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Cassava Processing and Rural Economic Change in Igalaland, Nigeria, 1967–2020: Technology, Labour and Commercialisation

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Abstract

Background and Aims: Cassava processing has contributed to agricultural livelihoods and rural economic activity in Igalaland, Nigeria; however, processing practices remain insufficiently examined. This study investigated technological change, labour organisation, and commercialisation in cassava processing across Igalaland between 1967 and 2020.

Methodology: A qualitative historical approach was employed, drawing on oral-history interviews conducted during 2022–2023, supplemented by field observations and published scholarship. Seventeen informants—including farmers, processors, traders, agricultural extension officers, community representatives, and knowledgeable residents—were interviewed in Anyigba, Egume, Ikanekpo, Ojapata, Agojeju-Ajocheji, and Abocho. Evidence was organised thematically and chronologically and compared across communities and processing stages.

Results: Technological change was gradual, selective, and uneven. Traditional practices, particularly manual sieving and frying, persisted alongside the increasing use of motorised graters and hydraulic presses. These technological shifts affected labour organisation and production processes. Nevertheless, available evidence permitted only limited conclusions concerning machine ownership, control over processing income, and the economic position of gender groups. Processors integrated established practices with newer technologies according to production conditions, labour requirements, capital constraints, equipment availability, market demand, and processing knowledge. Consequently, technological adoption did not follow a uniform progression from manual to mechanised production.

Conclusion: Cassava processing in Igalaland developed through adaptive combinations of traditional practices and selected technologies rather than through a linear transition from traditional to modern systems. The findings highlight processors' agency in responding to local production realities while demonstrating the need for further research on ownership, income distribution, gender relations, and the commercial consequences of mechanisation.

Keywords: Cassava processing; Igalaland; Rural economic history; Technological change; Gendered labour; Commercialisation; Local knowledge

Introduction

Fresh cassava roots are very perishable and have to be processed into storable, consumable, and tradable products in order to occupy an important place in the economic and social life of many Nigerian rural communities. Typical processing steps for cassava to gari include peeling, washing, grating, dewatering/pressing, fermentation, crumbling, sieving, and roasting/toasting, although the processing sequence and techniques may differ based on location and processing methods (Grace, 1977; Balagopalan et al., 1988; Ndjouenkeu et al., 2021). Such activities are not only able to change the nature of the biological crop into a food commodity, but also to organise labour and provide opportunities for rural economic activities and link cassava production to local and wider markets. The quality attributes of gari such as colour, appearance, texture, taste and smell, which are significant to both processors and consumers, are also influenced by the technical characteristics of the processing methods (Awoyale et al., 2021; Ndjouenkeu et al., 2021). Cassava processing has thus always been linked to the history of the technologies, working arrangements, preferences for products, and markets in which cassava became economically valuable.

The traditional activities of cassava processing were an important link between cultivation and consumption of cassava and the rural economy in Igalaland, especially in the processing of gari. Women have important roles in cassava processing and marketing all across Nigeria and other parts of sub-Saharan Africa, but roles differ by locality, production arrangements and access to productive resources (Doss & Morris, 2000; Doss, 2001; Forsythe et al., 2016; Ndjouenkeu et al., 2021). The emergence of new processing technologies, however, had consequences beyond changes in technology for the way in which the labour was organised to process the cassava. Technological adoption must not be equated

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with women's economic empowerment because factors such as access to complementary factors, labour, and decision-making opportunities can shape who gains from innovations in agriculture (Doss & Morris, 2000; Doss, 2001). The value of technological change in Igalaland thus has to be evaluated within the framework of the organisation of the process of production, not in terms of betterment for any individual group of women.

This article looks at the transformation of cassava processing in Igalaland from 1967 to 2020. The period is not treated as a single technological turning point but as a historical period in which the processing practices have changed, which can be traced back by means of retrospective oral information and published data. The first year of the period gives an idea of the historical baseline before the growing use of mechanised equipment, and the end of the historical reconstruction is taken as 2020. The study does not, therefore, assert that technological change started in the year 1967 in general or that there was an innovation in that year. Instead, the period is used to look at the patterns of continuity, technological incorporation, and change in the selected communities over a longer time frame.

There is enough existing scholarship on the technical, economic, and gendered knowledge on cassava production and processing, including research on the technologies for processing, cassava markets, value chains, product quality, and the role of women in cassava-related activities (Doss, 2001; Forsythe et al., 2016; Awoyale et al., 2021; Ndjouenkeu et al., 2021). Fewer studies, however, have focused on using technology to reconstruct the process of technological change over long periods of time in specific rural communities. This is important because the availability of a technology does not mean that it will be adopted immediately or uniformly. Studies of agricultural technology in Africa suggest that there is significant variation in the benefits of technologies and in the factors that limit their adoption (Doss & Morris, 2000; Adejumo et al., 2020; Suri & Udry, 2022). Local processors can then use some technologies and keep older processing technologies within their operations depending on production scale, labour availability, the capital needed, equipment availability, maintenance conditions, market opportunities and locally valued production practices. The historical question raised in this article is therefore not just about the introduction of new technologies; it is about the transformation of processing practices over time, and about the specific technologies that were brought in, kept and/or only partially utilised in different local contexts.

The results studied in this article show that the changes took place at various stages of the cassava-processing process and not at the same time and in the same process. Use of motorised graters gradually replaced manual graters, and use of pressing with ropes was supplemented or replaced in some settings by use of hydraulic presses, with locally-made bamboo sieves supplemented by manufactured sieves made of perforated iron or polyethylene. The same variability in cassava processing methods has been reported in broader research on gari production, where it was found that processors have different technological variants, depending on the locality, and their processing aims and product preferences (Grace, 1977; Ndjouenkeu et al., 2021). Meanwhile, manual sieving and frying remained the predominant methods that heavily depended on human labour and experience. The simultaneous presence of older and newer practices is, therefore, very salient to this historical pattern that is found in this study. The process of cassava processing did not proceed smoothly from one technological system to another, but rather, particular technologies were selectively integrated into current production technology.

Research Objectives

The general aim of this study is to discuss the historical evolution of the practices of processing cassava in Igalaland, Nigeria, from 1967 to 2020, emphasising the technological innovations, organisation of processing labour, and causes of adoption or retention of specific processing techniques. The study specifically seeks to: (1) discuss the significant changes in cassava processing in the selected communities in Igalaland from 1967 to 2020; (2) analyse the impact of changes in cassava processing technologies on the distribution and organisation of processing labour, especially the gender distribution of specific processing activities; and (3) review the socio-cultural, economic, technical and cultural drivers of cassava processing technologies that were adopted, adapted and/or continued for their use in Igalaland.

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Research Questions

The following research questions guided the study.

1. What are the main changes that have taken place in the processing of cassava in selected communities of Igalaland from 1967 to 2020?

2. What were the impacts of technology changes in cassava processing on the organisation and distribution of processing labour, especially the gendered allocation of specific processing labour?

3. What were the economic, technical, social and cultural determinants of the adoption, adaptation, or failure to adopt specific technologies for cassava processing in Igalaland?

Literature Review

The scholarship related to cassava processing in Igalaland can be categorised into four interrelated fields: technical research around cassava processing; studies of technological change and innovation; economic and market research around cassava processing; and gender and labour research in cassava value chains. Combined, these works of literature create a technical, economic, and social context for the value of cassava processing, but allow for a community-level history of the introduction, adoption, or adaptation of specific processing technologies over time.

Technical Studies of Cassava Processing

Cassava Processing is a series of interconnected operations that convert fresh cassava roots into products that are suitable for consumption, storage, and exchange. For gari, the major processing operations include peeling, washing, grating, dewatering or pressing, fermentation, crumbling, sieving, and frying, but the sequence and equipment employed vary depending on the processing environment (Grace, 1977; Balagopalan et al., 1988; Chuzel, 2001). More recent studies also indicate that there are multiple technological configurations in cassava-processing systems, not just one standardised process. Equipment types for grating, pressing, sieving, and frying differ, as does the process organisation of the different process steps (Ndjouenkeu et al., 2021; Akpoghelie et al., 2025).

The technical literature is therefore important to understand the processing sequence of cassava because a change in one processing stage does not necessarily equate to a change at another processing stage. As an example of research on gari production, the production process is linked not only to the technical aspects but also to the product properties desired. Processing options and consumer preferences are affected by the colour, texture, taste, aroma, and other quality characteristics (Ndjouenkeu et al., 2021). The addition of a new piece of equipment does not automatically mean that the existing equipment is abandoned in the other steps of the processing. Previous processing systems may continue to be effective if they are appropriate for product needs and if sufficient labour and local expertise are available.

Research on the processing technologies of the Nigerians confirms this. In a study of the technological needs of the users in cassava processing in Oyo State by Odebode (2008), the cassava processors had motorised graters, vibrating sieves, abrasive peelers, drum dryers and screw-jacks, which is a combination of the established and improved technologies. The study further recognised high equipment costs, transportation challenges, poor infrastructure, lack of labour, and also financial and market access as challenges to technology utilisation. Likewise, Fatuase et al. (2020) reported that the Ekiti State processors employed different types of processing equipment such as sieves, millers, peelers, hydraulic presses, graters, and dryers, and the number of technologies applied was correlated with processing experience, education, processing costs, and quantity of cassava processed.

In combination, the studies in this collection indicate that processing of cassava is not a technology that can be viewed as a linear progression of one technology replacing the other. Instead, various technologies can be applied in a single processing enterprise, and the use of the technologies can differ depending on the nature of specific processing steps and the circumstances of processing. This insight is of importance in the context of Igalaland, as manual sieving and frying were still the methods used, and further evidence within this study suggests that the incorporation of motorised grating and hydraulic pressing would be feasible.

Technological Change and Adoption

Research on agricultural technology adoption also shows that the presence of technological possibilities does not suffice to ensure that a technology is adopted consistently or widely. Abdoulaye et al. (2014) documented and identified evidence of farmers' use of improved cassava varieties and local cassava varieties at the national level based on 952 cassava farmers across four regions in Nigeria, who were using both household processing machines and commercial processing services. They also found a relationship between the availability of grating machines and the use of improved cassava varieties, which means that production and production technologies do not develop independently of each other.

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Implication: technology use is part of the larger production system. Furthermore, processing experience, education, family size, processing cost, and amount of cassava processed were correlated with the number of technologies adopted by cassava processors in Ekiti State (Fatuase et al., 2020). Similarly, research among rural women in Vandeikya, Benue State, also identified characteristics of processors and processing circumstances associated with improved cassava-gari processing technologies (Vihi et al., 2022). Awoyemi et al. (2020) identified constraints to cassava processing technologies use by the rural women processors in Kwara State, who once again showed that even when technology is available, economic and infrastructural conditions can affect its use.

The evidence of the study from Kogi State is in particular enough to be significant to the present study. Ocheni et al. (2024) reported high adoption of the recommended technologies among women cassava processors in Ankpa, with the mechanical grater having the highest rate of acceptance. The rate of adoption was, however, found to differ with various factors such as age, household size, and experience in the processing. The study is contemporary rather than historical, but it is located in Kogi State, which shows that the technological adoption in cassava processing is already a research problem in the region.

The wider literature therefore suggests that adoption is a process that is influenced by economic resources, access to equipment, experience, labour needs, processing scale, and institutional or infrastructural conditions, but not just technological availability. This is in line with the broader idea that agricultural technologies can have diverse impacts on various users and contexts (Suri & Udry, 2022). The following historical study extends this discussion, asking how these processes of incorporation, adaptation, and continuity went in Igalaland over a longer period of time.

Cassava Processing, Commercialisation and Rural Markets

Cassava processing is also significantly tied up with the development of rural markets, in that the processing activity allows the cassava, which is highly perishable, to be converted into storable, transportable, and exchangeable products. Literature related to the value chain of cassava in Nigeria therefore reveals that the processing sector plays a significant role between cassava production and markets for consumption. Olagunju et al. (2012) were among the studies that investigated the market structure, market conduct, and market performance of the gari-processing industry in southwestern Nigeria, highlighting the economic importance of the processing beyond subsistence level.

The urban market also plays a significant role in rural production. Ospina-Patino and Ezedinma (2015) conducted a study to explore the relationship between the urban and rural markets of cassava products in Nigeria, emphasising the role of market linkages in influencing the movement and commercialisation of cassava products. These kinds of connections are helpful in understanding the potential of an increasing role for processing technology as cassava transitions from the domestic market to broader commercial markets.

Research on the value chain more recently shows that the distribution of economic benefits is not always symmetrical along the chain. Donkor et al. (2022) identified gender differences in participation among cassava value-chain actors in Oyo State, where men were more represented in production while women were more represented in the processing and marketing value chain. It was also observed that there is a disparity in income distribution between farmers and processors/ traders in the study area. In a similar vein, Apata (2019) highlighted the significance of control of productive resources and household decision-making in the gender dimension of cassava commercialisation.

The present study is significant due to these findings, which suggest that commercialisation does not necessarily mean total mechanisation, nor does it mean that it leads to the same economic improvement for all. As markets grow larger, processors may be tempted to use equipment that will ease physical burden or allow processing at an adequate size; the extent of the incorporation of specific equipment will depend on the local economic and technical circumstances. The historical experience of Igalaland can thus be discussed in terms of a process that involved the interplay of market opportunities with the existing processing arrangements, and not just a simple path towards fully mechanised production.

Gender, Labour and Cassava Processing

Organisation of labour in cassava processing is an important dimension of gender, as work in the processing of cassava has been differentiated. In Nigeria, it has been noted that men and women may be involved in various steps of cassava-related activities. Odebode and Adetunji (2015) reported gender variations in cassava-processing operational activities in Ogun State; men and women engaged in different activities in the overall processing sequence. This helps to approach the processing of gender in the context of labour allocation and task organisation, instead of assumptions about gender roles.

Women's work is not simple with technology. Odebode (2008) listed some of the issues that hampered the use of cassava processing technologies, which include labour shortage, equipment cost,

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infrastructure, and availability of financial resources. The constraints illustrate why the same consequences do not occur with the introduction of a technology in all processors. The technology can change the physical nature of a specific task, but can leave other labour-intensive tasks untouched.

More recently, in north-central Nigeria, this distinction is supported. The livelihood outcomes of the women using the conventional and improved cassava-processing technologies were compared by Adeniyi et al. (2023), and differences were found between the two. This type of evidence can be employed to show that technology can have wider socioeconomic effects, but should not be brought in directly to the historical case that is being studied here. There is insufficient evidence in the present study to arrive at gender differences in machine ownership and processing income or economic empowerment. Rather, it focuses on how technological change influenced the organisation and distribution of the processing labour.

The literature thus backs an analytical stance that is more cautious. It is undeniable that women are very involved in cassava processing, but the involvement does not necessarily mean they have control over productive resources, nor is it an indicator of economic empowerment. The distinction is significant for a historical study where oral evidence is a source of information that comes from the past. In the present study, gender is considered first as a dimension of labour organisation and task allocation.

Technological Change, Continuity and Adaptation

The above literature collectively undermines a straightforward view of technological development as a process marching from older technology to newer technologies. Technical studies reveal that cassava processing can be done in several stages that can be changed independently; adoption studies have revealed that the adoption of technology depends on economic and social conditions; market studies have revealed that changes in technology produce changing incentives, which do not necessarily produce uniform outcomes; and gender studies have revealed that technology changes interact with existing labour arrangements. These strands collectively indicate that technological change could include the use of specific innovations and others that have already been used.

Adaptive technological change is a helpful framework for integrating these aspects. Ruttan (1977) focuses on the relationship between technological change and changes in economic conditions with his concept of induced innovation. Rogers' (2003) diffusion perspective focuses on the diffusion of innovations within certain social systems and over time, while David's (1985) discussion about technological path dependence emphasises the influence of prevailing practices, skills and technological arrangements on future choices. These opinions do not imply a sequence in which technological development occurs. Instead, they offer complementary approaches to explaining why some technologies are taken up, others are adapted, others are integrated with other existing practices, and others are not taken up.

Empirical evidence on this subject can be found in the Nigerian cassava literature. Abdoulaye et al. (2014) reported that both local and improved varieties were used by farmers, and farmers had both household and commercial processing systems. Odebode (2008) also reported on the utilisation of existing and improved processing techniques by cassava processors. Fatuase et al. (2020) also found that there were differences in processing technologies in cassava processing enterprises. This sort of evidence indicates that technological change can happen in a piecemeal fashion, by the incorporation of specific technologies, not by the wholesale replacement of an existing technological regime.

This approach is especially useful in the study of cassava processing as there are several interconnected steps involved in the process, such as grating, pressing, sieving and frying. If one stage changes, it doesn't mean that all other stages change. Thus, in a system for processing, two or more technological arrangements can be utilised, and processors can use the traditional methods as well as newer alternatives as they see fit. Technologies or practices may be adopted or maintained due to factors including equipment availability, processing needs, labour, capital, market factors, technical compatibility and knowledge.

In the literature, therefore, technological change is considered a process of continuity, selective incorporation, and adaptation. Most of the past research, however, has focused on specific technologies, on adoption conditions, or on current processing practices. Few studies have focused on trying to reconstruct these processes over a long period of time for a particular rural environment. This restriction is especially important for the processing of cassava in Igalaland, as the history of the practice has not been well established from 1967 to 2020. This study tackles this issue by analysing technological change as a historical process, in which other practices, new technologies, labour organisations, and local contexts intertwined over time.

Historical Context and Gap in the Literature

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Cassava processing in Igalaland should be analysed in the context of the broader process of agricultural and rural economic transformation in the region. Cassava began to play a greater role than ever as a food crop, but also in regard to the products of its processing for consumption and exchange within the household. The practical requirements of processors have also shifted with the development of processing and its linkage to production and marketing systems. These developments have led to conditions where certain practices in the processing of existing technologies were able to be retained, adapted, or replaced by new technologies. The historical importance of these changes is not to be found in the mere replacement of previous techniques, but in the nature of the changes in production conditions, labour needs, market opportunities, and equipment availability that faced processors.

Assessment of available evidence indicates that cassava processing was organised in a series of operations, and the rate of change was not equal across the various operations. Previously, most processing was carried out manually and with locally available implements. For instance, grating was very labour-intensive if done manually, and pressing or dewatering was also a labour-intensive process. Materials from the local area were also used for sieving, and frying was still closely related to the practical knowledge and direct control of the processing conditions. The practices were embedded in existing skills and routines and so offered a technological and organisational foundation for the later changes.

Newer processing options were introduced during the study period and were added to some of the processing locations. The use of motorised graters eliminated the need for total manual grating of cassava, and hydraulic presses were used to dewater grated cassava. The manufactured sieve materials were also added to the locally produced sieves. These changes, however, were not simultaneous across different levels of processing, nor was it always the case that a new technology would drive out an already established practice. Traditional methods, such as manual sieving and frying, still heavily relied on the skills and manual labour of people. The processing system then allowed for the simultaneous application of several technological arrangements at different processing steps.

This historical sequence is significant as it demonstrates that the technologies employed to process cassava changed and that there were multiple ways of responding. In some cases, a proven technique could be aided by a newer technology, and in other cases, a technology alternative could be used without changing the rest of the process. Alternatively, processors may also have a combination of technologies or may have existing technologies that they keep even though newer technology is unavailable, undesirable, cost-prohibitive, or not compatible with current processing needs and product requirements. The progression of cassava processing in Igalaland can therefore be viewed as a gradual process of technological incorporation and adaptation, instead of a single event, from one technological system to another.

The literature of the past has started to create the wider economic framework in which agriculture and food production systems have evolved and flourished in Igalaland. The significance of food production and local economic organisation in the area in the pre-independence days is illustrated in Ineke's (2025) research on the food economy of colonial Igalaland. A post-independence history of cassava-processing practice at the community level, however, has been given much less attention in the time period from 1967 to 2020. The existing technical and adoption studies offer valuable evidence on cassava processing technologies, their utilisation, product quality, and factors affecting technology adoption (Abdoulaye et al., 2014; Adejumo et al., 2020; Awoyemi et al., 2020; Fatuase et al., 2020; Ndjouenkeu et al., 2021; Ocheni et al., 2024). Much of the literature, however, focuses on specific technologies, sites, or conditions of contemporary adoption, not the longer historical trajectory of the evolution of processing practices in a particular region.

The geographical gap and historical gap are therefore the gaps that the present study addresses. The geographical scope of the study is limited to selected communities in Igalaland where a lack of reconstruction of cassava processing organisation and integration of processing technologies has been identified. Historically, it looks at the timeframe 1967-2020 as one of slow and uneven technological progress and not as a time of predetermined mechanisation. The study is then interested in the modifications of specific processing practices, the relative stability of certain processing steps, the restructuring of processing labour and the economic, technical, social and cultural factors that influenced processing technologies, and their adoption, adaptation, combination, or persistence.

As a reconstruction, it offers the historical context for the interpretation of evidence using the study's analytical framework. Technology change is not a simple process from existing technologies to new technologies; the study explores the dynamics of changing conditions, available technologies, local choice, and the persistence of accumulated knowledge and practice.

The model offers guidance for understanding the history without making the assumption that technological change was linear or inevitably advancing. It points out the relationship between

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technological advancements and the circumstances of processors' work. The analytical proposition of this study, therefore, is that the nature of cassava processing changes was determined not only by technology availability per se, but also by the practical match of some technologies to local labour arrangements, economic resources, production conditions, market conditions, and the knowledge of processing that was already in place. The co-existence of older and newer practices and the differential uptake of mechanisation within the cassava processing sequence in Igalaland is, therefore, explained in the model.

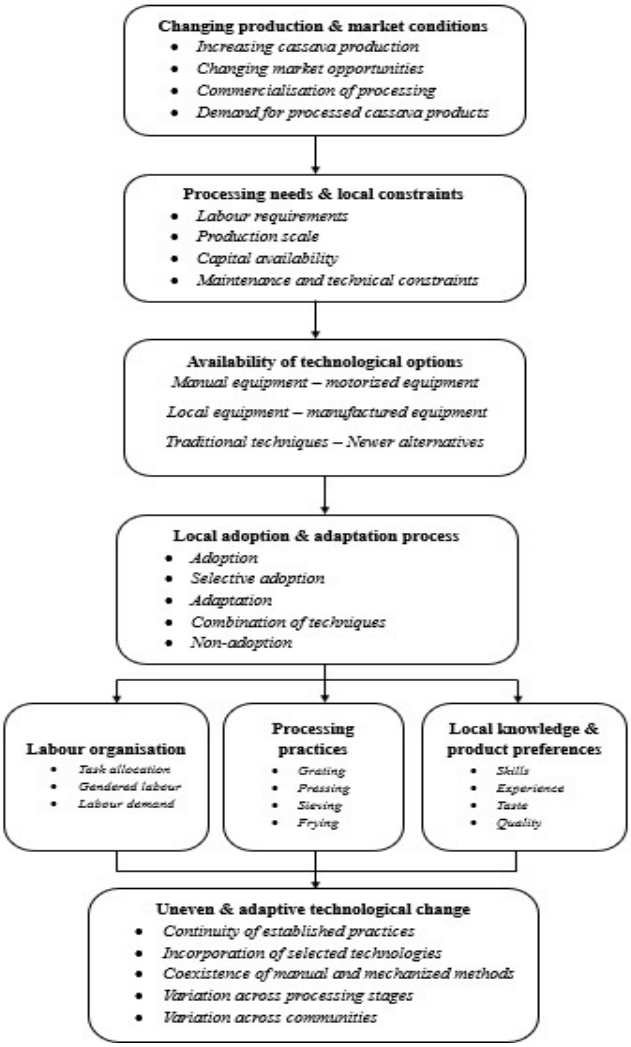


Figure 1: Analytical Model of Adaptive Technological Change in Cassava Processing in Igalaland, 1967–2020

Methodology

This study is qualitative and historical in nature, and aims to analyse the changes in cassava processing methods in Igalaland from the year 1967 to 2020. The method is suitable because the study aims to explain the evolution of processing technologies, processing organisation, and their links to rural economic life over a long period of time. The study is based primarily on oral-history interviews in which respondents were asked to answer questions, supplemented by secondary sources from documents and publications, and field observation. Oral history is important to the process of reconstructing parts of the rural economic history for which there are no continuous written records and can also be used to back up the written records, but it does need careful interpretation because memories of events several decades removed from the present can be inaccurate or incomplete in either detail or accuracy (Thompson, 2000).

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Study Area and Scope

It is a study of selected communities of Igala land in the present-day Kogi State of Nigeria. The communities that were covered included Anyigba, Egume, Ikanekpo, Ojapata, Agojeju-Ajocheji and Abocho. These communities were selected as the geographical setting to assess the variations in the processing of cassava and the experiences of people engaged in cassava-related activities. The study period is divided into history (1967–2020). The time span presented is the temporal limit of the historical reconstruction, but does not indicate a specific time when a given processing technology was adopted or when technological change ended in 2020.

Participants and Sampling

About six villages were purposively selected, giving rise to 17 participants. The information was obtained using purposive selection from people who have relevant experience and knowledge about cassava cultivation, processing, market, consumption, and changes over the years in the cassava processing industry. The participants included elders, community leaders, farmers, traders, women cassava processors and marketers, and youths. These categories were added to reflect various views on the evolution of cassava processing and its different economic and social value among the communities.

The participation of women was significant because women play significant roles in many African settings in cassava processing and marketing activities, and their experiences may yield insights into the organisation of processing labour and economic activities that may be of interest but may not be given adequate attention. The participation of women in the research, however, should not be interpreted as all women having the same economic status or the same control over the processing resources or income.

Data Collection

The researcher visited the selected communities to conduct the interviews orally. The interview questions were related to the history of cassava processing, the previous and later processing methods, experiences of the participants, organisation of the processing processes, selling, and socio-economic status of cassava processing in their communities. In addition, the issues of different processing stages (grating, pressing, sieving, and frying) were discussed in relation to changes in processing equipment and practices.

The researcher took written notes of participants' responses during the interviews. The interviews were also audio-recorded with participants' permission, using a mobile phone. The recordings were done to capture the participants' narratives and to help the researcher in decoding and presenting their testimonies. The oral data were considered to be retrospective historical evidence and used mainly to discover more general trends of continuity and change, and were not used to date events with accuracy, nor were they used to quantify changes in processing performance if the latter could not be measured.

Ethical Considerations

Oral evidence was collected while adhering to ethical guidelines. The researcher introduced himself to the interviewee and explained the purpose of the study before the interview. Participation was voluntary, and consent was obtained before the interviews and prior to audio recording. The participants were told that the information they gave would be for academic purposes.

The study thus makes a distinction between information that is offered as testimony of the personal and information that is established independently by documentary or published evidence. Oral testimony was then evaluated with documentary resources and field notes and relevant secondary resources to provide confirmation and context to the information gathered in the interviews. Oral evidence was presented with caution when there was insufficient evidence in the retrospective accounts to warrant precise chronological or quantitative claims, or when they were not able to make a precise claim for the oral evidence.

Sources and Corroboration of Evidence

Field observation and documentary and secondary sources were used to supplement the primary oral evidence. The local evidence was interpreted using the published findings from the cassava-processing technologies, the agricultural technology adoption, and the cassava markets and gendered labour. Where possible, documentary sources and secondary sources were also consulted to place the events in the history of Igalaland in the general context of cassava processing and rural economic transformation in Nigeria and other African settings.

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It was not understood that all oral evidence had to be backed up by a written documentary record for corroboration. Instead, evidence from various sources was analysed for patterns, to better understand the context of specific observations, and to avoid overreliance on isolated recollections of the past as a basis for claims of historical change. This is particularly relevant for a study spanning many decades, where memories of previous practices could capture important information on technological and social change but not necessarily give precise chronological information.

Data Analysis

The evidence was analysed both thematically and chronologically. Evidence was analysed chronologically to establish broad patterns of continuity and change in cassava processing from 1967 to 2020, and thematically to group the evidence under the headings of technological change, processing practices, labour organisation, marketing and socio-economic importance of cassava processing.

The analytical sequence was important to provide an organising structure, especially for grating, pressing, sieving and frying. Comparisons were also made between the different selected communities to find similarities, differences and variations in the use of processing technologies. Special focus was paid to the selection of technologies, selective adoption, adaptation, or the combination with established practices vs. not adopting technologies.

The analytical model developed for the study was used to guide the analysis. Technological change is interpreted as a process influenced by production and market conditions, processing requirements and local constraints, technological alternatives, local adoption and adaptation, labour organisation, processing practices and local knowledge and product preferences. This way, technological change can be interpreted without assuming that the technology could progress more or less evenly from an old technology to a new one.

Gender was dealt with firstly with regard to labour organisation and distribution in processing. It therefore explores the involvement of various gender groups in specific processes and the ways in which technology influenced the organisation of these processes. There is, however, no conclusive evidence on gender differences in machine ownership, control of processing income, access to credit and to wider economic empowerment. Any such statement is therefore not made as a conclusion of the study.

Limitations of the Historical Evidence

The results should be interpreted with caution in view of the following limitations.

First, the oral interviews were done in 2022 and 2023 in order to capture events leading back to 1967. The evidence, therefore, is more appropriate for suggesting general trends of continuity and change than for pinpointing the exact timing of the development of each individual technology.

Secondly, the study lacked the quantitative data normally collected for processing time, machine throughput, fuel consumption, and labour productivity. Thus, when discussing the impact of mechanisation, the emphasis will be on documented experiences, practices observed, and plausible trends from history rather than efficiency measures.

Third, the evidence available is too weak to draw any meaningful conclusions on who owns the machines, who controls the processing income, who gets credit, or the overall economic empowerment of women. Fourth, the study is not statistically representative of the communities in Igalaland, since it has been conducted in only certain communities, and the participants are purposively selected. Lastly, while oral history was taken into account in conjunction with documentary and published secondary sources, this study does not attempt to provide a comprehensive history of the cassava processing process in the region through the use of an archival approach.

The restrictions are not inconsistent with the historical reconstruction. Instead, they set the scope of the evidence from the study, the findings of which are to be treated as an interpretation of technological, labour and economic changes in cassava processing from 1967 to 2020 – in a community-level manner.

Results

Changes in Cassava-Processing Technologies

From the results of selected communities, it is seen that the practice of cassava processing has successively changed over the years during the study period, but the changing process is not uniform throughout the processing stage. Rather, certain technologies were integrated into established

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processing systems, and some practices remained the same. This led to a pattern of technological coexistence and of selective adoption and adaptation instead of the abandonment of previous practices.

The changes were more noticeable in the stages of grating, pressing and sieving. Motorised grating equipment was gradually replacing manual grating, and rope-based dewatering methods in some processing situations were increasingly being replaced by hydraulic presses. Likewise, locally-produced bamboo sieves remained in use in concert with manufactured bamboo and metal sieves with perforations and polyethylene sieves. These changes suggest that this technological development took place at certain junctures in the processing sequence and not all at once.

Practical knowledge and familiarity with accepted processing techniques were also apparent; e.g., in sieving and frying, manual methods continued to be used. The presence of multiple technologies indicates that the use of new technology need not have rendered the preceding technologies obsolete. Instead, processors used the available technology and the set of techniques that they were already using based on the specific requirements and conditions of processing.

This is in line with broader studies of cassava processing that show significant variation in processing technologies and practices in different locations. The various stages of cassava processing are not necessarily mechanised in their entirety; mechanisation may vary from one stage to another, depending on production conditions, labour needs, availability of machinery, capital availability, and product considerations (Grace, 1977; Balagopalan et al., 1988; Chuzel, 2001; Ndjouenkeu et al., 2021). In the same way, the evidence from Igalaland suggests a process of integration of selected technologies into the existing systems, with the other practices continuing.

The results thus indicate that technological progress in cassava processing in Igalaland was differential both within and between processing stages and in the local settings. The evolution of the industry is better seen as a process of selective technological incorporation and adaptation rather than a straightforward transition from a given technological system to another.

Table 1. Broad Chronology of Changes in Cassava Processing Practices in Igalaland, 1967–2020

Historical period	Processing practice/equipment	Character of change	Evidence-based interpretation
Earlier period within the study span	Manual grating	Established practice	Cassava roots were grated manually using locally available equipment.
Later period within the study span	Motorised grating	Selective incorporation	In some processing situations, motorised graters were gaining ground, and a small amount of manual grating was not going away.
Earlier period within the study span	Rope-based pressing/dewatering	Established practice	Much of the dewatering was done manually, and with pressing arrangements that were available locally.
Later period within the study span	Hydraulic pressing	Selective incorporation	In some cases, hydraulic presses were added, and the technical organisation of the dewatering stage changed.
Earlier and later periods	Bamboo sieving	Continuity with adaptation	In some contexts, locally-made sieves continued to be used in processing.
Later period within the study span	Perforated metal and polyethylene sieves	Material/technical change	Known sieve materials and known sieving methods were used in combination with the manufactured materials.
Earlier and later periods	Manual frying	Strong continuity	Frying continued to be heavily, if not almost exclusively, reliant on

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Historical period	Processing practice/equipment	Character of change	Evidence-based interpretation
			the human operator's skill, control and practice of processing conditions.
Throughout the study span	Combination of processing methods	Uneven technological change	There was individual variation in processing stages, with both older and newer methods being used.

Source: Reconstructed from retrospective oral-history accounts as well as field observations

Grating: From Manual to Motorised Processing

One of the important processes during production of cassava is grating, since the peeled cassava root should be mashed as small as possible before it is pressed, sieved, and processed. For the previous processing methods mentioned by the participants, grating was done using hand graters. It involved a hand grater and required a lot of manpower. Manual grating was therefore tightly coupled with the household and community-based organisation of cassava processing, where processors participated in various stages of the processing sequence.

During the study period, manual grating gradually started to be used in conjunction with motorised grating equipment in parts of the study area. It is not proven that motorised graters were introduced across Igalaland at a particular time. Instead, there is historical evidence that the use of motorised equipment to process cassava has been more gradual. This difference is significant since it indicates that the presence of a technology does not always lead to its rapid or even simultaneous adoption in a community.

The addition of motorised graters led to the grating stage being re-organised so that less of it was carried out manually. Retrospective accounts correlated motorised grating with a decrease in labour required for grating and an increase in the amount of cassava processed per day. The results are used as anecdotal evidence of local processors' experiences, but are not quantitative measures of technological efficiency, because there are no standardised measurements of processing time, throughput, fuel consumption, and labour productivity. However, the accounts provide some insight into the practical appeal of motorised grating, as processors had to process larger amounts of cassava that made manual grating more challenging.

The use of motorised grating is another example of the selectivity of technological changes in the study area. The motorised grater did not necessarily imply mechanisation of the entire processing system. The other processing stages required a significant amount of manual labour and local skills. Therefore, a complete processing flow was developed, including motorised grating, in which various technologies could coexist.

The phenomenon in Igalaland reflects the pattern that is found in other studies regarding cassava processing technologies from place to place and the different phases of processing that can be mechanised to different extents. The experience of cassava processing has been recorded, both with manual and mechanised equipment, and the technological options have been influenced by the local processing conditions and product requirements (Grace, 1977; Balagopalan et al., 1988; Chuzel, 2001; Ndjouenkeu et al., 2021). Research on agricultural technology adoption also shows that other factors such as the benefits that can be gained, labour availability, the size of the production, and the availability of equipment can affect the adoption of agricultural technology besides technical characteristics of the technologies (Doss & Morris, 2000; Suri & Udry, 2022).

The importance of the introduction of motorised grating in Igalaland is therefore not just about replacing a hand tool with a machine but the reorganisation of one of the processing stages. Manual and motorised methods of grating might be used side by side; the decision between them might be dictated by local conditions. The evidence thus suggests that technological change in cassava grating has not taken place in a manner of a one-to-one replacement of technology but in a selective manner, with mechanised technologies being incorporated in the process.

Pressing and Dewatering: From Rope-Based to Hydraulic Pressing

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The cassava mash needs to be further processed after being grated by dewatering it before the next steps. The drying process is an important part of gari making as it causes the moisture content of the grated cassava to be reduced and generates a dry enough mash for sieving and frying. These presses can affect the way the labour is organised and can influence the equipment needed for this processing stage (Grace, 1977; Balagopalan et al., 1988).

The techniques of pressing recalled earlier in the study relate to the rope-based method for compressing the grated mash of cassava. A lot of manual work and locally available materials were used in the process of this method. The process was a part of the sequence of activities laid down in the process of cassava changing from grated roots to a form that would be used in further processing. Its continued use also indicated that materials were available and that the operators had the necessary know-how to use the method.

Hydraulic pressing was gradually being adopted for cassava processing in some areas of Igalaland in the study period. Again, like motorised grating, there is no evidence of a single year for hydraulic presses throughout the study area. Instead, it appears that a gradual and uneven assimilation of hydraulic equipment was taking place. The technology was therefore not just replacing the previous systems in the various processing sites but was complementing them.

Hydraulic pressing is a major reorganisation of the dewatering process. Rope-based pressing required more direct application of force, while hydraulic equipment provided a mechanical way of pushing the cassava mash. This changed the nature of the technology for the operation and decreased the amount of manual labour required for pressing. The present study does not, however, provide any standardised measurements for pressing-time, pressing-pressures, throughput and labour requirements. Based on the evidence available, it is premature to quantitatively attribute a productivity advantage to hydraulic pressing.

The use of hydraulic pressing can, however, be explained in the context of the selective technological change that is found in Igalaland. Adoption of agricultural technologies can be triggered by specific constraints and opportunities, and the choice of technologies can be influenced by factors such as the availability of labour, production scale, capital needs, access to technology, and benefits of the technology adoption (Doss & Morris, 2000; Suri & Udry, 2022). Technological shifts from rope-pressing to hydraulic equipment further indicate that technical decisions were linked with the processing needs rather than with the technical superiority of a specific machine.

Importantly, the entire sequence of cassava processing did not change due to the change in pressing technology. Other processes such as sieving or frying still relied heavily on processing knowledge and manual labour, and hydraulic pressing was integrated into a system. Technological differentiation within the processing sequence is thus shown: there may be significant technological change in one stage of the processing sequence and no change or relatively little change in other stages.

The overall conclusion on the historical development of pressing in Igalaland corroborates the general result that cassava-processing technology evolved by selection and co-existence. The shift from rope-based pressing to hydraulic pressing would indicate a technological shift in means of dewatering cassava, but not necessarily a total departure from the previous practice. Rather, the technology was part of a maturing processing system that continued to function with the addition of new machinery and known technology.

Sieving: Continuity and Material Change

Another crucial process in the production of gari from cassava mash is sieving. After drying, the cassava mash is sieved to remove coarse particles, and the granules formed have the desired size following the sieving process to ensure good frying quality in the next step. The operation needs to be carried out with suitable equipment and practical knowledge, as the sieves used and the material and construction to be used can influence the granules obtained and the consistency of the processed material (Grace, 1977; Balagopalan et al., 1988; Ndjouenkeu et al., 2021).

The findings of the study suggest continuity as well as material change in the sieving by the equipment. The traditional methods used significant numbers of locally manufactured bamboo sieves. All these implements were considered to be part of the so-called fabricated processing system, and were reliant on the locally available materials and the practical know-how of their construction and usage.

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The continued relevance of these skills and materials, developed locally, is an example of the significance of locally developed skills and materials in cassava processing.

As time goes on, manufactured substitutes, such as perforated metal and polyethylene sieves, were used in the processing activities. These alternatives brought about a shift in the materials employed for sieving, but did not lead to the disappearance of bamboo sieves. Instead, various kinds of sieves operated simultaneously. The evidence thus indicates a process of material substitution which is partial and not complete.

It is important to note that the appearance of locally produced and manufactured sieves is significant in the understanding of the nature of technological changes in Igalaland. The evidence indicates that processors could retain existing processors and introduce manufactured alternatives to the system, rather than replacing one technology with another, where the old technology is abandoned. This is in line with broader findings on the selective adoption of agricultural technologies (Doss & Morris, 2000; Suri & Udry, 2022) and local users making a "creative use" of available technologies when they feel they can, rather than giving up their existing technologies entirely.

Bamboo sieves are also a reminder of how local knowledge can be instrumental in technological change. The locally available materials and techniques used are not merely inertia, but the culmination of practical experience in cassava processing. Understanding, then, must be incorporated into, and not beyond, this existing knowledge system when manufactured sieves are considered. New materials might be used to process without losing any of the knowledge from the previous processing.

The importance of the changes in sieving, however, is greater in some respects than the more significant technological changes in grating and pressing. Changes in Sieving were mechanical alternatives to activities that relied more on manual force, and the use of alternative materials and equipment for an activity that remained very manual and practical. The evidence thus shows that technology change happened at varying intensities in the different phases of the processing sequence.

In conclusion, the evolution of sieving in Igalaland shows that things have been the same and yet changed. Perforated metal and polyethylene were introduced into the repertoire, but bamboo sieves continued. The trend is consistent with the main conclusion of the study: the technology of processing cassava did not emerge automatically and synchronously from the existing technology, but rather was developed in a selective way, with each cassava production unit introducing new technology into its own processing unit.

Frying: Persistence of Manual Processing and Product Preferences

The last processing step in the preparation of cassava mash into gari is frying, which is the roasting or toasting of the prepared cassava mash in a heated frying pan or a suitable receptacle. In contrast to grating and pressing, in which the study found that motorised and hydraulic equipment were increasingly used, frying was still very much hand-labour intensive during the time period surveyed. The fact that manual frying is still being practiced is therefore an important aspect of the technological history of the processing of cassava in Igalaland.

Technological changes did not impact all aspects of cassava processing in the same way, as indicated by the continued use of manual frying. Though mechanical equipment was used in the preceding steps, the sieving of the mash and its subsequent processing into gari still involved human effort and skill. The heat and handling of the mash and its movement are permanent and critical in the frying process, and therefore the processor's experience is important for the product. This therefore implies that the use of mechanised equipment in one stage of the processing did not create a pressure for mechanising the following stages.

Product properties are an important context that helps to explain the continuity of manual frying. Retrospective accounts were correlated with established frying practices, such as the taste, texture, aroma, and appearance of the gari. These accounts are not considered as standardised measurements of consumer preference, but as a local perception. However, this significance of gari characteristics aligns with vast studies that have indicated that the quality and likability of gari are influenced by various attributes, including colour, taste, aroma, appearance, texture, and gari granule characteristics (Awoyale et al., 2021; Ndjouenkeu et al., 2021; Ngoualem Kégah & Ndjouenkeu, 2023).

Therefore, the enduring usage of manual frying should be interpreted as a result of more than just the lack of acceptance of technological innovations. Rather, it demonstrates how processors evaluated

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and implemented technologies according to their processing requirements and product specifications. Where techniques were still yielding desirable characteristics that were desired by processors and consumers, there was little reason for those techniques to be removed just because there was an alternative technique available.

The changes in technology that are described in grating and pressing are therefore particularly interesting in the context of the frying process. Mechanical alternatives were introduced by motorised graters and hydraulic presses at certain stages of processing, and manufactured sieves were alternatives for some local graters. But there was still a significant hand labour requirement for frying. This processing system was therefore a combination of manual and mechanised processes. Rather, various technologies were used at various points, resulting in a hybrid technology where mechanical and manual processes are used together.

The pattern is similar to the general literature on cassava processing, where processing technologies are influenced not only by the technical factors but also by the local processing goals, the quality of the product, the labour circumstances and the situation in which the processor operates (Grace, 1977; Chuzel, 2001; Ndjouenkeu et al., 2021). Continuity in technological change is not technological changelessness, in this context, but rather the continued use of manual frying.

The history of the development of frying in Igalaland further validates the major result that the technology for processing cassava has not been evenly distributed between the various stages of processing. The fact that manual frying was still being used in conjunction with mechanically grated cassava, as well as hydraulic presses and other sieving materials, shows that processors used technological alternatives to some extent, but kept their traditional methods, which could fit into their requirements and local product preferences.

Technological Change and the Organisation of Processing Labour

The use of new technologies in cassava processing also impacted on the structure of labour in the processing sequence. The evidence indicates that technological change did not lead to the complete substitution of human labour in cassava processing, but rather to changes and the redistribution of labour-intensive activities across different stages of the process. Some of the equipment used for grating and dewatering, like the motorised graters or the hydraulic presses, reduced the use of manual physical effort, whereas others, including sieving or frying, still relied heavily on human labour. Technological change was therefore not just manifested as the substitution of labour by machines, but as the shift in the human labour-equipment-process mix.

This pattern is related to the gendered organisation of processing labour, which is also relevant to the understanding of this pattern. Previous studies on cassava production and processing in Africa indicate that women have always been involved in the processing and marketing of cassava, though the roles taken up differ between communities and production systems (Doss, 2001; Forsythe et al., 2016; Ndjouenkeu et al., 2021). The findings from the selected communities also show that there were differentiated participations in cassava processing across different activities. Processing-related activities were very much at the forefront of women's work, and other activities may be undertaken by men, young people, and other household/community members as a result of the social and production context.

Some of them were changed by the introduction of motorised equipment. Previously, the process of grating involved a lot of manual work, but with the introduction of motorised graters, a new processing step was added, making the process more equipment-dependent. Likewise, hydraulic pressing was an alternative way to dewater and modified the physical demand of water removal from cassava mash. The adjustments were not such that human labour was no longer needed. Rather, labour continued to be needed to prepare the cassava, feed and handle it, transport processed mash to the next processing step, and to finish other processing steps. Technological change thus entailed a reorganisation of labour around equipment and not a total displacement of labour.

This is also reflected in the continued use of manual sieving and frying. Even when mechanised equipment was used at an early stage, these activities had to be dependent on human skill, attention and experience. In particular, the manual frying process demanded that the processor observe and adjust the frying mash and assess the product characteristics during the frying process. These activities show how

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technological incorporation may mean less physical work in certain moments and more in others without eliminating other types of knowledge and/or labour.

The evidence also indicates that changes in labour due to technological change need to be considered in terms of scale and organisation of processing. When motorised or hydraulic equipment was available, processors could integrate it into specific parts of the process without necessarily re-structuring the processing system. This led to a segregation of equipment-dependent stages and activities, which still involved a lot of manual labour. This meant that the resulting system became a combination of labour and machinery, or manufactured implements, where they were found to be useful and accessible to carry out essential tasks.

However, it is important to note that these changes do not necessarily equate to women's economic empowerment. While women played a significant role in processing cassava, the evidence does not indicate who owned specific machines, who controlled the income generated from processed cassava, or the impact of technology on household decision-making. There is evidence from previous studies that involvement in agricultural value chains does not automatically mean increased access to productive resources and economic returns, as factors such as access to assets, labour, markets and decision-making power affect outcomes (Doss, 2001; Apata, 2019). The present study thus only addresses the 'observed' organisation and gendered distribution of processing labour.

The overall impression was that much adjustment - rather than labour displacement - was going on in Igalaland in the wake of technological change. Motorised graters and hydraulic presses altered the physical and organisational needs of some of the processing steps, and manual sieving, frying and other steps still relied on human labour and know-how. Gender did continue to be a factor in the organisation of processing work, as was demonstrated by the use of women in processing, although there was no evidence for the larger claims of ownership, control of income or empowerment. Technology change is thus viewed as a reorganisation of processing labour, based on a blend of existing practices and chosen technological alternatives.

Factors Shaping Adoption, Adaptation and Continuity

The unequal technological change observed along the cassava processing sequence indicates that the adoption of the new technologies was affected by economic, technical, labour, market and social factors. Newer or more mechanically advanced technologies do not appear to have been adopted because they were so. Instead, specific technologies were added if they were deemed to fit the current processing environment and to have added value in meeting particular practical needs. This is similar to the broader literature on heterogeneous adoption of agricultural technology that has also documented various socio-economic factors affecting adoption, including resource availability, technology costs, production conditions, and expected benefits (Doss & Morris, 2000; Suri & Udry, 2022).

Labour Requirements and Physical Effort

Labour requirements were an important consideration in the incorporation of technologies at particular processing stages. When used manually, the process of grating or pressing requires significant physical effort, and so if motorised graters and hydraulic presses are available, then there are practical benefits of using them. The study of technology choice in cassava processing also shows that labour demand, along with technology cost, processing capacity and availability of technology, can be a factor that determines processors' technology choice (Adejumo et al., 2020). In this study, these technologies have been linked to reduced workload for specific tasks in the past. But the evidence available does not offer standardised measures of labour time or labour productivity. The importance of labour should thus be understood qualitatively as the influence of specific technologies on the perceived usefulness of the technology, not as a measure of productivity.

Labour considerations did not lead to an even spread of mechanisation, as evidenced by the continued use of manual labour at other stages. Although mechanised equipment was introduced at earlier stages of processing, the use of human labour was still significant in the sieving and frying stages. This reflects broader evidence that changes in technology in agricultural processing do not necessarily take place at the same rate at all stages of production (Chuzel, 2001; Ndjouenkeu et al., 2021). So, it seems that processors have responded to labour needs selectively - adding equipment when it met specific constraints, and continuing to use manual methods when these remained practicable and acceptable.

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Production Scale, Capital and Equipment Accessibility

The potential for technological incorporation was also constrained by the amount of processing and resources needed for acquiring and operating equipment. Mechanised equipment typically requires access to the equipment and can be costly, involve maintenance and technical support. The presence of a technology therefore does not necessarily mean that it is available to all processors or communities. Research on the adoption of agricultural technology also shows significant variation in adoption depending on access to resources and technologies (Doss & Morris, 2000; Suri & Udry, 2022).

From Igalaland, therefore, it is evident that there is no automatic relationship between the availability of technological alternatives and their adoption or incorporation into an already established processing practice. A motorised grater or hydraulic press may be part of the processing environment without having to make all the manual equipment redundant. This is why various processing systems might be viable in the same general region. The end product was a technology space that was not necessarily uniform; it represented various access opportunities and local contexts.

Technical Compatibility and Processing Requirements

Another important consideration was technical compatibility. Cassava processing is a multi-stage process, and a change in one stage does not necessarily require a change in the other. Mechanisation of sieving or frying may not be required at the same time as the motorised grater is added. Likewise, hydraulic pressing can be applied to the dewatering process, and other processes could be done with existing tools and hands-on experience. Studies of cassava processing technologies also found that cassava processing technologies are diversified, with different technological configurations found within the cassava-processing systems, in different locations and processing contexts (Grace, 1977; Chuzel, 2001; Ndjouenkeu et al., 2021).

This mode of processing indicates that the processors did not consider the overall sequence of processing to be mechanised in the same way that they considered technologies to be mechanised according to the specific problem they were tackling. The selective adoption is in line with the larger body of literature on agricultural technology that focuses on the adoption of technology being determined by production conditions and heterogeneous constraints rather than just the technical attributes of an innovation (Doss & Morris, 2000; Suri & Udry, 2022). It was thus a practicable method of adaptation to have a number of technologies working together in the same processing system. It enabled processors to use some of the alternatives and to keep other practices that were acceptable to their processors.

Market Considerations and Product Preferences

Technological decisions were also influenced by market conditions and preferences with regard to the properties of processed cassava products. Several product characteristics- colour, taste, aroma, texture, and appearance- have been identified as being important in valuing gari (Awoyale et al., 2021; Ndjouenkeu et al., 2021). Therefore, it is not appropriate to judge processing technologies on the basis of the amount of physical work involved. They should also be taken into account along with the quality of the final product.

This is especially applicable to the fact of manual frying. Even though mechanisation took place at the earlier stages, manual frying still played a significant role as the final stage of processing involved practical knowledge and control of the characteristics of the final product. No evidence was found to show that manual frying was objectively better than mechanised alternatives, nor to show that there were standardised consumer measurements. It instead suggests that existing processing methods remained relevant where processors appreciated the attributes of these methods.

Local Knowledge, Experience and Adaptation

Another factor in the continuity of established practices was the local knowledge and processing experience. Cassava processing goes through a series of processes, during which the processors gain practical knowledge regarding the handling of cassava mash, dewatering, sieving, and frying. The significance of processing practices and product properties in understanding the use and evaluation of technologies is also highlighted in research on cassava processing (Grace, 1977; Balagopalan et al., 1988; Ndjouenkeu et al., 2021). This knowledge did not necessarily become outdated with the addition of new equipment. In contrast, processors needed to incorporate equipment into their already established production flow, and still use their hands-on expertise in manual processes.

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This explains the adaptive characteristics of technological change in Igalaland as new technologies were not alien to the prevailing practices but complemented them. Processors could use both motorised and manual methods in the same production process as appropriate depending on the stage of the production process and the context of the processing. The implication from the resulting system is that technological change was both the introduction of new technology and the use of existing technology and knowledge. This interpretation echoes the general notion of agricultural technological change, which is a phenomenon influenced by local conditions, prior experience of technology, and the match between technology and previous production patterns (Ruttan, 1977; Rogers, 2003; Suri & Udry, 2022).

Adoption, Selective Adoption and Non-Adoption

Combined, the evidence indicates that the technologies of cassava processing in Igalaland can be explained using various forms of technological incorporation. Some technologies were introduced into processing practice while others were selectively adopted at specific points; some were integrated or modified to fit in with current technologies; others were not replaced by any technology in processing. These classification levels should not be taken as descriptors of specific communities, rather as a description of the diversity of patterns within the processing flow.

The pattern is similar to the analytical framework that was constructed for the study, which views technological change as an economic, labour, technical, market and local knowledge continuum process. It also aligns with the existing literature on agricultural technology that warns against expecting technology change to occur in a consistent manner or that the outcomes of technology adoption are identical in various contexts (Doss & Morris, 2000; Suri & Udry, 2022).

The historical data from Igalaland thus implies that there was no uniform process of technological replacement but rather introduction as per local conditions. Lack of capital and equipment limited adoption; equipment was available at some stages to encourage incorporation; some technologies could be adopted in isolation of others depending on the technical requirements; product preferences helped to maintain some practices; and some technologies were more readily accepted because of accumulated knowledge. This led to an uneven, selective, and adaptive technological change, where different technological systems were not eliminated but remained simultaneously.

Discussion

The results show that there was not a universal transfer to new technology for cassava processing in Igalaland in the history of the development of cassava, but rather a selective and uneven incorporation of the technology into the indigenous processes of processing the cassava. They experienced different changes throughout the processing sequence and were influenced by the specific needs, resources and situation of each activity. The processing systems produced were a combination of motorised graters and hydraulic presses with locally produced and manufactured sieves, with frying still mainly based on practical knowledge built up in the process. Important implications of these results are that the technological change took place within, and not by replacing, an existing technological system and was manifested in changes in specific processing activities.

Technological Change as Local Adaptation

The findings support the use of adaptive technological change as a tool for analysing cassava processing in Igalaland. The evidence suggests that processors reacted to specific functional demands, addressing specific points of the processing sequence, by incorporating technologies. The use of motorised grating was an alternative to the physically demanding manual grating, and hydraulic pressing was another way of applying pressure during dewatering. In the meantime, the manual sieving and frying process were still part of the processing system. Technological change thus meant the introduction of some of the alternatives within a given system, and not the substitution of the system itself.

This is in keeping with the overall theme of agricultural technologies not being taken up the same way in all contexts. Doss and Morris (2000) prove that the technological choices made in African agriculture are dependent on resource differences, institutional conditions, and the nature of the agricultural producers, and Suri and Udry (2022) stress the diversity of agricultural technology adoption and effects in African settings. This paper contributes to the existing literature by demonstrating the

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historical and process-specific nature of the evidence of the Igalaland of how such selectivity was enacted in a series of closely allied tasks.

The results also expand the comparative information available from Chuzel (2001), who discusses the technological development of cassava processing in Brazil, where innovation is combined with the continuation of the existing technologies. The combination of manual and mechanised processes was not a mishmash of a poorly completed transition in the case of Igalaland. It was a practical solution, where processors used existing technology and existing solutions. This system, therefore, was more adaptive and hybrid than technological.

Induced Innovation and the Influence of Processing Conditions

The findings can also be explained in terms of the induced technology change logic. Induced innovation is a concept of Ruttan (1977) that suggests technological change as a reaction, partly, to changing economic and resource conditions. The case studies of Igalaland showed that, under specific conditions, given the scale and organisation changes in cassava processing, certain technological options became helpful. The lack of a general trend toward mechanisation can therefore be seen as a response to specific processing needs in the form of increasing use of motorised grating and hydraulic pressing.

This interpretation is crucial as it directs the focus away from the technology and towards the issue the technology was designed to solve. While hydraulic pressing was used as an alternative way of applying pressure during dewatering, motorised grating was used to fulfil physical demands required in converting cassava roots into mash. These technologies were thus relevant due to their suitability for specific parts of the processing chain.

But the induced-innovation approach cannot account for the full pattern. One would expect similar mechanisation throughout the stages if the dictator of technological change were processing requirements. That manual sieving and frying continued to be important shows that other factors played a part. The practicality of a technological alternative was related to its applicability to the specific task at hand and to its availability and the context of production of acceptable gari. The Igalaland experience, therefore, indicated that the incentive for technological change was generated by economic and processing pressures which were transformed into practice by the local circumstances.

Diffusion, Selective Adoption and Local Variation

The findings are also in line with the diffusion view that underpinned Rogers (2003), which focuses on the diffusion of innovations over time and through social systems instead of spreading all at once for all potential adopters. The data from the Igalaland shows that there is a lot of variation between communities and processing stages in terms of processing technologies used. Not all alternatives to a technology – the fact that they were available – were actually being used in practice.

This is illustrated in the case of motorised grating. In retrospect, it seems that in some processing situations, more and more motorised equipment was used, while in other situations manual grating was used. Likewise, bamboo sieves were replaced by manufactured sieves, but manual sieving still played an important role. This implies that there was no one region-wide moment of technological replacement, but rather a selective diffusion.

The results also suggest that social impacts of technological diffusion were context-specific. Gendered processing participation still remained strong, although the evidence available indicates that the impact of technology on gender was not consistent across localities. Women were involved in the operation of equipment in some places, and gender divisions of labour varied from place to place. This helps to shape a gendered interpretation of technology change that emphasises the contextual, as opposed to technologically deterministic, approach. The social outcome of the introduction of equipment was far from determined; it was related to the nature of the previous working system and to the nature of the specific processing system.

Technological Path Dependence and the Persistence of Established Practices

Another way to explain the endurability of established processing practices is through the concept of technological path dependence. Skills, routines, knowledge, and complementary practices build up around previous systems, as shown in David's (1985) work, which illustrates the importance of previous technological choices on subsequent possibilities. Elements of this process are exhibited in the Igalaland findings. Processors knew proven processing sequences, tools, and product qualities, and new

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technology was added to existing processing flows; new technology was not added in an institutional or technical void.

One of the biggest points to note is the fact that manual frying is still prevalent. Manual methods and practical skills remained of major importance for frying, while a few of the stages were already motorised. As other sections of the process changed, so did established knowledge, as seen in the continuation of this practice. Likewise, the persistence of manual sieving even in the face of manufactured sieving methods indicates that changing equipment materials did not necessarily result in the cessation of the manual method.

This does not imply that already established practices were invariably better technically or that processors shied away from innovation. Instead, it meant that technology was dependent on the knowledge and practices that were already established. New equipment thus needed to be designed to be compatible with an existing system of work. In this regard, continuity and change went hand in hand instead of being contradictory.

Technology, Labour and Gender

The findings add to the existing literature on gender and cassava processing as they show that technological change impacted labour organisation, but not necessarily the value of human labour. Technological options were also introduced to other stages, and women continued to be strongly engaged in processing activities, including sieving and frying. The consequence was a reorganisation or a change in the distribution of processing labour with specific technologies rather than its total substitution.

This finding aligns with research that highlights the significant role of women in cassava processing as well as stressing that participation does not necessarily mean economic empowerment (Doss, 2001; Apata, 2019). The evidence from Igalaland confirms the latter, that gender continued to be an important factor in labour organisation during technological change. However, it does not offer enough evidence for identifying owners of specific machines, who made the profits from the processing, or whether the incorporation of technology brought about any measurable shifts in the economic power of women. Such conclusions would have to be based on evidence outside of the scope of the present study.

The gender dimension therefore helps to prove the interpretation of technological change as an adaptive process instead of a uniform technological transition. Social impacts of a technological innovation were partly related to the interaction between the equipment and labour organisation at the time. The processing tasks were not assigned to any particular technology. Instead, technological incorporation happened in already established social structures, which differed in each locality.

Commercialisation without Complete Mechanisation

Another conclusion from the results relates to the technological change and commercialisation relationship. The previous studies have identified the relationship between cassava processing and market integration as well as the flow of cassava products between rural and urban markets, respectively (Olagunju et al., 2012; Ospina-Patino & Ezedinma, 2015). The Igalaland evidence indicates that there has been an increase in commercial orientation, which has provided the necessary factors for the uptake of technologies that could meet specific processing needs. But the complete mechanisation of processing was not achieved with commercialisation.

This is an important difference: It would not be necessary for a commercially-oriented processing system to be fully mechanised. Commercial processing in Igalaland may be a combination of motorised grating, hydraulic pressing, manufactured sieves, manual sieving and manual frying. The technological set-up was thus the outcome of the interplay of market pressures and local processing realities.

The findings as such therefore contradict the interpretation of the process of commercialisation as a complete substitution of existing technologies. Processors maintained practices that were still working for them despite the creation of incentives for specific technological incorporation in the context of the commercialisation. Technology and commercialisation were not the same thing, and this was reflected in the participants' views. In this way, technology and commercialisation were intertwined rather than synonymous, and this was reflected in the participants' views.

Implications for Understanding Rural Technological Change

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Combined, the results indicate that a process of negotiation between technological potential and local conditions is what should be considered in the case of rural technological change. The external technologies enlarge the range of possibilities for the processors, but they are only actually implemented when, for example, labour requirements, production size, equipment and capital availability, technical compatibility, product aspects and existing knowledge are considered.

This historical experience of cassava processing in Igalaland thus calls into question the notion of a linear process of technological modernisation. There is no evidence to suggest that manual technology was replaced systematically by mechanised technologies. Rather, various technologies were used in different stages of the processing process, and their importance varied depending on local conditions. Some practices were replaced or supplemented, some adapted, and others remained the same.

It is, therefore, the historical and interpretive aspect that is the major contribution of the study. It illustrates that technological change in rural cassava processing goes beyond the introduction of new machines and concerns the introduction of technological changes to the existing technology system, which involved the adoption, blending, and retention of technologies by processors. This is then an example of adaptive technological change in which continuity was not a contradiction to innovation but one of the ways in which innovation was accommodated locally.

Conclusion

This study analysed the historical evolution of the cassava processing practices of Igalaland from 1967 to 2020, including technological changes and the organisation of processing labour, as well as the factors driving the adoption, adaptation and persistence of specific technologies. The evidence shows that there was no straight and linear path from manual production to mechanised production of cassava processing. Rather, technological change was piecemeal, at specific phases in the processing sequence and between localities.

Some important changes were made in specific processing operations such as the use of motorised graters and hydraulic presses, and manufactured sieves were substitutes for some handmade sieves. In the meantime, manual sieving and frying continued to be very important. The parallel use of these arrangements reveals that new technologies have not resulted in a system-wide change at this point. Technology change was therefore cumulative and not steady, having both continuity and incorporation of new alternatives.

It also illustrates how technology was intimately linked with the organisation of labour. The mechanisation changed the physical and organisational needs of some tasks; however, human manpower was not completely removed from cassava processing. Women were also highly engaged in processing activities, especially in sieving and frying, and there was some variation among localities in the involvement of women in machine operation. The evidence is thus consistent with a view of technological change as a reshaping of labour used in processing and not just as a replacement of labour. The study does not, however, confirm larger shifts in machine ownership, or women's control of the income from machine processing, or in women's economic empowerment.

Technological change had many driving forces. Socio-economic factors such as labour requirements, production scale, equipment availability, technical compatibility, product factors and accumulated processing knowledge all affected the actual introduction and/or maintenance of specific technologies. An alternative technological solution, therefore, was not always available and, as a consequence, did not always get used. Processors integrated technologies where they determined they had a specific technology need and situation, and used technologies that would otherwise not have been included, but were still useful, available, or compatible with local processing goals and outcomes.

Therefore, there is ample evidence for the concept of adaptive technological change from the historical experiences of cassava processing in Igalaland. This study demonstrates the ways in which processors utilise existing practices and choose from among available technological options instead of viewing technological development as a continuum of replacement of earlier technologies by newer ones. This adaptive process is a better way to describe the technological change in the rural sector, where technology, labour, markets, resources, and local knowledge evolve.

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Limitations of the Study

The findings should be interpreted with some caveats. The study's reliance on oral history gathered between 2022 and 2023 produced, of course, an uneven balance of data, with a heavy emphasis on retrospective memory.

First, the study was dependent on a lot of oral history collected over several decades, between 2022 and 2023. The memories about previous practices may therefore vary among participants, and retrospective accounts are more appropriate for finding general trends of continuity and change than for pinning down accurate dates for technological innovation.

Secondly, the study did not take quantitative measurements of processing time, throughput, fuel use, or labour productivity, as these are standard practices. The result is that the significance of a technology's reduced use of physical effort or its practical use is read as reported experiences and qualitative observations, not as actual technological-efficiency results.

Third, the study does not offer adequate data to show systematic trends in the ownership and control of machines, in income from processing, or in credit status, or access to economic empowerment for specific gender groups. The gender analysis is thus restricted to the organisation and distribution of processing labour, on which it focuses.

Fourthly, the study was conducted in selected communities, and participant selection was done in a purposive manner. The results of this study should therefore be read as historical interpretations of the settings chosen and not as statistically typical results about all communities in Igalaland.

Lastly, this study should not be seen as a complete account of the cassava processing history of the area. The analysis is based on oral evidence, field study, and available published data, but the evidence does not allow for specific definitive dates of introduction or detailed reconstruction in every community of all technological developments.

Recommendations

As a result of the findings, a number of recommendations are made.

1. The development of the technologies should be based on the real processing conditions. Agricultural and rural development programmes should encourage processing technologies which meet specific labour and technical needs, and not try to mechanise all steps of cassava processing.

2. Small-scale processors should be considered in technology interventions. Access to equipment and capital can affect adoption; therefore, interventions need to take into account the affordability, accessibility, maintenance, and suitability of the technologies for small-scale processing.

3. Knowledge of the local context needs to be fed into the development of technology. Programmes involving new equipment for cassava processing should acknowledge the existing skills and practices and not deem local knowledge as a hurdle for technological development. Technologies are more likely to be useful if they fit into existing processing sequences, and the actual features of products valued locally.

4. Gender sensitive technology interventions should focus on access and participation. As women are still playing key roles in cassava processing, programmes should ensure that women are given opportunities to learn the knowledge and skills needed to use the relevant processing equipment. If there is no evidence of ownership, income control and decision-making, this type of intervention should not be conflated with participation in processing.

5. Further study should be a blend of both historical and quantitative methods. Processing time, throughput, labour, fuel, equipment cost and maintenance requirements could be measured in future studies for the different technologies. The quantitative empirical evidence would support the qualitative historical account developed in this study and allow a more accurate estimation of technological performance.

6. The geographic and documentary evidence base should be extended in future research on history. Further research, with other communities, with archival materials, with the records of agricultural development and with longer-term oral-history research, may be able to provide a more detailed reconstruction of the time at which certain technologies became available, and the pattern of their diffusion within Igalaland.

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7. The influence of changing markets on processing technology should be explored. Further studies might explore the impact of rural-urban trade, consumer preferences, market access, and the organisation of cassava value chains on technological decisions in the past.

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Conflict of Interest

The authors declare that they have no conflict of interest.

Data Availability

The data gathered and analysed within this study comprise the majority of retrospective oral-history interviews, field notes, and related qualitative data that were gathered by the researcher. Due to the fact that the materials include participant accounts that were gathered from field interviews, they are not offered to the general public as a data set. The evidence presented in the article is qualitative and derived from these materials and relevant published and documentary sources. The information and the research materials can be made available by the corresponding author, depending on the participant consent and maintaining the confidentiality of the materials.

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