-oriented crop into a more productive, commercially viable and climate-resilient food commodity (Table 5).



Table 5. Local Implications for Bauchi State

Global Research Insight	Identified Local Bottleneck (Bauchi)	Targeted Intervention Strategy (Tafawa Balewa & Bogoro LGAs)	Expected Socio-Ecological Outcome
Advanced Mechanized De-husking	High grit content and tedious manual processing by rural women.	Deploy localized, solar-powered mechanical threshing units to women's cooperatives.	Cleaner grain products, reduced labor demands, and increased urban market entry.
Decentralized Breeding Successes	Lack of access to high-yielding, certified seed landraces.	Establish community seed banks and collaborative participatory breeding plots with state universities.	Improved local seed security, higher yields, and better adaptation to climate variations.
Functional Food Properties	Low consumer demand in urban centers and complete institutional exclusion.	Introduce fonio into local school feeding programs, hospital meals, and government canteens.	Diversified regional cereal diets and steady, guaranteed income streams for local farmers.
GIS Climate Niche Models	Shifts in rainfall patterns across arid and semi-arid savanna zones.	Map localized micro-climates to optimize planting dates and locate resilient expansion zones.	Decreased risk of crop failure and improved long-term climate resilience.

DISCUSSION

The bibliometric profile of 452 publications from 1995 to 2025 underscores fonio's transition from a relatively neglected traditional cereal to an increasingly recognized crop for nutrition, climate resilience and sustainable food systems. The accelerating growth in publications, particularly after 2001, reflects a paradigm shift in global scientific attention toward underutilized and orphan crops as strategic resources for diversifying food systems and strengthening food security under climate change (Ayo & Nkama, 2004; Burton *et al.*, 2026).

The identified notable spatial distribution highlights a significant geographical asymmetry in fonio research, where the intellectual and collaborative drivers are increasingly concentrated in advanced research systems, while the empirical field implementation remains rooted in West Africa, where fonio is traditionally cultivated (Burton *et al.*, 2026). In Nigeria, however, an important research gap persists with existing studies largely emphasizing the highland production areas of Plateau State, while the distinctive socio-ecological conditions of Bauchi State particularly Bogoro and Tafawa Balewa LGAs, remaining comparatively under-documented. This geographic and knowledge gap underscores the need for locally grounded research that connects global fonio research priorities with the specific production, ecological and socioeconomic realities of Bauchi State.

The thematic structure emerging from the keyword co-occurrence analysis serves as a key link between global research patterns and field-level realities in Bauchi State. Global agronomic evidence identifies fonio's short maturation period (approximately 80–120 days) as an important insurance measure that enables the crop to escape terminal drought and variable rainfall across the West African savannas (Burton *et al.*, 2026). Comparable resilience is reported among local fonio landraces in Bogoro LGA, where farmers maintain relatively stable production under fluctuating rain-fed conditions (Danladi *et al.*, 2025). However, this potential remains constrained by limited technical knowledge regarding optimal seed rates, sowing methods and other recommended agronomic practices (Danladi *et al.*, 2025).

Despite fonio's well-documented food, nutritional and health attributes, including its gluten-free nature, favourable nutritional profile and relatively low glycaemic potential, its consumption remains limited in urban and institutional markets in Bauchi State (Ayo & Nkama, 2004). This underutilization is closely associated with persistent post-harvest processing constraints (Ayo and



Nkama, 2004), which remain among the major barriers to the wider commercialization of fonio (FAO, 2011). Fonio threshing and de-husking are traditionally performed manually and are highly labour-intensive, with rural women often bearing much of the processing burden (Ayo and Nkama, 2004). Inadequate processing and cleaning can also result in excessive grit, sand and other impurities, compromising product quality and limiting access to formal and institutional markets, including school-feeding and health-facility programmes (FAO, 2011; Danladi *et al.*, 2025). Addressing these processing constraints is therefore critical to unlocking fonio's nutritional and commercial potential in Bauchi State.

For an increase in Bauchi State production, local agricultural production policies needs to more clearly focus on removing this processing bottleneck by replicating the use of locality-specific, mechanized clean processing equipment into the Bogoro and Tafawa Balewa production corridors.

CONCLUSION AND RECOMMENDATION

This study provides a scientific bibliometric assessment of 452 research articles published between 1995 and 2025, tracing the evolution of fonio production research, major constraints and emerging research priorities. The findings highlight a growing global scientific interest in fonio as a climate-resilient, nutritionally valuable and potentially sustainable crop, yet its adoption and commercialization in its production corridor in Nigeria and in Bauchi State in particular remain constrained by persistent value-chain bottlenecks. In the principal production areas of Bogoro and Tafawa Balewa LGAs, these constraints include traditional production practices, limited standardization of seed rates and intensive manual threshing, de-husking and cleaning. Addressing these bottlenecks requires employing relevant advances in climate-smart agronomy, improved seed systems, mechanized post-harvest processing and market development into decentralized, state-led extension services. Such interventions could substantially enhance fonio's contribution to food security, farmer livelihoods and sustainable agricultural development in Bauchi State.

Based on the synthesized trends and localized socio-ecological insights, the following interventions are recommended to strengthen fonio production, commercialization and sustainability in Bauchi State:

- The State Government, in collaboration with relevant agricultural engineering and research institutions, especially the Abubakar Tafawa Balewa University, should support the development and deployment of solar-powered hullers, threshers and destoners through women's processing cooperatives in Bogoro and Tafawa Balewa LGAs. This would reduce labour intensity, minimize grit and impurities, improve product quality and enhance access and competitiveness in formal urban markets.
- Building on the experience of the Bauchi State Agricultural Development Programme (BSADP), farmer field schools and extension programmes should promote evidence-based recommendations on seed rate, planting density, sowing time and crop management. Promising locally adapted landraces, such as Chid-wandad, should also be evaluated and promoted where agronomically appropriate to improve productivity and climate resilience.
- The State Government should establish structured public procurement and institutional feeding programmes that incorporate fonio-based foods such as *gwote acha* and *tuwo acha* into school-feeding programmes, public hospitals and government canteens. This would create predictable demand, strengthen local value chains and provide more reliable markets and income opportunities for smallholder producers.
- Community-managed seed banks should be established in collaboration with agricultural research institutions, universities and extension agencies to conserve locally adapted fonio genetic resources and improve farmers' access to quality planting materials. Such seed systems would strengthen local seed security, conserve agrobiodiversity and facilitate the dissemination of early-maturing and climate-adapted landraces.



REFERENCES

- Abdullahi, M. B., Idi, S. and Ahmed, A. (2014). Community Participation and Project Sustainability in Rural Nigeria. *African Journal of Sustainable Development*, **4**(1): 67-74
- Adelabu, S., & Franke, J. (2023). Quality assessment of agricultural bibliometric data across Scopus, Web of Science, and Google Scholar. *International Journal of Agricultural Information Systems*, **14**(2): 88–101.
- Adoukonou-Sagbadja, H., Wagner, C., Dansi, A., Ahlemeyer, J., Duttke, S., Akpagana, K., ... & Friedt, W. (2006). Genetic diversity and population structure of Fonio millet (*Digitaria exilis* Stapf) from West Africa: A comparative analysis using SSR and AFLP markers. *Theoretical and Applied Genetics*, **112**(8): 1578–1589. <https://doi.org/10.1007/s00122-006-0261-y>
- Aria, M., & Cuccurullo, C. (2017). bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics*, **11**(4): 959–975. <https://doi.org/10.1016/j.joi.2017.08.007>
- Ayo, J. A., & Nkama, I. (2004). Effect of Acha (*Digitaria exilis*) grain flour on the physico-chemical and sensory properties of bread. *International Journal of Food Properties*, **7**(3): 561–569. <https://doi.org/10.1081/jfp-200032971>
- Burton, G. P., Botey, H. M., Ceci, P., Chater, C., Gutaker, R. M., Jackson, A. C., Ryan, P., Seal, E. C., Turnbull, C. G. N., Vorontsova, M. S., Mattana, E., & Ulian, T. (2026). Impacts of climate change on fonio millet: Seed germination ecology and suitability modelling of an indigenous West African cereal. *Annals of Botany*, Advance online publication. <https://doi.org/10.1093/aob/mcag041>
- Cruz, J. F., Beavogui, F., & Drame, D. (2016). *Fonio: An exceptional cereal*. CIRAD/Presses Agronomiques de Gembloux.
- Danladi, S., Garba, A. A., & Sabo, M. U. (2025). Effect of seed sowing type and seed rate on the productivity of fonio (*Digitaria exilis* L.) in Bogoro, Bauchi State, Nigeria. *Nigerian Journal of Agriculture and Agricultural Technology*, **5**(1A): 139–156. <https://doi.org/10.59331/njaat.v5i1A.978>
- FAO. (2011). Food and Agriculture Organization. *Review of the African millet diversity*. Food and Agriculture Organization of the United Nations.
- Gyang, S. S., Jideani, I. A., & Jideani, V. A. (2019). Production, processing, and consumption patterns of acha (*Digitaria exilis*) in northern Nigeria. *Journal of Culinary Science & Technology*, **17**(4): 312–328. <https://doi.org/10.1080/15428052.2018.1465503>
- Jideani, I. A. (1999). Traditional acha/fonio (*Digitaria exilis*) meals of the Hausa people of Northern Nigeria. *International Journal of Food Sciences and Nutrition*, **50**(2): 105–115. <https://doi.org/10.1080/096374899101256>
- Jideani, V. A., & Jideani, I. A. (2011). Developments on the cereal grains *Digitaria exilis* (acha) and *Digitaria iburua* (iburu). *Journal of Food Science and Technology*, **48**(3): 251–259. <https://doi.org/10.1007/s13197-010-0208-9>
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., ... Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, **372**, Article n71. <https://doi.org/10.1136/bmj.n71>
- Zhu, F. (2020). Fonio grains: Physicochemical properties, nutritional potential, and food applications. *Comprehensive Reviews in Food Science and Food Safety*, **19**(6): 3365–3389. <https://doi.org/10.1111/1541-4337.12608>