CASSAVA–WHEAT COMPOSITE FLOUR PROCESSING AND BREAD-MAKING

A LEARNER'S HANDBOOK

Adebayo Abass, Abdul-Rasaq Adebowale, Gregory Nwaoliwe,
Adeniyi Ogunkoya, and Simon Lukombo



IITA Transforming African Agriculture
CGIAR SCIENCE FOR A FOOD-SECURE FUTURE
AFRICAN DEVELOPMENT BANK GROUP
GROUPE DE LA BANQUE AFRICAINE DE DÉVELOPPEMENT
TAAT Technologies for African Agricultural Transformation
ATA-RDC Agenda de la Transformation Agricole
CVCD PROJECT

Published by the International Institute of Tropical Agriculture (IITA)

The International Institute of Tropical Agriculture (IITA) is a not-for-profit institution that generates agricultural innovations to meet Africa's most pressing challenges of hunger, malnutrition, poverty, and natural resource degradation. Working with various partners across sub-Saharan Africa, we improve livelihoods, enhance food and nutrition security, increase employment, and preserve natural resource integrity. IITA is a member of CGIAR, a global agriculture research partnership for a food secure future.

International mailing address:
IITA Ltd, Suite 32,
5th Floor, AMP House,
Dingwall Road
Croydon
CR0 2LX, UK

Headquarters:
PMB 5320, Oyo Road
Ibadan, Oyo State
Nigeria

ISBN 978-978-131-436-0

Correct citation: Abass, A., Adebowale, A., Nwaoliwe, G., Ogunkoya, A., and Lukombo, S. 2026. Cassava–wheat composite flour processing and bread-making: A learner's handbook. IITA, Ibadan, Nigeria. 96 pp.

Printed on demand

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Scoping, background research, planning, rewriting, editing, revisions, design, layout, and proofreading: Green Ink (www.greenink.co.uk).

The illustrations in this manual were created using AI-assisted image processing. AI tools were also used to support the drafting of text content. All material has been reviewed and approved by the authors.

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About IITA. The International Institute of Tropical Agriculture (IITA) is a non-profit institution that generates agricultural innovations to meet Africa's most pressing challenges of hunger, malnutrition, poverty, and natural resource degradation. Since 1967, IITA has worked with international and national partners to improve livelihoods, enhance food and nutrition security, increase employment, and preserve natural resource integrity. As one of 15 research centers in CGIAR, a global partnership for a food secure future, IITA is engaged in several CGIAR Research Programs (CRPs). IITA has delivered more than 70% of the CGIAR's impact in sub-Saharan Africa and remains committed to the science-driven improvement of agriculture and related food value chains. To help address poverty and the high number of unemployed young men and women in sub-Saharan Africa, IITA has initiated a Youth Agripreneurs program to create jobs by making agriculture and agribusiness appealing to the youth. The program is integrated into the Business Incubation Platform (BIP), the technology delivery arm of IITA, which serves as a model to stimulate product development and to provide opportunities for market expansion.

About TAAT. The Technologies for African Agricultural Transformation (TAAT) Program is the African Development Bank (AfDB) flagship program and a major component of the Feed Africa Strategy. The program is being implemented by a consortium of international agricultural research and development institutions led by the International Institute of Tropical Agriculture (IITA). TAAT is deploying proven agricultural technologies and innovations to African farmers in more than 35 countries with a focus on African priority commodities: cassava, maize, rice, fish, high-iron bean, wheat, orange-fleshed sweet potato, sorghum and millet, soybean, aquaculture, and small livestock. These value chains have high potential for helping Africa achieve food security and participate in global agricultural trade while reducing food importation. The consortium of national and international organizations is organized as a Compact around each commodity, design interventions, and national strategies to introduce the technologies and innovations to help nations transform their agriculture. The TAAT ecosystem of experts assists countries in designing, planning, and executing their agricultural loan projects as a vital element of the approach to attaining the desired agricultural transformation.

About the DR Congo Agricultural Transformation Agenda. ATA-RDC is a program of the Government of the Democratic Republic of the Congo designed to modernize the agricultural sector as part of the government's agenda to develop the 145 territories of the country. It focuses on the key value chains of cassava, rice, maize, soybeans, banana, beans, and aquaculture. IITA provides technical assistance to the nationwide program. It aims to double agricultural yields using improved crop varieties, fish breeds, and production inputs. Its goal is to create wealth and jobs through modernized agriculture by consolidating and building on several ongoing agricultural projects financed by development partners and banks. The program works closely with and provides technical assistance to a range of private sector entities, chiefly the Bio AgroBusiness (BAB) that operates on behalf of the Ministry of Agriculture. An essential priority of ATA-RDC is to develop the infrastructure and human competencies for the production of bread-making cassava flour (BCF) or high-quality cassava flour (HQCF) and its use in the bakery industry to reduce dependency on imported wheat.

About the CVCD Project. Cassava Value Chain Development to Support Food Security and the Bread Industry in DRC (CVCD) is an American government–funded project. It builds on American government bilateral interventions in deploying improved cassava production technologies to enhance the economic potential of the crop. The project aims to improve the livelihoods of small-scale producers and women while creating jobs for youth. The value chain approach seeks to strengthen cassava processing activities to produce high-quality food products, which can replace imported food items such as wheat flour. This will boost cassava agro-industrial and agribusiness activities, thereby attracting private sector participation. The goal of the project is to assist DRC in ameliorating food shortages resulting from the impact of Russian Federation's war on Ukraine. The project collaborates with other ongoing projects with similar objectives, such as the TAAT Program and ATA-DRC, to contribute to the cassava value chain development efforts of the DRC Government aimed at reducing the importation of wheat by at least 10% through substitution with bread-making cassava flour.

ACKNOWLEDGEMENTS

This manual combines the science and art of bread baking with the experience of using high-quality cassava flour in Nigeria and Democratic Republic of the Congo bakeries. The Nigerian experiences were contributed by Adekola Adegokeldris Ayinde, Bashirat Bello, and Dola Adeboye. Josana Sanginga, Guelord Nsuanda, Doline Matempa Tanda, Nazareth Ambua, Bobo Kasampu, Hervé Bondonga, and Cynthia Kamunga of IITA-DRC contributed the DRC experiences. Dapo Arowona, Sunday Akinola, and Olaitan Alade provided wheat milling industry insights.

Green Ink (www.greenink.co.uk) provided editorial service: customizing for the four target audiences; writing and editing the modules; production of the visual aids; design, layout, and proofreading.

Prof. Taofik Akinyemi Shittu contributed to the technical review of the document.

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ABBREVIATIONS

ARSO	African Organisation for Standardisation
BCF	bread-making cassava flour
CFU	colony forming unit
CODEX STAN	Codex standard
CVCD	Cassava Value Chain Development to Support Food Security and the Bread Industry in DRC
DRC	Democratic Republic of the Congo
EAS	East African Standard
FIFO	first-in first-out
GHP	good hygiene practices
GM	genetically modified
GMP	good manufacturing practices
HQCF	high-quality cassava flour (another name for BCF)
IITA	International Institute of Tropical Agriculture
ISO	International Organization for Standardization
ROI	Return on investment
SME	small and medium-sized enterprise
TAAT	Technologies for African Agricultural Transformation

PREFACE

Cassava is one of Africa's most important staple crops, yet its full potential in commercial baking remains largely untapped. As many African countries aim to reduce their reliance on imported wheat and strengthen local food systems, high-quality cassava flour (HQCF) offers a sustainable and locally available alternative. Integrating HQCF into bakery products not only supports farmers and processors but also opens new economic opportunities for bakers and entrepreneurs.

Cassava–wheat composite flour processing and bread-making: A learner's handbook is part of IITA's intellectual contribution to a structured training program designed to empower learners with the foundational knowledge and practical skills needed to bake successfully with cassava–wheat composite flour. It aligns with broader national and regional governments' strategies to promote cassava value chains and food self-reliance in sub-Saharan Africa.

The handbook is organized around 11 modules, each designed to support step-by-step learning.

1. **Introduction to cassava–wheat composite flour:** key terminology; what cassava–wheat composite flour is; benefits for processors, millers, bakers, consumers, and national economies; professional opportunities in the cassava flour industry.
2. **Technical foundations of bread-making cassava flour (BCF):** BCF processing; quality issues; storage and handling; common quality issues and solutions.
3. **Hygiene and food safety in cassava processing plants and bakeries:** personnel hygiene; handling and storage; product safety; equipment cleanliness; facility management; documentation.
4. **Understanding standards and quality control:** international, continental, regional, and national standards for flours and products; labelling.
5. **Bread-making principles and process:** flour blending; bread-making from ingredients to sale; quality characteristics; special considerations for composite flour use.
6. **Quality assessment and testing methods:** flour and other ingredient quality testing; bread evaluation; troubleshooting quality issues.
7. **Equipment and production methods:** descriptions and user guidance for machinery and equipment for cassava processing and bread-making; production workflow and equipment adaptation.
8. **Recipe development and adaptation:** sample recipes; scaling; local adaptation; temperature-sensitive stages; documentation for consistency.
9. **Business and economic considerations:** introducing financial planning, investment needs, pricing, record-keeping, market opportunities, supply chain management, and regulatory compliance.
10. **Practical applications and case studies:** successful bakeries; common challenges and solutions; product diversification; building customer acceptance.
11. **Troubleshooting and problem-solving:** problem analysis; common production issues and solutions; documentation and problem prevention; equipment malfunction and repair.

Each module contains clear objectives, key learning points, practical exercises, and illustrations to aid understanding. The language is simple and direct, suited for students at vocational, secondary, and community training levels. It is also designed for inclusive learning, adaptable to both classroom and self-guided study.

The target readership includes: students and trainees in vocational bakery programs; aspiring bakers and youth entrepreneurs entering the food sector; apprentices in local bakeries and processing centers; and community-based learners, especially in rural areas where cassava is widely grown. It can also serve as a supplementary guide for trainers and facilitators, complementing the associated *Trainer's manual* and *Practitioner's workbook*.

By using this handbook, learners will:

- Gain confidence in using cassava–wheat composite flour without compromising product quality
- Learn how to assess ingredient quality and apply safe production practices
- Acquire practical, scalable recipes for bread
- Understand how to troubleshoot common baking issues and manage a small baking business
- Be better prepared to pursue employment, self-employment, or further training in agro-processing.

This publication is part of a wider toolkit—including a *Trainer's manual*, *Entrepreneur's guide*, and *Practitioner's workbook*—designed to support a complete ecosystem for cassava-based bakery development.

INTRODUCTION

THE OPPORTUNITY OF CASSAVA FLOUR IN AFRICAN BREAD-MAKING

Africa is experiencing a transformation in its food systems. While the continent produces more cassava than the rest of the world combined, most of this valuable crop has traditionally been used for direct consumption or basic local processing. Today, there is growing recognition that cassava can play a much larger role in food security, economic development, and reducing dependence on expensive food imports.

Bread has become an increasingly important food across Africa, consumed daily by millions of people in cities and towns. However, most bread is made entirely from imported wheat flour, creating a significant drain on national economies. The Democratic Republic of the Congo (DRC) alone spends between US$78 million and US$184 million annually on wheat imports. When geopolitical conflicts disrupt global wheat supplies—as happened with the war in Ukraine—bread prices rise sharply, affecting families and businesses across the continent.

This creates both a challenge and an opportunity. The challenge is to reduce dependence on imported wheat while maintaining the bread quality that consumers expect. The opportunity is to use Africa's abundant cassava production to create local solutions that support farmers, reduce import costs, and build more resilient food systems.

CASSAVA FLOUR AS A BREAD INGREDIENT

Bread-making cassava flour (BCF)—also known as high-quality cassava flour (HQCF)—represents a breakthrough in cassava processing technology. Unlike traditional cassava flours, BCF is specifically processed to meet the technical requirements of commercial bread-making. When properly processed and incorporated, BCF can replace 5–20% of wheat flour in bread recipes and 35–100% in pastry products, while maintaining product quality that consumers accept and enjoy.

The production of BCF requires careful timing and quality control. Fresh cassava roots must be processed within 24 hours of harvest through a series of steps: peeling, washing, grating, dewatering, drying, and milling (Figure 1.1). The result is a white, odorless, fine flour that blends seamlessly with wheat flour to produce bread with the organoleptic qualities that consumers prefer.

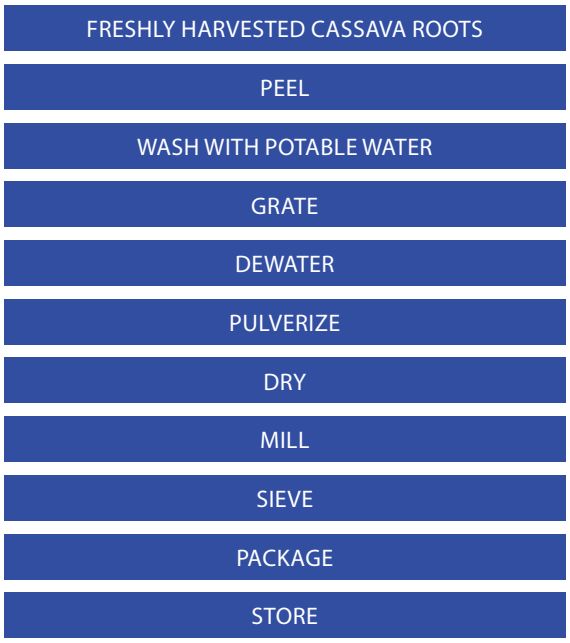


Figure 1.1. Process flow diagram showing cassava root to BCF production steps.

NATIONAL POLICIES AND MARKET DRIVERS

Governments across Africa are recognizing the potential of cassava flour to address food security and economic challenges. Several countries have developed policies and programs that support or mandate the inclusion of cassava flour in commercial bread production to reduce wheat imports. DRC, for example, mandates minimum inclusion levels of 5% BCF for bread and 10% for pastry products. The East African Community's harmonized standards for BCF facilitate regional trade, creating larger markets for successful cassava-flour producers and bakers.

Similar policies exist in other cassava-producing countries.

These policies create new opportunities for:

- **Cassava farmers**, who gain access to industrial markets with higher prices
- **Wheat flour millers**, who can source local raw materials and reduce dependence on imports through the manufacture and sale of cassava–wheat composite flour
- **Bakers**, who can lower production costs while maintaining product quality
- **Consumers**, who benefit from more affordable bread with enhanced nutritional properties
- **National economies**, which save on foreign exchange, create jobs, and build local value chains that expand small-scale rural industries (Fig. 1.2).

BENEFITS ACROSS THE VALUE CHAIN

The adoption of cassava–wheat composite flour creates benefits at every level of the food system, from cassava producers and processors to millers, bakers, and consumers (see Fig. 1.3 and Module 1, section 1.3 for details).

TECHNICAL FOUNDATIONS FOR SUCCESS

Success with cassava–wheat composite flour requires understanding both the science and art of wheat milling and bread-making. The presence of two different types of starch—from cassava root and wheat kernel—affects water absorption, mixing requirements, and fermentation patterns. Correct techniques ensure that these differences enhance rather than compromise bread quality.

Quality control becomes even more critical when working with composite flour. Every step from ingredient selection to final product storage must meet established bread-making standards. BCF must be properly processed, tested, and stored to maintain its bread-making properties. Mixing, fermentation, and baking parameters may need adjustment to optimize results with composite flour formulations.

The regulatory environment also requires attention to labeling, documentation, and compliance with national and international standards. Professional cassava processors, wheat flour millers, and bakers must understand these requirements to operate legally and access broader markets.

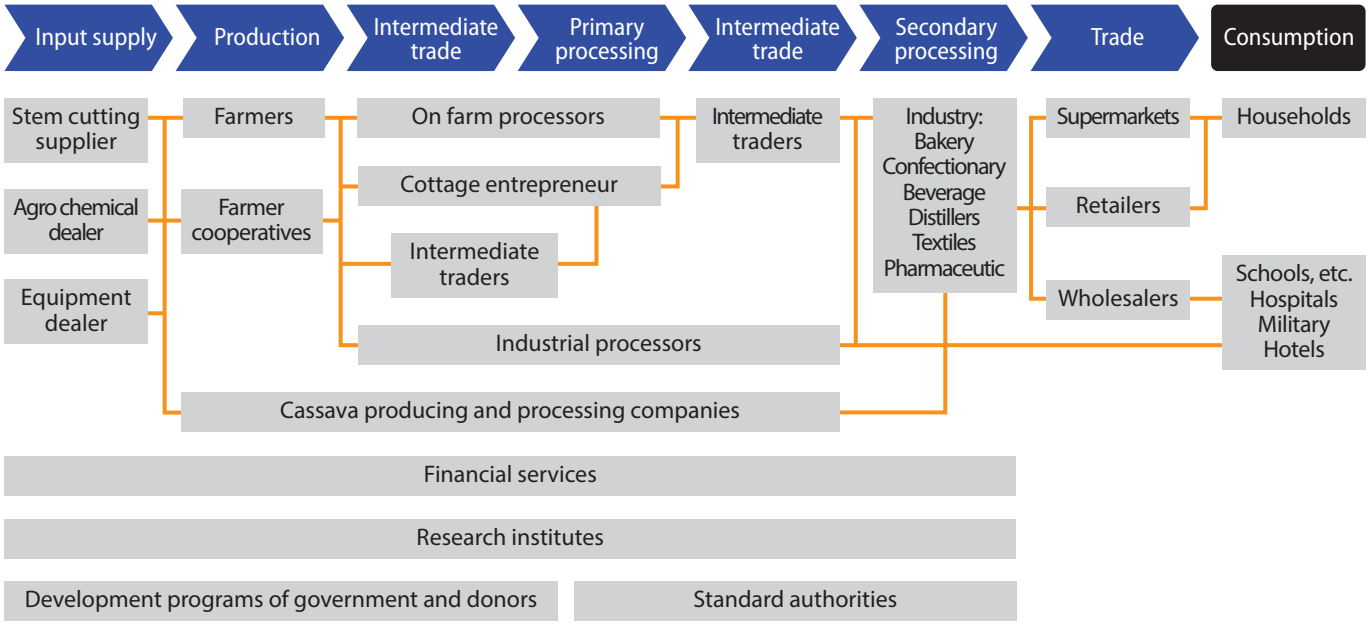


Figure 1.2. A typical cassava value chain map.

Source: Adapted from Sanni et al. (2016).

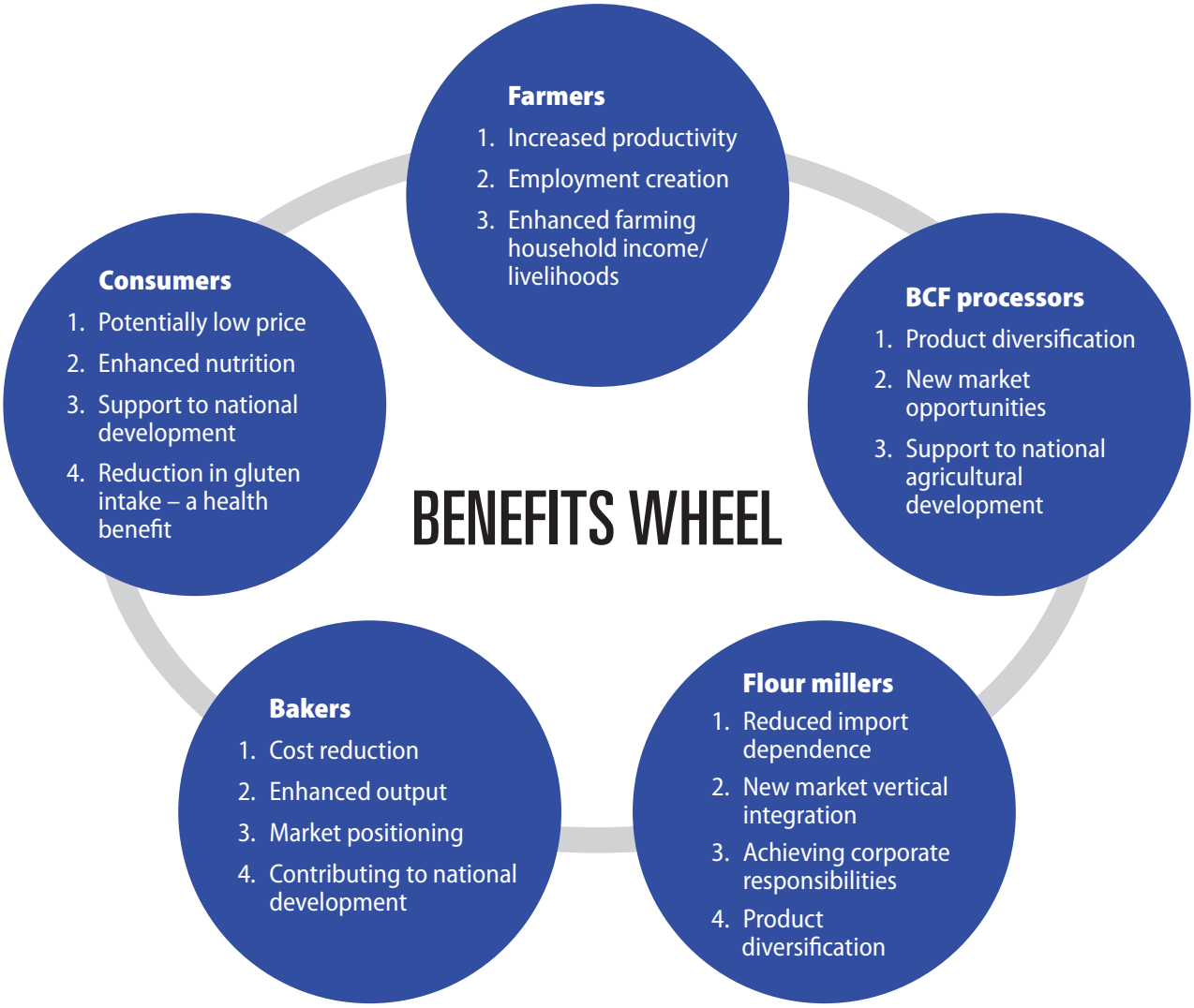


Figure 1.3. Benefits wheel showing advantages for each stakeholder group.

YOUR LEARNING JOURNEY

This handbook is designed to guide the reader through a comprehensive learning journey from understanding the fundamentals of cassava flour to mastering commercial bread production using composite flour formulations. The content builds systematically, beginning with technical foundations and progressing through practical applications to business considerations.

Each module includes clear learning objectives that state exactly what skills and knowledge will be gained. Key terms are defined in simple language, and complex processes are broken down into manageable steps. Visual aids, including diagrams and photos, support a clear understanding of technical concepts and procedures.

The handbook emphasizes hands-on learning through practical exercises that allow the reader to apply what is learned with minimal professional supervision. Case studies from successful African bakeries show how the techniques work in real-world settings, while troubleshooting guidance helps to address common problems that arise in commercial production.

Throughout the modules, the reader will develop both technical competency and business understanding. This dual focus prepares the readers not just to make quality bread with BCF, but to do so profitably and sustainably in their professional careers.

HOW TO USE THIS HANDBOOK

This handbook is structured to support different learning approaches and situations. While the modules build upon each other, experienced bakers may find they can move more quickly through familiar territory while spending more time on new concepts specific to cassava flour.

Each module begins with clear learning objectives and ends with key takeaways that summarize essential points. Within modules, information is organized in short sections with descriptive headings, making it easy to find specific information when needed.

The handbook has been prepared and designed to aid learning through:

- **Learning objectives** per module
- **Quick reference boxes** containing key formulas and procedures
- **Calculation examples** worked through step-by-step
- **Equipment alternatives** for resource-limited settings (section 7.8)
- **Key takeaways** per module
- **Self-assessment questions** (and answers) per module.

The appendices provide practical resources that students can use in their study, including quality control checklists, calculation worksheets, and regulatory compliance templates. These materials are designed for workplace use as well and can serve as ongoing references throughout a professional career.

BUILDING PROFESSIONAL COMPETENCY

The global food industry increasingly values professionals who can work with diverse ingredients and adapt to changing market conditions. By mastering either BCF processing or bread-making with cassava–wheat composite flour, you will position yourself at the forefront of an important technological and economic trend.

This handbook emphasizes practical competency that meets industry standards. You will learn not just what to do, but why specific techniques are important and how to adapt them to different situations. This deeper understanding enables you to troubleshoot problems, train others, and continue learning as the BCF technology evolves.

The skills you develop extend beyond flour production and bread-making to include quality management, cost control, regulatory compliance, and business planning. These capabilities are valuable whether you work for established processors or bakeries, start your own business, or move into related food industry roles.

Your success contributes to a larger transformation in African food systems. Every processor, miller, or baker who masters composite flour techniques helps build local value chains, support rural communities, and demonstrate the potential of African agrifood innovation. This handbook prepares you to be part of that positive change while building a rewarding professional career.

The journey begins with understanding the importance and benefits of cassava–wheat composite flour, which we explore in Module 1. Let us start building your expertise in this important and growing field.

MODULE 1:
INTRODUCTION TO CASSAVA–WHEAT COMPOSITE FLOUR

LEARNING OBJECTIVES

By the end of this module, you will be able to:

- Define bread-making cassava flour (BCF) and explain how it differs from traditional fermented cassava flour
- Describe the benefits of using cassava–wheat composite flour for cassava processors, bakers, wheat flour millers, and consumers
- Explain the economic impact and food security benefits of BCF adoption
- Use key terminology related to cassava flour and composite flour bread-making correctly
- Identify opportunities for professional growth in the expanding cassava flour industry.

1.1 KEY TERMINOLOGY AND DEFINITIONS

Bread-making cassava flour (BCF): Unfermented cassava flour specifically processed for commercial bread production within 24 hours of harvest.

High-quality cassava flour (HQCF): Alternative name for BCF, emphasizing the quality standards required for bread-making and other industrial applications.

Composite flour: A blend of BCF and wheat flour used for bread and pastry production.

Recovery rate: The percentage of BCF obtained from fresh cassava roots, typically around 25–30%.

Good manufacturing practices (GMP): Systematic procedures to ensure consistent quality and safety in flour, bread, and pastries production.

Good hygiene practices (GHP): Sanitation and cleanliness procedures essential for producing food-grade flour, and safe bread and pastries.

Inclusion level: The percentage of BCF substituted for wheat flour in composite flour blends (typically 5–20%).

Biofortified cassava: Cassava varieties with enhanced nutritional content, particularly yellow-fleshed varieties high in beta-carotene.

Fermentation: The natural process that must be prevented in BCF production to keep it odorless, tasteless, and white (or yellow/cream colored if from biofortified cassava).

Moisture content: The amount of water in a product, which in BCF must be no more than 10% to prevent spoilage and maintain quality.

1.2 WHAT IS BREAD-MAKING CASSAVA FLOUR?

Bread-making cassava flour (BCF) is a specially processed flour made from freshly harvested cassava roots. Unlike traditional cassava flour that may be fermented or roughly processed, BCF is specifically designed to meet the technical requirements of commercial bread-making.

Key characteristics of BCF

BCF has specific qualities that make it suitable for bread production:

- **White color:** Properly processed BCF is white (or cream/yellow if made from biofortified cassava)

- **Odorless and tasteless:** Unlike fermented cassava products, BCF has no smell or taste
- **Fine texture:** The flour is smooth and fine, similar to wheat flour
- **Clean composition:** Free from foreign matter, fungus, and excessive bacteria
- **Controlled moisture:** Contains no more than 10% moisture to prevent spoilage
- **Neutral pH:** Maintains pH levels (5.8–7.0) that support proper yeast activity.

The recovery rate from fresh cassava roots to BCF is typically around 25%, meaning that 100 kg of fresh cassava roots will produce about 25 kg of BCF. The recovery rate may be higher by 3–5% if cassava varieties with higher dry matter are used to produce BCF.

Why BCF is different

BCF differs from traditional fermented cassava flour in that it is:

- **Unfermented:** Processed quickly to prevent fermentation that would create sour tastes and undesirable odors
- **Carefully timed:** Processed within 24 hours of harvest to maintain quality
- **Carefully processed for safety:** Processed following specific steps that remove cyanogenic and other potentially toxic substances from the flour
- **Quality controlled:** Meets specific standards for moisture, particle size, and purity required for bread-making.

The detailed processing steps are covered in Module 2, section 2.1.

1.3 BENEFITS FOR CASSAVA PROCESSORS, BAKERS, MILLERS, AND CONSUMERS

The adoption of cassava–wheat composite flour creates benefits throughout the food system, making it an attractive opportunity for various stakeholders.

Benefits for cassava processors

New skills: Because BCF production is so different from traditional (fermented) cassava flour production, processors are learning new skills in the processing of raw cassava.

A new profitable product: Because BCF is a higher-quality product than traditional cassava flour (hence its alternate name of "high-quality cassava flour", HQCF), it is likely to fetch a higher price than its traditional counterparts.

Market expansion: BCF can be used as a partial substitute for wheat flour in baking products such as bread, cakes, biscuits, and pastries. This substitution is attracting the attention of various African governments, enabling cassava processors to tap into the growing industrial demand for BCF-based products.

New customers: Wheat flour millers and bakers have no use for traditional cassava flour, so by targeting them with BCF, cassava processors are opening up new markets for their products.

Social and economic: Processing cassava into BCF creates economic opportunities for small- and medium-scale processors, especially women and youth who are key value chain actors.

Benefits for bakers

Cost reduction: Locally produced BCF typically costs less than imported wheat flour, directly reducing production expenses (this is also likely the case where intraregional trade in cassava flour is cost-effective and viable). Evidence from major cassava-producing countries, including DRC and Nigeria, shows that using 10% BCF can significantly reduce flour costs and increase food product quality.

Increased output: Many bakers report that bread and biscuits made with 10% BCF produce more loaves and cartons per batch than those made with 100% wheat flour, increasing revenue while using less-expensive ingredients.

Product quality: When used properly, BCF maintains bread quality that consumers accept because of its improved texture and crust appearance.

Safety: BCF contains very little residual cyanogenic substances that do not pose any health risks to consumers.

Market positioning: Bakers can market their products as supporting local agriculture and offering enhanced nutritional benefits.

Benefits for wheat flour millers

Reduced import dependence: Incorporating BCF allows millers to source local raw materials, reducing their exposure to volatile international wheat prices and supply disruptions.

New markets: Wheat millers will develop specialized products and market niches, differentiating their offerings from purely imported alternatives. BCF is particularly suitable for replacing cake and biscuit flour when blended with wheat flour; it can also be used alone (without any wheat flour) for cakes and biscuits.

Vertical integration: BCF adoption presents opportunities for backward integration into cassava farming and processing, ensuring stable raw material supplies while supporting local agriculture.

Corporate responsibility: Adopting composite flour aligns with national policies and demonstrates a commitment to local economic development.

Benefits for consumers

Potentially lower prices: Cost savings in flour production can translate to more affordable bread prices for consumers.

Enhanced nutrition and health benefits: Studies suggest that bread that incorporates BCF produces a lower glycemic response than 100% wheat bread. Composite-flour bread may thus be promoted as a healthier alternative for people managing their blood sugar levels. Meanwhile, in apparently healthy individuals, the lower glycemic response may enhance physical endurance by maintaining a more stable glucose level after consumption. BCF is a suitable alternative to wheat flour in producing acceptable pastries and confectionary for people struggling with gluten intolerance.

Improved digestibility: Cassava flour has greater dietary fiber content than wheat flour and also acts as a prebiotic supporting digestive health. Bread made with composite flour is thus more easily digestible than 100% wheat bread, which is beneficial to consumers with sensitive digestive systems.

Supporting local development: Purchasing composite-flour bread supports local cassava farmers and reduces national dependence on food imports.

1.4 ECONOMIC IMPACT AND FOOD SECURITY BENEFITS

National economic benefits

Many African countries spend substantial amounts on wheat imports. This expenditure represents a significant drain on foreign exchange reserves. When global conflicts disrupt wheat supplies (e.g., the war in Ukraine), bread prices rise sharply, affecting families and businesses across the continent.

Policy responses: Governments in cassava-producing African countries are developing policies to promote BCF use. The DRC requires minimum inclusion levels of 5% BCF for bread and 10% for pastry products. Similar policies are being developed in other major cassava-producing countries, including Ghana, Guinea, Kenya, and Nigeria.

Food security implications

Supply stability: Local cassava production provides a more reliable supply chain than dependence on international wheat markets subject to weather, conflict, and trade disruptions.

Market opportunities for farmers: BCF creates industrial demand for cassava, providing farmers with higher-value markets beyond traditional food uses.

Value chain development: The BCF industry creates employment opportunities in processing, transportation, and marketing, contributing to rural economic development.

Regional integration: The African Organisation for Standardisation (ARSO) and the East African Community's harmonized standards for BCF and composite flour facilitate intracontinental and regional trade, creating larger markets for successful producers.

1.5 PROFESSIONAL OPPORTUNITIES IN THE CASSAVA FLOUR INDUSTRY

The growing cassava flour industry creates diverse career opportunities for trained professionals.

Production roles: BCF processing facilities need skilled operators, quality control technicians, and production supervisors who understand both cassava processing and food safety requirements.

Bakery applications: Bakers with expertise in composite-flour techniques are increasingly valuable to commercial bakeries, hotels, and food service operations.

Technical services: Equipment suppliers, ingredient companies, and consulting firms need professionals who can provide technical support to BCF producers and users.

Quality assurance: The industry requires specialists in testing, quality control, and regulatory compliance to ensure products meet national and international standards.

Business development: Entrepreneurs can establish BCF processing operations, composite-flour distribution businesses, or specialized bakeries focusing on cassava-based products.

Extension and training: Agricultural extension services and training organizations need professionals who can teach BCF production and utilization techniques to local entrepreneurs, processors, and bakers.

The skills you develop in this course will position you to participate in this growing industry while contributing to African food system transformation.

KEY TAKEAWAYS

- **BCF is a specialized product:** Unlike traditional fermented cassava flour, BCF is specifically processed within 24 hours of harvesting the cassava roots to meet commercial bread-making requirements.
- **Multiple stakeholder benefits:** BCF adoption creates cost savings for bakers, business opportunities for millers, and nutritional benefits for consumers.
- **Economic significance:** Cassava flour substitution can substantially reduce national wheat import costs while supporting local agriculture.
- **Food security contribution:** BCF provides supply chain resilience and creates market opportunities that strengthen food system stability.
- **Growing industry:** The cassava flour sector offers diverse professional opportunities for trained individuals across production, processing, application, marketing, and support services.
- **Policy support:** Government policies across Africa are promoting BCF adoption through mandatory inclusion requirements and supportive regulations.

Self-assessment questions

1. **Multiple choice:** What is the maximum time allowed between cassava root harvest and completion of the drying process for BCF production?

   (a) 12 hours (b) 24 hours (c) 48 hours (d) 72 hours

2. **Short answer:** List three key characteristics that distinguish BCF from traditional fermented cassava flour.

   1. _____

   2. _____

   3. _____

3. **True/False:** BCF typically costs more than wheat flour, making it less attractive to commercial bakers.

4. **Application:** A baker in Nigeria is considering switching from 100% wheat flour to a 10% BCF composite flour. Explain three potential benefits this baker might experience.

   1. _____

   2. _____

   3. _____

5. **Definition:** In your own words, define "composite flour" and explain why government policies across Africa are promoting its use.

   _____

   _____

   _____

6. **Analysis:** The recovery rate for BCF is typically around 25%. What does this mean, and why is this information important for someone planning to enter the BCF processing business?

   _____

   _____

   _____

See Appendix F for answers.

MODULE 2:
TECHNICAL FOUNDATIONS OF BREAD-MAKING CASSAVA FLOUR

LEARNING OBJECTIVES

By the end of this module, you will know how to:

- Identify the essential processing steps and timing requirements for producing BCF, also called high-quality cassava flour
- Evaluate BCF quality using physical, chemical, and microbiological criteria
- Apply proper storage and handling techniques to maintain BCF quality
- Diagnose common quality problems in BCF and recommend solutions
- Explain why specific processing parameters are critical for bread-making applications.

2.1 BCF PROCESSING STEPS AND TIMELINE—GOOD MANUFACTURING PRACTICE

The production of BCF requires precise timing and systematic processing to achieve the quality standards needed for commercial bread-making.

Critical timing requirement

24-hour no fermentation rule: The entire process from harvesting cassava roots to completing the drying stage must occur within 24 hours. This prevents fermentation and maintains the white color and neutral taste essential for bread applications.

Step-by-step processing procedure

Step 1: Root selection and preparation

- Use only wholesome, freshly harvested cassava roots
- Choose mature roots (12–18 months after planting) for optimal starch content
- Select high dry-matter content varieties for higher BCF recovery rates or output
- Avoid roots with visible damage, rot, or excessive fiber.

Step 2: Peeling

- Remove the peel completely using sharp stainless-steel knives
- Eliminate all peel and stalks/peduncles to prevent flour discoloration
- Work systematically to avoid leaving any skin remnants
- Wear gloves to prevent injury during knife use
- Immediately place peeled roots in clean containers.

Step 3: Washing

- Wash immediately after peeling to maximize final product whiteness
- Wash peeled roots thoroughly (several times) in clean water to remove soil and debris
- Use scrubbing brushes or sponges for heavily soiled roots
- Do not leave roots in water for more than one hour (to avoid fermentation)
- Do not leave or expose peeled roots to the sun or air too long (to prevent discoloration).

Step 4: Grating

- Grate the roots immediately after washing
- Use a mechanical grater or wet hammer mill to create fine pulp
- Run clean water through the equipment before use to wash it and provide lubrication
- Never use chippers for bitter cassava varieties, as they cannot sufficiently reduce cyanide levels
- Ensure grating drums are sharp for efficient rasping (grating)
- Wet milling produces finer pulp and may improve BCF yield more than dry milling
- Collect the "mash" in clean containers and transfer to clean polypropylene sacks
- Tie off the sacks and keep them clean and away from the dewatering machine
- Clean the equipment and store it in a clean place.

Step 5: Dewatering—removing cyanide by pressing excess water out of the cassava mash

- Dewater as soon as possible to avoid fermentation
- Use hydraulic presses or other forms of dewatering machines to remove excess moisture from the cassava mash
- To use hydraulic presses, load grated pulp (standard amounts, e.g., 10–15 kg) into clean, water-permeable but solid-impermeable bags (e.g., propylene)
- Place bags evenly across the press cage with wood corners for support
- If a jack is used, place a wooden or metal plate underneath it
- Press systematically to achieve uniform water removal
- Allow liquid (called "liquor") to drain adequately to reduce the moisture to 35% or lower
- Clean the press and jack and store them in a clean place
- A centrifuge or filter press may be used for dewatering on an industrial scale
- Only trained staff should operate dewatering equipment.

Step 6: Pulverization/Granulation

- Break pressed cake and pass it through motorized grater or mill—this creates uniform granules for efficient drying
- Collect granulated material in clean, dry containers or pass directly to the dryer in a continuous process
- Clean granulation equipment before and after use.

Step 7: Drying

- Dry granulated cassava to achieve ≤ 10% moisture content

  The East African standard allows up to 12% moisture, but IITA recommends no more than 10%

- Flash dryers are preferred for BCF to achieve rapid processing and good final product quality
- Alternative mechanical dryers include cabinet, tunnel, and rotary dryers
- Complete the drying operation within 24 hours of harvest of the raw material to prevent fermentation and off-odors
- Collect the dry granules in clean containers or bags
- Ensure the equipment is maintained and regularly serviced
- Only trained technicians should operate drying equipment.

Step 8: Milling

- Mill dried cassava into fine, uniform flour
- Target particle size of 250 µm for optimal bread-making properties

  Check relevant standards, especially national, in case they require finer flour

- Allow flour to cool completely in a cool, dry environment to avoid moisture reabsorption
- Clean equipment thoroughly, especially after processing other products.

Step 9: Sieving

- Sieve milled flour to achieve a uniform particle size
- Remove any foreign matter or oversized particles
- Produce fine, free-flowing flour suitable for blending with wheat flour.

Step 10: Packaging and storage

- Package cooled BCF in clean laminated polypropylene bags with polyethylene liners
- Seal bags properly
- Cooling, milling, sieving, and packaging must be done within the shortest possible time after drying to prevent moisture ingress
- Label with processing date, best before date, batch/lot number, and address of the manufacturer
- Store in clean, dry, well-ventilated areas off the ground using pallets
- Check stored products regularly for quality stability
- Follow first-in first-out (FIFO) rule in flour sale.

SUMMARY OF GOOD MANUFACTURING PRACTICE (GMP) FOR BCF

Step 1. **Always use good-quality cassava roots**
to ensure optimum recovery and white color of BCF

Step 2. **Within 12 hours of harvest, peel roots removing any rot**
to minimize waste as roots will start to deteriorate 12 hours after harvest

Step 3. **Wash peeled roots in clean water**
to achieve low microbiological levels in flour

Step 4. **Keep the washed roots in clean water for a short period (< 1 hour) and grate immediately**
to avoid discoloration and ensure white color

Step 5. **Produce a wet mash by grating or using a wet hammer mill (never use a chipper!)**
to facilitate water removal and remove cyanide from the flour

Step 6. **Remove as much water from grated mash as possible using a dewatering machine such as a hydraulic press and granulate the resulting cake**
this is to increase the surface area to speed up the drying process

Step 7. **Completely dry the wet granules as quickly as possible**
to avoid fermentation, bad odor, sour taste, and mold

Step 8. **Mill dried cassava grits**
to produce a fine flour

Step 9. **Sieve with 250 µm mesh (or less if required by national standards)**
to produce a fine free-flowing flour and remove foreign matter

Step 10. **Bag in polypropylene bags with liner and keep in hygienic dry aerated store**
to maintain quality and prolong shelf life

The whole process from root harvesting to final drying must be completed within 24 hours.

Quality control during processing

Critical control points must be monitored throughout processing:

- Raw material quality at intake
- Cleanliness of water used for washing
- Completeness of peeling operation
- Efficiency of dewatering process
- Achievement of target moisture levels during drying
- Particle size consistency during milling and sieving
- Proper packaging and storage conditions.

2.2 QUALITY SPECIFICATIONS AND STANDARDS

BCF must meet specific quality criteria to function effectively in bread-making. These specifications ensure consistent performance and food safety.

Note: This section presents IITA recommendations. Detailed international and national standards are covered in Module 4.

Physical properties

Appearance and color

- White (from white-fleshed cassava) or yellow/cream (from biofortified cassava)
- Free from visible foreign matter, mold, or discoloration
- Fine, smooth texture without lumps or coarse particles.

Particle size

- Target: 250 µm (or national standard specification)
- Must pass uniformly through standard sieves
- Consistent particle size ensures proper blending with wheat flour.

Moisture content

- Maximum 10% for optimal storage stability
- Lower moisture prevents microbial growth and extends the shelf life
- Critical for maintaining free-flowing properties.

Chemical requirements

pH level

- Target range: 5.8–7.0
- Neutral pH supports optimal yeast performance during bread fermentation
- pH outside this range can negatively affect bread quality.

Starch content

- Minimum 60% by mass.

Cyanide content

- Maximum 10 mg/kg (10 ppm)
- Essential for food safety
- Proper processing reduces cyanide levels from fresh cassava.

Microbiological safety limits

Bacterial contamination

- Low bacterial counts indicate good hygiene during processing
- High counts suggest contamination, poor hygiene practices, or inadequate drying.

Yeast and mold

- Must be within acceptable limits for food safety (per national standards or Codex Alimentarius)
- Excessive levels indicate moisture problems or poor storage.

Pathogenic organisms

- There must be none present (*E. coli*, *Salmonella*, harmful *Staphylococcus*)
- Critical for consumer safety.

Aflatoxin levels

- Must meet established food safety standards
- Regular testing required, especially in humid storage conditions.

Testing BCF quality

While detailed laboratory testing requires specialized equipment, basic quality assessment can be performed using simple methods. Details of these tests are presented in Module 6, section 6.1.

2.3 STORAGE AND HANDLING REQUIREMENTS

Proper storage and handling maintain BCF quality from production through use in bread-making.

Storage environment

Temperature control

- Store at ambient temperature in dry conditions
- Avoid areas with large temperature fluctuations
- Protect from direct sunlight and heat sources.

Humidity management

- Maintain low relative humidity in storage areas
- Use moisture-proof packaging to prevent moisture ingress
- Monitor storage areas for condensation problems.

Ventilation requirements

- Ensure adequate air circulation around stored products
- Prevent stagnant air that can promote mold growth
- Maintain clean, dust-free storage environment.

Insects and rodents

- Ensure complete sealing of the walls, doors, windows, ceilings, and roof of the store to prevent insects and rodents from entering
- Implement recommended disinfection or fumigation protocol for the store.

Packaging considerations

Primary packaging

- Use laminated polypropylene bags or polypropylene bags with polyethylene liners
- Ensure complete sealing to prevent moisture entry
- Select appropriate bag sizes for handling convenience.

Labeling requirements

- Common name or product: "Bread-making cassava flour" or "High-quality cassava flour"
- Name and address of manufacturer
- Brand/trade name
- Weight of contents (metric units, e.g., kg)
- Country of origin
- Batch/lot number (for traceability)
- Production date (for inventory management)
- Best before date
- "Human food"
- Storage instructions.

Inventory management

First-in-first-out (FIFO) system

- Use older stock before newer production
- Rotate inventory systematically
- Monitor expiration dates regularly.

Storage organization

- Store bags on pallets, never directly on floors
- Maintain access space around storage areas for inspection
- Keep storage areas clean and pest-free
- Separate different production batches clearly.

Handling procedures

- Use clean handling equipment and containers
- Avoid contamination during transport and use
- Protect from moisture during handling
- Train staff in proper handling techniques.

2.4 COMMON QUALITY ASSURANCE ISSUES AND SOLUTIONS

Understanding common BCF quality issues helps prevent problems and maintain consistent product quality. The listed problems and solutions are based on the principles of hazard analysis and total quality management.

Processing-related problems

Problem: Yellow or dark coloration

- Causes: Delayed processing, inefficient peeling, inadequate washing, fermentation
- Prevention: Do not use rotten roots or roots from a farm field that has been burned. Process within 24 hours of harvest, wash thoroughly, do not leave in water for more than 1 hour
- Solution: Proper peeling, improve timing and washing procedures.

Problem: Sour or fermented odor

- Causes: Exceeding 24-hour processing timeline after roots were harvested, inadequate drying, contaminated equipment
- Prevention: Maintain strict timing, achieve correct moisture levels, sanitize equipment
- Solution: Reject affected roots or batches, review processing procedures.

Problem: Coarse or gritty texture

- Causes: Inadequate milling, worn grinding equipment, insufficient sieving
- Prevention: Maintain sharp grinding equipment, proper sieving procedures
- Solution: Re-mill if possible, replace worn equipment parts.

Storage-related problems

Problem: Mold growth

- Causes: Excessive moisture content, poor storage conditions, damaged packaging
- Prevention: Achieve proper drying, use moisture-proof packaging, maintain dry storage
- Solution: Discard affected batches, improve drying procedures, upgrade storage facilities.

Problem: Caking or clumping

- Causes: Moisture absorption, temperature fluctuations, poor packaging
- Prevention: Proper moisture control, stable storage environment, quality packaging
- Solution: Improve storage conditions, check packaging integrity.

Problem: Foreign matter contamination

- Causes: Inadequate cleaning, poor processing hygiene, contaminated containers, processing machines, or storage
- Prevention: Implement thorough cleaning procedures, maintain processing hygiene
- Solution: Review and improve cleaning protocols.

KEY TAKEAWAYS

- **Timing is critical:** The 24-hour processing timeline from harvest to drying is non-negotiable for quality BCF production
- **Each step matters:** Every processing step from peeling through packaging affects final product quality and bread-making performance
- **Quality specifications are interconnected:** Physical, chemical, and microbiological parameters work together to determine BCF suitability for bread-making
- **Proper storage preserves quality:** Good storage and handling practices maintain BCF quality from production through use
- **Prevention is better than correction:** Understanding common problems and their causes enables proactive quality management
- **Simple testing works:** Basic visual, tactile, and odor assessments can identify most quality issues without expensive laboratory equipment.

Self-assessment questions

1. **Multiple choice:** At what age are most cassava varieties at optimum maturity for harvesting and subsequent processing into BCF?

   (a) 6–12 months after planting (b) 12–18 months after planting (c) 18–24 months after planting
   (d) any time after 12 months after planting, as cassava is perennial

2. **Short answer:** List three critical quality parameters that must be controlled during BCF processing and explain why each is important for bread-making.

   1. _____ Why: _____
   2. _____ Why: _____
   3. _____ Why: _____

3. **True/False:** BCF should be properly fermented to have a slightly sour smell.

4. **Problem-solving:** A baker receives BCF that appears yellowish and has a slightly sour odor. What likely went wrong during processing, and what should the baker do?

   Problem: _____

   Action: _____

5. **Application:** You are setting up BCF storage for a small processing facility. List four essential requirements for proper storage that will help maintain quality for 12 months.

   1. _____
   2. _____
   3. _____
   4. _____

6. **Analysis:** Explain why the particle size specification (250 µm) is important for BCF used in bread-making. What problems might occur if the particle size is too large?

   Too large: _____

See Appendix F for answers.

MODULE 3:

HYGIENE AND FOOD SAFETY IN CASSAVA PROCESSING PLANTS AND BAKERIES

LEARNING OBJECTIVES

By the end of this module, you will know how to:

- Apply proper personnel hygiene practices in BCF and bread production environments
- Implement safe ingredient handling and storage procedures
- Perform effective equipment cleaning and sanitization
- Manage facilities to prevent contamination and pest problems
- Maintain essential documentation for food safety compliance.

Good hygiene and food safety practices are essential for protecting consumers, maintaining product quality, and building a successful business. Poor hygiene can lead to foodborne illness, product spoilage, customer complaints, and business closure. Personnel and environmental hygiene are very important in bakeries, as bread is highly prone to contamination from the environment, including workers. Yet, local bakeries are generally characterized by poor hygiene. This module covers practical hygiene and safety procedures that must be implemented in all cassava processing or bakery settings.

3.1 PERSONNEL HYGIENE REQUIREMENTS

Personnel hygiene is your first line of defense against food contamination. Every person working in food processing and bread production must follow strict hygiene standards.

- Do not work when unwell
- Wash hands
  - Before starting work
  - After visiting the toilet
  - Before handling raw materials and products
  - After handling eggs and before contact with other food
  - After touching your face, hair, or clothes
  - After handling cleaning materials
  - Before handling ready-to-eat products
  - At the end of the work shift.

Protective equipment and clothing

- Wear a clean apron or work clothing daily
- Hairnets or caps covering all hair completely
- Wear clean gloves when handling raw materials and products
- Closed, nonslip shoes suitable for cleaning
- Wash and dry all aprons, shoes, and work clothing after each workday.

What to avoid or do

- Remove jewelry except plain wedding rings
- Avoid loose clothing that could come into contact with food or get caught in machinery
- Never handle bread or pastry products with bare hands—wear clean gloves.

3.2 INGREDIENT HANDLING AND STORAGE

Purchase and receipt procedures

- Purchase ingredients from reliable suppliers approved by government agencies
- At delivery:
  - Check that ingredients are not expired
  - Ensure ingredients have been properly packaged and transported at appropriate temperatures (chilled products at 4 °C or lower)
- Keep invoices of ingredients purchased for traceability purposes.

Storage requirements

- Adopt the first-in-first-out (FIFO) approach
- Do not use ingredients beyond their expiry/best before date
- Store ingredients at appropriate temperatures
- For yeast:
  - store yeast at the manufacturer's recommended temperature to preserve its effectiveness—as the bakery environment is usually hot, yeast should be kept inside a refrigerator, never in a hot environment
  - always respect the expiry date of yeast—expired yeast will not give good bread
  - *substandard yeast storage or yeast expiry result in poor bread volume and quality in local bakeries—a fact that is often not obvious to many traditional bakers*
- For eggs:
  - store eggs at a cool temperature until needed
  - if storing at room temperature, use the current batch daily and replenish stocks daily.

Cross-contamination prevention

- Use clean gloves when handling raw materials and products
- Keep raw eggs away from other food, especially cooked and ready-to-eat food
- Clean equipment, utensils, and preparation surfaces thoroughly with soap and water after every step of preparation.

3.3 PRODUCT SAFETY

General

- Do not handle flour, bread, or pastries with bare hands—wear clean gloves.

Cooling

- Allow freshly heat-dried cassava grits to cool to ambient temperature before milling
- If necessary, allow freshly milled BCF to cool to ambient temperature before sealing the packaging, to avoid condensation
- Cool fresh-baked bread on clean racks
- Ensure good air circulation
- Keep products covered as much as possible during cooling.

Packaging

- Use clean food-grade packaging
- Label with product name, name and address of the manufacturer, and best before date.

WORKING WITH EGGS

- Ensure eggshells are not cracked upon receipt—discard cracked eggs
- Store eggs at a cool temperature until needed
- If storing at room temperature, use the current batch daily and replenish stocks daily
- When pooling eggs:
  - Pool only the required quantity
  - Use all pooled liquid egg on the same day
  - Do not top up with new eggs
- Keep raw eggs away from other food, especially cooked and ready-to-eat products
- Wash hands, utensils, and surfaces thoroughly after handling eggs.

3.4 EQUIPMENT CLEANING AND SANITIZATION

Daily cleaning procedures

Core cleaning principles: Follow the eight equipment sanitation rules.

EQUIPMENT SANITATION RULES

1. After each shift, disassemble and thoroughly clean all surfaces that come in contact with cassava or dough
2. Read the equipment manual to ensure complete disassembly of all parts
3. Use approved and correct cleaning agents
4. Perform deep cleaning at least once a month to sanitize any crevices that might get neglected during routine daily cleaning
5. Stock spare parts that undergo significant wear and tear
6. Replace damaged or worn parts that can have uneven surfaces, allowing microbes, flakes, and crumbs to settle
7. Follow a disciplined, regular sanitation schedule and ensure proper waste disposal
8. Remember that cassava-processing and bread-making equipment is designed with efficiency and cleanliness in mind.

Daily cleaning is required for:

- All areas (e.g., each zone of the processing plant, stores, transport vehicles, bakery area, make-up room, display areas)
- All equipment and utensils
- Display cases.

Equipment, utensils, and work areas used for the operations listed below should also be cleaned after each production step:

BCF processing

- Peeling
- Washing
- Grating
- Dewatering
- Granulation
- Drying
- Milling
- Packing.

Bread-making

- Ingredient weighing
- Flour blending
- Mixing
- Proofing
- Baking
- Cooling
- Slicing.

3.5 FACILITY MANAGEMENT AND PEST CONTROL

Essential daily tasks

- Clean oven fuel, wood, or gas storage area, bakery area, make-up room, and display areas
- Clean all utensils and equipment
- Sweep and mop floors thoroughly
- Empty waste containers and replace liners
- Check storage areas for cleanliness and organization.

Display area management

- Store bread loaves in clean display cases, covered at all times
- Ensure breads are stored at appropriate temperatures
- Do not display bread with perishable fillings (e.g., sardine bread) beyond 4 hours at room temperature
- Adopt a first-in-first-served approach for bread display
- Consider time/date-stamping bread packages to inform consumers of best-before dates.

Waste management and cleaning

Waste handling

- Practice good waste management with regular removal
- Clean waste containers regularly
- Maintain adequate drainage systems.

General facility cleaning

- Plan and follow a systematic cleaning schedule
- Clean floors, walls, and work surfaces daily
- Maintain proper ventilation
- Ensure adequate lighting for cleaning visibility.

Daily cleaning schedule										
	Mon	**Tue**	**Wed**	**Thu**	**Fri**	**Sat**	**Sun**	**Cleaning materials**		
Date:								*Only use the cleaning materials stated below*		
Area:										
Peeling										
Knives										
Basins/buckets										
Flooring								Clean water	Disinfectant	
Washing										
Tiles										
Flooring										
Basins/buckets										
Grating										
Tiles										
Flooring										
Basins/buckets										
Pressing										
Tiles										
Flooring										
Basins/buckets										
Pressing machine										
Hydraulic jack										
Bags/sacks										
Drying										
Flooring										
Flash dryer feed unit										
Flash dryer discharge unit										
Bagging and storage										
Packaging/bags										
Basins/buckets										
Flooring										
Pallets										
Report any issues to the supervisor or manager										

Figure 3.1. Sample cleaning schedule template with daily tasks.

Pest control measures

- Implement effective pest control programs
- Conduct regular facility inspections
- Maintain equipment properly to prevent damage that attracts pests
- Promptly repair or replace damaged equipment to prevent contamination
- Install window netting
- Cover all openings from the processing or baking building to the outside with wire gauze
- Keep ingredients, food, and flour stored in sealed containers
- Remove food debris and standing/waste water
- Document all pest control activities.

3.6 DOCUMENTATION AND RECORD-KEEPING FOR FOOD SAFETY

Why documentation matters

Legal and business reasons

- Demonstrates compliance with food safety regulations
- Provides evidence of systematic quality management
- Helps identify problems and perform corrective actions before they become serious
- Protects business reputation and reduces liability
- Helps with traceability
- Required for regulatory inspections and certifications.

Operational benefits

- Helps track ingredient usage and costs
- Identifies patterns in equipment problems
- Supports continuous improvement efforts
- Facilitates staff training and accountability.

Essential records to maintain

Ingredient traceability

- Keep invoices of ingredients purchased for traceability purposes
- Record supplier information and delivery dates
- Track ingredient storage conditions and usage
- Monitor best before dates and rotation.

Cleaning and maintenance logs

- Document daily cleaning activities
- Record equipment maintenance and repairs
- Track sanitizer usage and effectiveness
- Note any problems discovered during cleaning.

Temperature monitoring

- Record storage temperatures for temperature-sensitive ingredients
- Monitor and document proofing and baking temperatures
- Track equipment calibration and performance.

Documentation templates

These are set up for a bakery environment, but could easily be modified for use in a cassava processing plant.

Daily hygiene and cleaning checklist

Date: _____

Personal hygiene:

- All staff wear clean protective clothing, gloves, and shoes
- All staff follow proper handwashing procedures
- Clean gloves used when handling raw materials and bread products
- Staff not working when unwell

Ingredient handling:

- Raw eggs prepared away from other ingredients and food
- Equipment and surfaces cleaned after each preparation step
- Proper storage temperatures maintained

Equipment cleaning:

- All dough-contact surfaces cleaned after each shift
- Equipment properly disassembled for cleaning
- Approved cleaning agents used
- Deep cleaning performed (monthly)

Facility management:

- Bakery, cloakroom, and display areas cleaned
- All utensils and equipment cleaned
- Display cases clean and covered
- Pest control measures maintained

Problems noted:

_____

_____

_____

Corrective action taken:

_____

_____

_____

Completed by: _____

Signature: _____ Time: _____

Supervisor's signature: _____ Time: _____

Ingredient traceability log

Date: _____ Supplier: _____

Item: _____ Quantity: _____

Expiry/Best before date: _____

Transportation temperature (chilled items): _____ °C

Storage location: _____

Quality check on receipt:

☐ Not expired ☐ Proper packaging ☐ Correct temperature ☐ Approved supplier

Invoice kept for traceability: ☐ Yes

Problems noted:

_____

_____

_____

Received by: _____

Signature: _____ Time: _____

Supervisor's signature: _____ Time: _____

Equipment cleaning record

Equipment: _____

Date: _____ Shift: _____

- Disassembled per manufacturer's instructions
- All dough-contact surfaces cleaned thoroughly
- Approved cleaning agents used
- Equipment properly dried before reassembly

Deep cleaning (monthly):

- Crevices and hard-to-reach areas cleaned
- Worn parts identified and replaced

Problems noted:

_____

_____

_____

Parts needing replacement: _____

Completed by: _____

Signature: _____ Time: _____

Supervisor's signature: _____ Time: _____

Record-keeping best practices

- Keep records organized and accessible
- Train staff in proper completion of documentation
- Review records regularly to identify issues
- Use records to improve procedures.

KEY TAKEAWAYS

- **Environmental and personnel hygiene** are major issues in traditional bakeries.
- **Personnel hygiene prevents contamination:** Proper handwashing, clean gloves, and staff not working when unwell.
- **Eight equipment sanitation rules must be followed:** Systematic cleaning after each shift, proper machine disassembly, approved cleaning agents, monthly deep cleaning, parts replacement, disciplined schedules, and maintaining equipment design standards.
- **Ingredient handling requires specific procedures:** Eggs must be prepared away from other food, proper storage temperatures must be maintained, and FIFO rotation must be followed.
- **Facility management is daily work:** Clean display cases, proper storage, effective pest control, and systematic cleaning schedules.
- **Documentation demonstrates compliance:** Keeping invoices for traceability and maintaining cleaning records demonstrates an effective food safety management system.
- **Everyone shares responsibility:** Food safety requires commitment from every person in the plant or bakery.

Self-assessment questions

1. **Multiple choice:** Which of the following is *not* one of the eight equipment sanitation rules?

   (a) Disassemble and clean all dough-contact surfaces after each shift;
   (b) Use approved cleaning agents;
   (c) Clean equipment only when visibly dirty;
   (d) Replace damaged parts that can harbor microbes.

2. **True/False:** You can handle bread products with your bare hands as long as you wash your hands first.

3. **Short answer:** List four specific times when you must wash your hands during bread production.

   1. _____
   2. _____
   3. _____
   4. _____

4. **Application:** Describe the proper procedure for handling eggs in bread production, including storage and preparation requirements.

   Storage: _____

   Preparation: _____

5. **Problem-solving:** You notice that display bread has been sitting at room temperature for 5 hours and contains perishable sardine filling. What should you do and why?

   Action: _____

   Reason: _____

6. **Analysis:** Explain why keeping invoices for ingredient purchases is important for food safety and traceability.

   _____

   _____

   _____

See Appendix F for answers.

MODULE 4:
UNDERSTANDING STANDARDS AND QUALITY CONTROL

LEARNING OBJECTIVES

By the end of this module, you will be able to:

- Explain why different standards exist and how they work together
- Compare key requirements across international, continental, regional, and national standards for BCF and composite flour
- Identify where standards overlap, conflict, or cover different requirements
- Apply appropriate standards for different market destinations (national, regional, continental, international)
- Determine correct labeling requirements based on your target market
- Use standards compliance as a competitive advantage in your bakery business.

Understanding standards is essential for any professional baker or BCF processor. Standards protect consumers, ensure fair trade, and help you access larger markets. While standards may seem complex, they follow logical patterns that become clear once you understand the system.

4.1 WHY STANDARDS MATTER: THE MULTILEVEL SYSTEM

The standards pyramid

Food standards exist at four main levels, each building on the ones "below".

International level (Codex Alimentarius)

- Provides baseline food safety requirements recognized worldwide
- Establishes maximum limits for contaminants, pesticides, and toxins
- Sets principles for good manufacturing practices
- Forms the foundation for all other standards.

Continental level (African Standards—ARSO)

- Harmonizes requirements across African countries
- Focused on facilitating intra-African trade
- Adapts international standards to African conditions and priorities
- Covers products particularly important to Africa, such as BCF.

Regional level (East African Community, ECOWAS, etc.)

- Creates common standards within trading blocs
- Enables free movement of goods between member countries
- Often more detailed than continental standards
- May include specific technical requirements for regional priorities.

National level (individual country legislations)

- Enforces standards within the country's borders
- May add specific requirements for local conditions
- Required for legal operation in any country
- Can be more or less strict than higher-level standards.

Why multiple levels exist

This system exists because:

- **Food safety is universal**—basic safety requirements apply everywhere
- **Trade needs consistency**—common standards enable commerce between countries
- **Local conditions vary**—different climates, equipment, and markets need specific adaptations
- **Sovereignty matters**—each country must control its own food processing and supply.

Practical implications for you

A baker or processor must comply with standards at all relevant levels.

- **Domestic sales:** Meet national standards (which incorporate international requirements)
- **Regional exports:** Meet national standards, regional harmonized standards, and the standards of target export countries
- **Continental exports:** Meet national, regional, and continental requirements
- **International exports:** Meet all levels plus any additional requirements of the target importing country.

Hypothetical example: A Congolese processor exporting BCF to Kenya must meet DRC national standards, East African Community regional standards, and any additional Kenyan national requirements.

This handbook uses the examples of East African regional standards and DRC national standards. For other regions and countries, a processor or baker would need to follow different regional and national standards to ensure compliance.

4.2 BCF AND COMPOSITE FLOUR STANDARDS

Note that among the four levels, only Africa and East Africa have specific standards for bread-making cassava–wheat composite flour. DRC covers some aspects of both BCF and composite-flour standards within its standard for bread and pastries. The Codex Alimentarius and DRC have no specific standards for BCF.

Key areas where standards overlap

All levels of standards agree on fundamental requirements:

- Food safety basics: No harmful bacteria, acceptable contaminant levels
- Basic quality: Product must be suitable for intended use
- Hygiene principles: Good manufacturing and hygiene practices are required
- Labeling fundamentals: Products must be properly identified and dated.

Where standards differ significantly

Particle size requirements (examples)

- Continental (African): 95% through 250 µm (0.25 mm) (BCF); 90% through 250 µm (composite)
- Regional (East African): 90% through 250 µm (0.25 mm).

pH requirements (examples; BCF only)

- Continental (African): Not specified
- Regional (East African): 5.5–7.0.

Cyanide limits (examples; BCF only)

- Continental (African): Not specified
- Regional (East African): ≤ 10 mg/kg.

Moisture content (examples)

- Continental (African): Not specified in BCF standard
- Regional (East African): ≤ 12%.

Note: IITA recommends ≤ 10% moisture content for optimal storability and bread-making performance, which is stricter than the official standard.

Composite flour inclusion requirements

This is where national policies create the biggest differences. Minimum BCF inclusion levels:

- International: No requirements
- Continental: No requirements
- Regional (East African): Minimum 10% for any composite flour
- National (DRC): Minimum 5% for bread, 10% for pastry.

Practical impact: DRC allows lower inclusion levels than regional standards, giving DRC bakers more flexibility for gradual adoption.

Requirements found only at specific levels

Microbiological limits (detailed specifications)

- Specified in African and East African standards
- Both set specific limits for *E. coli*, *Salmonella*, yeasts, and molds

- African standards also set limits on total plate count, *Vibrio cholera* (both for BCF only), *Staphylococcus aureus*, and coliform bacteria.

Starch content minimum

- Only specified in East African (≥ 60%)
- Ensures adequate functional properties for bread-making.

Aflatoxin limits

- Continental (African): ≤ 10 µg/kg total, ≤ 5 µg/kg for aflatoxin B1
- Regional (East African): Not specifically addressed.

Nutritional values

- Crude fiber (maximum): EAS 5%.

Practical compliance strategy

To operate successfully across markets, BCF processors and bakers must:

1. **Meet the strictest requirements** in all countries where they plan to sell
2. **Document compliance** with testing and quality control records
3. **Understand their target markets**—know which standards apply where
4. **Plan for growth**—design processes to meet regional standards even if starting locally.

4.3 WHEAT FLOUR STANDARDS

Since composite flour contains wheat flour, processors and bakers must also understand wheat flour standards. These are more harmonized across levels than the BCF standards.

Notes:

- International standards refer to all wheat flours derived from common/bread wheat and/or club wheat
- The African standard refers to "fortified wheat flour" with several subtypes, including "baker's flour"
- The EAS refers to several types of wheat flour, but "baker's flour" is relevant here
- DRC has adopted the Codex (international) standard for wheat flour.

Key similarities across all levels

- Food safety: Same principles for contamination control; contaminant levels, except for *S. aureus*, yeasts, and molds.

Important differences

Moisture content

- Codex/DRC: 15.5% maximum
- African and EAS: 13% maximum.

Protein content requirements

- International (Codex): Minimum 7% (dry basis)
- Continental (African): Minimum 11% for baker's flour
- Regional (East African): Minimum 11% for baker's flour
- National: varies by country.

Practical impact: Higher protein requirements at continental and regional levels ensure better bread-making performance.

Particle size

- Codex/DRC: 98% through 212 µm
- Continental and EAS: 99.2% through 180 µm.

Shelf life specifications

- Only East African standards specify shelf life: 6 months for most flours, 3 months for whole grain flour
- Other standards leave this to producers and national regulations.

Prohibited additives

- East African standards specifically prohibit azodicarbonamide (ADA) and potassium bromate
- Other standards may not specifically prohibit these, where nationally permitted
- This reflects different safety assessments at the regional level.

Why wheat standards matter for composite flour

When you blend BCF with wheat flour:

- **Final product must meet composite flour standards** *and* underlying wheat flour standards
- **Protein content may be diluted**—10% BCF substitution does not reduce protein content sufficiently to significantly reduce bread quality
- **Functionality changes**—flour improvers may be needed to maintain bread quality at BCF inclusion levels higher than 10%
- **Labeling becomes more complex**—labels must declare both flour types, product name, name and address of the manufacturer, and the best-before date.

4.4 BREAD AND PASTRY PRODUCT STANDARDS

Continental standards (African)

The African Standard for Cassava Bread (CD-ARS 853) covers:

- **Quality requirements:** Free from abnormal flavors, odors, and living insects
- **Technical parameters:** Maximum 12% moisture, pH 5.3–6.0, maximum 10 mg/kg residual cyanide
- **Microbiological limits:** Specific bacterial counts, no *E. coli* or *Salmonella*
- **Labeling:** Comprehensive requirements including ingredient lists.

National standards (DRC example)

DRC's standard for bread and pastries specifies:

- **Mandatory inclusion:** 5% BCF for bread, 10% for pastry
- **Product categories:** Nine types of bread, four types of pastry products
- **Regulatory controls:** Genetically modified (GM) ingredients require Ministry of Health authorization
- **Quality characteristics:** Golden-brown crust, light airy texture, even crumb structure.

Key differences and overlaps

Focus and approach

- Continental: Technical specifications and testing requirements
- National (DRC): Regulatory compliance and product categorization.

Quality parameters

- Continental: Detailed numerical limits (moisture ≤ 12%; pH 5.3–6.0; microbiological counts, e.g., maximum 10,000 CFU per gram)
- National (DRC): Qualitative descriptions (golden crust, light texture).

Testing requirements

- Continental: Specific test methods for each parameter
- National (DRC): References to general Codex testing procedures.

Practical compliance for bakers

Recipe formulation

- Ensure BCF inclusion meets minimum requirements for your market
- Maintain ingredient quality to meet finished product standards
- Document recipes and ingredient sources for traceability.

Quality control

- Test finished products for key parameters (moisture, appearance, shelf life)
- Maintain production records showing compliance
- Train staff in quality standards and procedures.

Market positioning

- Use standards compliance as a marketing advantage
- Highlight local content requirements you exceed
- Build customer confidence through demonstrated quality management.

4.5 LABELING REQUIREMENTS: WHAT MUST BE ON YOUR PRODUCTS

Proper labeling is a legal requirement and helps build customer trust. Requirements vary by standard level and product type.

Universal labeling requirements (all levels)

All standards require:

- **Product name:** Must accurately describe the product
- **Ingredient list:** In descending order by weight
- **Net weight:** In metric units
- **Manufacturer information:** Name and address
- **Date information:** Manufacturing date and/or best before date.

BCF labeling requirements

Continental (African) requirements

- Product name: "High-quality cassava flour"
- Storage instructions: "Store in a cool, dry place, away from contaminants"
- Lot/batch identification for traceability
- Country of origin
- Instructions for the disposal of used packaging.

Regional (East African) requirements

- Product name: "High-quality cassava flour"
- "Human food" statement must appear on the package
- Storage instructions
- More detailed manufacturer information required.

National (DRC)—follows Codex requirements

- Product name: Must be accurate and not misleading
- Comprehensive ingredient and nutritional information if claims are made.

Composite flour labeling

Regional (East African) specific requirements

- Product name: "Cassava–wheat composite flour"
- Percentage substitution: Must declare the percentage of wheat substituted with cassava
- Ingredient list: all ingredients must be listed in descending order
- Storage instructions
- Instructions for safe package disposal.

Bread and pastry labeling

Continental (African) requirements for cassava bread

- Product name: "Cassava bread"
- Complete ingredient list, including any flavorings used
- Storage and package disposal instructions
- Lot identification for traceability.

National (DRC) requirements

- Must comply with national food labeling standards (NCD CODEX STAN 1-2018)
- Weight must comply with national regulations
- Any GM ingredients must be declared (requires Ministry of Health authorization).

Export labeling considerations

Multiple market compliance

If the product is to be exported to different regions, the label must meet *all* applicable requirements:

- Home country's national requirements
- Destination country's national requirements
- Any applicable regional requirements
- Continental requirements for intra-African trade.

Language requirements

- Regional standards may require local language translations
- International exports often require English or other specified languages (e.g., French, Portuguese)
- Technical terms must be accurately translated.

Additional declarations

- Some markets require additional statements (e.g., organic, halal, allergen warnings)
- Nutritional information may be mandatory in some destinations
- Special handling instructions may be required.

Practical labeling strategy

Design for multiple markets

- Include all possible required information to access the maximum markets
- Use a clear, professional design that builds product credibility
- Ensure durability—labels must remain legible throughout the product's shelf life.

Maintain flexibility

- Design labels that can be easily updated for different markets
- Keep digital files for easy modification
- Plan for seasonal or promotional variations.

Quality control

- Verify all information is accurate before printing
- Check that dates, weights, and batch numbers are correctly applied
- Train staff on proper label application and quality checks.

KEY TAKEAWAYS

- **Standards work as a system:** International, continental, regional, and national standards build upon each other to ensure food safety while facilitating trade.
- **Know your target markets:** Different markets require different standards compliance—plan your processes to meet the strictest requirements where you want to sell.
- **Focus on practical differences:** Key areas where standards differ include particle size, pH levels, cyanide limits, and inclusion requirements—these directly affect processing and formulation.
- **Wheat standards matter too:** Composite flour must meet BCF and wheat flour standards, creating additional complexity in formulation and labeling.
- **Documentation is essential:** Proper labeling and record-keeping demonstrate compliance and enable market access—invest in good documentation systems.
- **Plan for growth:** Design quality systems to meet regional standards even if starting locally—this provides flexibility to expand markets later. This is especially relevant for bread-making cassava–wheat composite flour manufacturers, as flour has a longer shelf life and travels better than bread and pastry products.
- **Use compliance as a competitive advantage:** Meeting higher standards than required can differentiate products and build customer confidence.

Self-assessment questions

1. **Multiple choice:** If you are a DRC baker planning to export bread to Kenya, which standards must your product meet?

   (a) Only DRC national standards
   (b) DRC national and Kenyan national standards
   (c) DRC national, East African regional, and Kenyan national standards
   (d) Only international Codex standards.

2. **True/False:** The particle size requirement is the same across all standards levels for BCF.

3. **Application:** You are designing a label for cassava–wheat composite flour (10% BCF) for sale in the East African market. List five specific pieces of information that must appear on your label according to regional standards.

   1. _____
   2. _____
   3. _____
   4. _____
   5. _____

4. **Problem-solving:** A wheat flour mill wants to produce composite flour for both domestic sale and export to regional markets. The domestic market requires 5% minimum BCF inclusion, but regional markets require 10%. What inclusion level should they use and why?

   Inclusion level: _____

   Reason: _____

5. **Practical application:** A bakery wants to use standards compliance as a marketing advantage. Describe three specific ways they could promote their adherence to quality standards to attract customers.

   1. _____
   2. _____
   3. _____

See Appendix F for answers.

MODULE 5:
BREAD-MAKING PRINCIPLES AND PROCESS

LEARNING OBJECTIVES

By the end of this module, you will know how to:

- Blend composite flour effectively
- Control dough development through proper mixing and kneading techniques
- Monitor and manage the fermentation processes for optimal bread quality
- Shape and mold dough using appropriate techniques for different bread types
- Apply correct baking parameters and cooling procedures
- Identify key quality characteristics of well-made composite-flour bread
- Adapt standard bread-making techniques for the special requirements of bread-making cassava–wheat composite flour.

Bread-making is both an art and a science. Success requires understanding not just what to do, but why each step matters and how the ingredients work together. When working with cassava–wheat composite flour, this understanding becomes even more important because of the need to manage two different types of starch and adjust traditional techniques for optimal results.

This module takes you through the complete bread-making process, from ingredient preparation through final packaging. You will learn the fundamental principles that govern each stage, and the practical techniques needed to produce consistent, high-quality bread using composite flour.

5.1 COMPOSITE FLOUR BLENDING

Proper blending of BCF with wheat flour is essential for achieving consistent product quality and optimal performance in bread production.

If possible, bakers should source preblended composite flour from millers rather than blend their own. This is because millers have the capacity and equipment to ensure a consistent, quality product. The details of blending BCF and wheat flour on an industrial scale are presented in Appendix A.

If a bakery is unable to source preblended cassava–wheat flour, cassava and wheat flour can be blended during mixing. Proper blending ensures consistent results and prevents uneven flour distribution that could affect bread quality.

Understanding composite flour characteristics

BCF and wheat flour have different properties that affect how they behave in bread-making.

BCF characteristics

- Has a different starch profile to wheat
- Has no gluten-forming proteins
- Absorbs water differently from wheat flour
- Contributes to improved digestibility.

Wheat flour characteristics

- Contains gluten-forming proteins (gliadin and glutenin) essential for bread dough structure
- Provides the framework that traps gas during fermentation

- Contributes to bread's characteristic texture, crust color, and volume.

Blending procedure

Step 1: Measure ingredients accurately

Use a digital weighing scale for precision. Standard inclusion levels are:

- 5% BCF minimum for bread (as required by DRC regulations)
- 10% BCF commonly used for good results
- Up to 20% BCF possible if it is handled correctly.

Step 2: Pre-blend dry ingredients

- Ensure that the BCF is as fine as the wheat flour (same particle size, not bigger)
- Sieve both flours for uniformity
- Combine BCF and wheat flour in a large, clean mixing bowl, depending on the quality needed
- Mix thoroughly in a machine, by hand, or with a dry mixing paddle
- Ensure complete distribution with no visible streaks or lumps.

Step 3: Check blend uniformity

- Consistent color throughout
- No visible separation of different flour types
- Smooth, uniform texture when rubbed between fingers.

Critical points for composite flour blending

Storage: If blended flour must be stored, use airtight containers and follow the first-in, first-out (FIFO) principle (see Module 3).

Quality control: Each batch of blended flour should be visually inspected for uniformity and fineness before proceeding to dough mixing.

5.2 INGREDIENTS AND THEIR FUNCTIONS

Understanding ingredient functions helps bakers make informed decisions about recipes and troubleshoot problems when they arise.

Primary ingredients

Composite flour

- Function: Provides structure, texture, and calories
- BCF contribution: Enhanced fiber content, improved water absorption capacity and digestibility
- Wheat flour contribution: Gluten development for structure and gas retention.

Water

- Function: Hydrates flour proteins and starches, enables gluten development
- Special consideration for composite flour: Water absorption may differ from 100% wheat flour recipes
- Quality requirement: Use clean, potable water at an appropriate temperature.

Yeast

- Function: Fermentation agent that produces carbon dioxide for dough rise
- Types: Fresh yeast, dry active yeast, instant yeast
- Quality check: Test yeast viability before use (see Module 6, section 6.2).

Salt

- Function: Flavor enhancement, gluten strengthening, yeast (fermentation) control
- Preferably use iodized salt (as specified in bread standards).

Secondary ingredients

Sugar

- Function: Yeast food, flavoring, crust browning
- Types: Granulated sugar is most commonly used for bread.

Fats (oil, butter, margarine)

- Function: Texture improvement, shelf-life extension, flavor
- Consideration: Cassava flour naturally contains less fat than wheat flour
- Types: Vegetable oil is commonly used in Nigerian and some DRC recipes.

Eggs

- Function: Structure, texture, color, nutritional enhancement
- Handling: Follow food safety procedures outlined in Module 3 (section 3.2)
- More commonly used in pastries.

Additional ingredients (baking powder, colorants)

- Functions: Vary by specific ingredient and recipe
- Usage: Follow manufacturer instructions and regulatory requirements
- Quality: Source from approved suppliers and visually inspect before use (see Module 3).

5.3 BREAD-MAKING PROCESS

The bread-making process follows a logical sequence of steps, each building on the previous one to create the final product.

Step 1: Ingredient preparation

1. Mix the composite flour and other dry ingredients thoroughly
2. Add margarine (if needed) and measure the quantity of water to be used
3. Add the water gradually while mixing.

Step 2: Dough mixing and kneading

- Keep mixing and kneading until a smooth dough is formed.

Understanding dough development

Proper dough mixing serves several critical functions:

- Distributes ingredients uniformly throughout the dough
- Begins gluten development through mechanical action
- Incorporates air that contributes to the final bread texture
- Creates the foundation for successful fermentation.

Special considerations for composite flour

When working with cassava–wheat composite flour, the mixing process requires attention to several factors—see section 5.5 for details.

Mixing procedure

Hand mixing (traditional method):

1. Combine all dry ingredients in a large, clean wooden mixing box or bowl
2. Create a well in the center of the dry ingredients
3. Add water gradually while mixing by hand or paddle
4. Work the mixture until a cohesive dough forms
5. Knead until properly developed
6. Adjust water content as needed to achieve proper consistency.

Mechanical mixing:

1. Place dry ingredients in the mixer bowl
2. Use graduated mixing speeds to accommodate different starch granule sizes:
   - Start at a slow speed to allow proper alignment of small and large starch granules
   - Gradually increase speed as ingredients incorporate
   - This allows adequate mixing with other ingredients without overworking the dough
3. Add water gradually while mixing
4. Monitor dough development and adjust water as needed
5. Follow equipment-specific procedures (see Module 7, section 7.3 for mechanical mixer details).

Kneading technique and purpose

Kneading develops the gluten network essential for bread structure:

- Ensures uniformity by evenly distributing the ingredients throughout the dough
- Develops the viscoelastic dough matrix (gluten network) needed for proper bread texture.

Hand kneading method:

1. Place dough on clean, lightly floured surface
2. Push dough away from you with the heel of your hand
3. Fold dough back over itself
4. Turn dough 90 degrees and repeat
5. Continue until dough becomes smooth and elastic.

Mechanical kneading:

1. Use the dough hook attachment at the appropriate speed
2. Knead for the time specified in the recipe or until proper development is achieved
3. Monitor dough temperature to prevent overheating
4. Check dough development by visual and tactile assessment.

Dough consistency assessment

Properly developed dough should be:

- Smooth and elastic when stretched
- Slightly tacky but not sticky
- Able to stretch thin enough to be translucent without tearing (windowpane test—see box)
- Consistent in temperature throughout.

Step 3: Fermentation monitoring and control

- Leave the dough in a greased container to ferment (either bulk or in baking pans).

Understanding fermentation

Fermentation is the process by which yeast converts sugars into carbon dioxide and alcohol:

- Carbon dioxide creates bubbles that make dough rise
- Alcohol evaporates during baking
- Enzyme activity increases food supply to yeast, and improves dough extensibility and texture
- Proper fermentation is essential for bread texture and taste.

WINDOWPANE TEST DEMONSTRATION GUIDE

Purpose

The windowpane test helps bakers determine whether their dough has been kneaded enough to develop proper gluten structure. This test is especially important when working with composite flours to ensure adequate dough strength.

Method

Step 1: Sample collection

- Take a small piece of dough (about the size of a golf ball, i.e., c.4.3 cm in diameter)
- Let it rest for 5 minutes to relax the gluten.

Step 2: Stretching technique

- Hold the dough gently between your hands
- Slowly stretch it by pulling outward from the center
- Use your fingertips to carefully thin the center
- Continue until the dough forms a thin membrane.

Step 3: Assessment

Properly developed dough:

- Creates a thin, translucent membrane when stretched
- Stretches without immediately breaking
- Holds its shape without tearing
- Shows elasticity (i.e., contracts a little) when released.

Underdeveloped dough:

- Tears easily
- Cannot form a membrane
- Breaks immediately
- Shows no elasticity.

Overdeveloped dough:

- Breaks down quickly
- Feels slack or sticky
- Lacks elasticity
- Cannot hold shape.

Special considerations for composite flour

When testing composite flour dough (10% BCF):

- The membrane may be slightly less translucent than with 100% wheat dough
- The dough may require longer kneading time to achieve proper development
- The final membrane might be slightly less elastic
- It should still form a stable window without tearing.

Common issues

- Stretching too quickly
- Using too much force
- Testing dough that is too cold
- Not allowing proper rest time.

Notes

- Regular testing helps develop judgment
- Different flours require different development times
- Test indicates optimal mixing/kneading completion
- Testing is critical for consistent bread quality.

Optimal fermentation conditions

- Temperature: 20–30 °C (achievable in most tropical environments)
- Humidity: Sufficient to prevent drying out
- Time: Typically 1.5–3 hours (DRC experience), depending on environmental conditions, recipe, and bread size
- Protection:
  - An enclosed proofing cabinet maintains appropriate humidity levels
  - If there is no proofing cabinet, use a clean cover to prevent contamination and moisture loss
- Monitor dough development visually for best results
- Allow the fermented dough to relax prior to cutting and shaping.

Bulk fermentation

- Place the mass in a greased bowl, cover with a clean cloth
- Allow the entire dough mass to ferment at the optimum fermentation temperature
- Turn the dough occasionally to ensure even fermentation.

Monitoring fermentation progress

Visual indicators of proper fermentation:

- Dough increases in size and almost fills up the pan
- Surface appears slightly domed
- Dough springs back slowly when lightly pressed
- No over-fermentation signs (collapsed structure).

Special considerations for composite flour

- Fermentation timing may differ a little from 100% wheat flour
- Monitor dough development carefully during initial trials
- Adjust timing based on observed results and local conditions
- Temperature control remains critical for consistent results.

Step 4: Shaping and molding

1. Knead the fermented dough mass until it is smooth
2. Cut into the desired sizes
3. Grease the baking pans with margarine
4. Shape dough pieces and place in baking pans.

Pan fermentation

- Allow final rise to double the size in pans before baking.

Purpose of shaping

Proper shaping serves several functions:

- Allows for different bread types and customer preferences
- Creates uniform product shape and size for consistent baking
- Prepares dough for final fermentation phase.

Basic shaping techniques

For round loaves:

1. Divide the dough into portions of the desired weight
2. Shape each portion into a smooth ball
3. Create surface tension by rolling against the work surface.

For pan loaves:

1. Flatten the dough portion into a rectangle
2. Roll tightly from one end to create a cylinder-like shape that tapers on both sides
3. Place seam-side down in a greased baking pan
4. Ensure the loaf fits the pan properly for even baking.

For traditional African bread shapes: Follow local preferences and market requirements for specific shapes and sizes.

Working with composite flour dough

- Dough may handle slightly differently from 100% wheat flour
- Use minimal additional flour during shaping to avoid toughening
- Work efficiently to prevent over-handling
- Allow adequate relaxation time between shaping steps if needed.

Step 5: Baking

1. Use an appropriate oven (see Module 7, section 7.6)
2. Clean and heat up the oven to the desired temperature
3. Arrange the baking pan containing the fermented dough into the oven as quickly as possible to avoid temperature reduction (heat loss)
4. Close the oven to maintain the desired baking temperature (e.g., 200 °C for Nigeria/British bread, and 230–273 °C for baguettes/French bread)

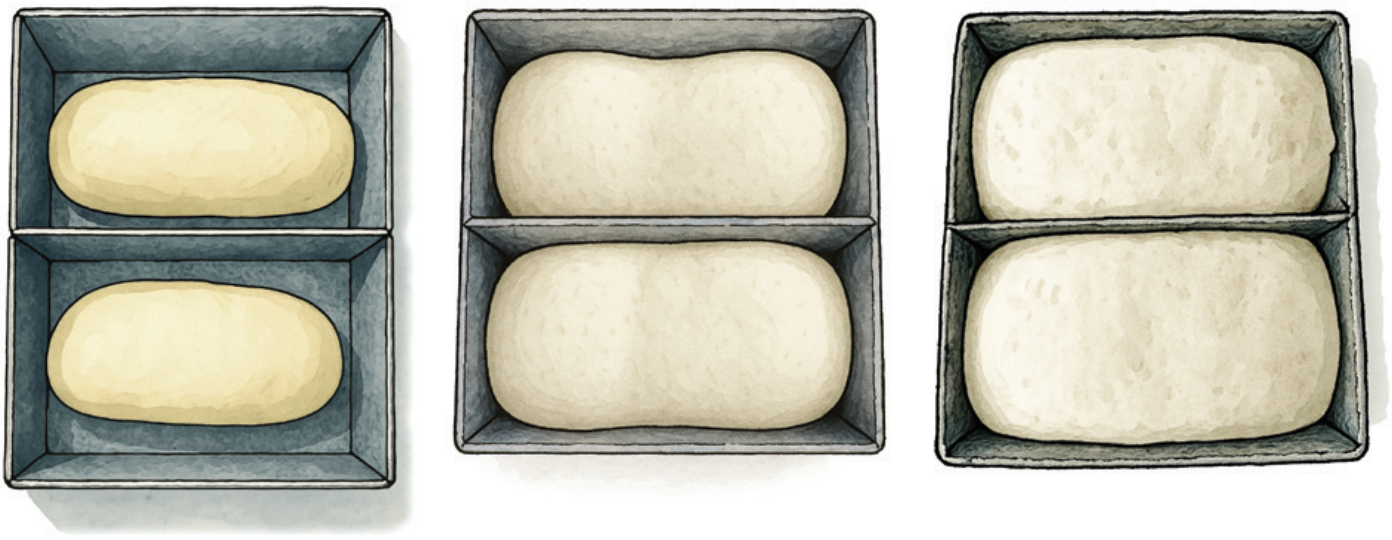


Figure 5.1. Progress of fermentation.

5. Leave the dough to bake for the desired time of 15–20 minutes—intermittently check the baking progress.

Understanding the baking process

Traditional baking ovens are often made of earthenware and are heated with firewood or charcoal. Modern ovens are made of food-grade metals materials and heated by gas or electricity (heating elements, plates, or microwave energy).

During baking, several important changes occur:

- Starch gelatinization occurs when the internal temperature reaches 60–80 °C
- At these temperatures, proteins denature and coagulate, setting the bread structure
- Carbon dioxide trapped during fermentation expands, creating a final volume increase
- Gluten coagulation fixes loaf size and shape
- Surface (Maillard) reactions[1] create crust color and flavor
- Moisture evaporates from the surface, forming a crust
- Yeast activity stops.

Baking temperature and timing

Based on DRC bakery experience:

- Oven temperature: 230–273 °C
- Baking time: Approximately 15 minutes for standard loaves
- Temperature managed by experience rather than precise instruments
- Variations depend on loaf size, oven type, and desired crust characteristics.

Oven preparation and operation

- Preheat the oven to the proper temperature before loading the bread
- Ensure even heat distribution throughout the oven chamber
- Load bread systematically for uniform baking
- Monitor baking progress without opening the door too often
- Adjust timing based on loaf size and oven characteristics
- Follow manufacturer's guidelines for optimal performance
- Avoid opening the oven door unnecessarily during baking.

Monitoring baking progress

Visual indicators:

- Golden-brown crust color development
- Loaves pulling slightly from pan sides
- Hollow sound when tapped on the bottom (for free-form loaves, i.e., loaves not baked in a loaf tin).

Internal temperature:

- Use thermometer to check internal temperature (90–95 °C when done)
- Insert in the center of the thickest part of the loaf.

Adapting for different oven types

- Wood-fired ovens: Monitor temperature carefully, may require longer baking times
- Electric ovens: Provide more consistent temperature control
- Gas ovens: May create slightly different moisture conditions (see Module 7, section 7.6 for detailed equipment information).

Step 6: Cooling

- When baked, remove the bread from the oven and cool for about 2 hours at room temperature.

1. Remove bread from the oven carefully using appropriate tools
2. Turn out of pans immediately for most bread types
3. Place on clean cooling racks for air circulation
4. Allow adequate spacing between loaves to cool
5. Cover lightly to prevent excessive moisture loss if needed
6. Clear crumbs after each use.

Purpose of proper cooling

Cooling serves important functions:

- Allows internal structure to set completely
- Prevents condensation that could make the crust soggy
- Reduces internal temperature for safe handling
- Enables proper slicing and packaging.

Food safety during cooling

- Use clean cooling racks and handling utensils (see Module 3 for sanitation procedures)
- Protect from contamination during the cooling process
- Monitor cooling area temperature and cleanliness
- Follow proper handling procedures to prevent contamination.

Step 7: Packaging, storage, and display

1. Allow the bread to cool completely
2. Slice before packing (if to be sold sliced)
3. Pack in food-grade packaging material.

1 The Maillard reaction is a chemical process that contributes to browning, flavor, and aroma development in baked bread, notably in the crust. At high temperatures, amino acids (from proteins) react with reducing sugars (e.g., glucose and maltose), resulting in a complex mixture of flavor compounds responsible for the brown color.

Packaging requirements

Proper packaging maintains bread quality and meets regulatory requirements:

- Use food-grade packaging materials
- Ensure complete cooling before packaging to prevent condensation
- Apply appropriate labels as required by standards (see Module 4, section 4.5)
- Include production date and best before information.

Storage considerations

- Store at appropriate temperature and humidity
- Protect from physical damage during handling
- Follow first-in-first-out (FIFO) inventory management
- Monitor storage conditions regularly for cleanliness to prevent contamination or pest infestation.

Display requirements

For retail sales:

- Use clean, covered display cases
- Maintain appropriate temperature
- Rotate stock regularly to ensure freshness
- Follow time limits for perishable products (see Module 3, section 3.5).

5.4 KEY CHARACTERISTICS OF QUALITY BREAD

Understanding quality indicators helps you evaluate your products and make improvements when needed.

Visual characteristics

Crust appearance

High-quality bread should exhibit:

- A variety of hues ranging from golden brown to light golden color
- Even color distribution without dark spots or pale areas
- Smooth surface without blemishes or cracks
- Appropriate thickness for bread type.

Shape and size

- Uniform shape appropriate to bread type
- Consistent size within batches
- Good volume development relative to dough size.

Internal structure

Crumb characteristics

- Even distribution of air pockets of various sizes
- Slightly glossy interior finish
- Uniform color throughout
- Springs back when pressed gently with a finger.

Texture evaluation

- Soft, tender crumb with an even spongy texture (not dense or gummy)
- Easy to slice without excessive crumbling
- Pleasant feel in the mouth when eaten
- Appropriate moisture content for bread type.

Sensory qualities

Flavor profile

Quality bread should have:

- Clean, pleasant bread flavor without off-tastes
- Appropriate level of saltiness and sweetness
- No bitter, sour, or chemical flavors.

Aroma

- Pleasant bread aroma when fresh
- No off-odors or fermented smells
- Appealing smell that attracts customers.

Comparing composite flour bread with wheat bread

Enhanced characteristics from BCF inclusion

- Enhanced crust color
- Slightly denser than 100% wheat bread
- Enhanced fiber content (though not always noticeable to consumers)
- Potentially better digestibility for some consumers.

Maintaining wheat bread qualities

- Proper gluten development is still essential for structure
- Gas retention properties are maintained through proper production techniques
- Traditional bread appearance and eating qualities preserved
- Consumer acceptance is maintained through quality production.

5.5 WORKING WITH COMPOSITE FLOUR: SPECIAL CONSIDERATIONS

Using cassava–wheat composite flour requires understanding how it differs from working with pure wheat flour and adapting techniques accordingly.

Water absorption differences

Understanding the science

Water absorption in composite flour is more complex than with wheat flour alone due to the following.

Dual starch system effects:

- Cassava starch absorbs water differently from wheat starch
- Each type of starch has different molecular structures affecting hydration
- The combination creates unique water absorption patterns that may differ from standard wheat flour recipes.

Protein and starch content impact:

- Starch content directly affects how much water the flour can absorb
- Protein content (primarily from wheat flour) influences gluten development and water binding
- Understanding your flour composition helps predict mixing outcomes and water requirements.

Starch granule size considerations:

- Different starch granule sizes absorb water at different rates
- Uniform (generally small) granules align more easily during mixing (e.g., 100% wheat-flour bread)
- Smaller granules may hydrate more quickly than larger ones
- Large granules pose higher resistance during mixing and kneading
- Appropriate timing of water addition; combined and graduated mixing (starting slow) accommodate these different absorption rates to enable the granules to align for uniform dough development and uniform ingredient distribution.

Understanding quality control measures in bread-making

Mixing: Practical approach

- Add water gradually during mixing
- Assess dough consistency and adjust water level as needed
- Document successful formulations for future use
- Be prepared for some experimentation, especially in early adoption stages.

Dough handling: Texture differences

- Composite flour dough may feel slightly different during mixing and kneading—it may be less elastic than 100% wheat-flour dough
- It may require gentler handling in some cases
- Final dough should still pass standard quality tests.

Fermentation considerations

- Timing may differ slightly from pure wheat flour
- Monitor fermentation visually rather than relying solely on time
- Environmental conditions remain critical
- Yeast performance is generally unaffected if pH is within the correct range
- Yeast viability, however, is strongly influenced by storage conditions (see Module 3, section 3.2 "Storage requirements").

Monitoring points

- Pay extra attention to water absorption during initial trials
- Monitor fermentation progress more closely during adoption phase
- Evaluate finished product quality against established standards
- Document any adjustments needed for consistent results.

Troubleshooting common issues

See Module 11.

Achieving consistency

- Develop standard procedures based on successful trials
- Train all production staff on composite flour techniques
- Maintain detailed production records
- Continuously monitor and improve processes.

Recipe adaptation principles

Starting point

- Begin with proven recipes from reliable sources
- Change one variable (ingredient amount, temperature, time) at a time when adapting recipes
- Test small batches before full production
- Document all changes and results.

Key variables to monitor

- Water absorption rates
- Mixing times and techniques

- Fermentation timing
- Baking time and temperature adjustments.

Success factors

- Patience during initial learning period
- Systematic approach to recipe development
- Consistent ingredient quality (especially BCF)
- Regular evaluation against quality standards.

KEY TAKEAWAYS

- **Composite flour blending requires attention to uniformity:** Proper blending of BCF and wheat flour creates the foundation for consistent bread quality.
- **Each ingredient serves specific functions:** Understanding ingredient roles helps optimize recipes and troubleshoot problems.
- **The bread-making process is systematic:** Each step builds on the previous one, making consistency and attention to detail essential.
- **Fermentation control is critical:** Proper temperature, timing, and monitoring ensure optimal bread development.
- **Quality assessment guides improvement:** Understanding quality characteristics enables continuous improvement of products and processes.
- **Composite flour requires adaptations:** Working with BCF involves some differences from 100% wheat flour that require attention and possible recipe adjustments.
- **Documentation supports consistency:** Recording successful formulations and techniques enables repeatable results.
- **Initial experimentation is normal:** Expect some trial and adjustment, especially with water levels, during early adoption of composite flour techniques.

Self-assessment questions

1. **Multiple choice:** What is the most important factor when blending BCF with wheat flour for bread-making?
   (a) Speed of mixing (b) Uniform distribution (c) Temperature control (d) Container size.

2. **Short answer:** List three key functions that proper dough mixing serves in bread-making.

   1. _____

   2. _____

   3. _____

3. **True/False:** Composite flour dough always absorbs exactly the same amount of water as 100% wheat flour dough.

4. **Application:** You are making bread with 10% BCF inclusion and notice the dough seems drier than expected during mixing. What should you do and why?

   Action: _____

   Reason: _____

5. **Problem-solving:** A baker reports that bread made with composite flour is not rising properly during fermentation. List four possible causes and solutions.

   Cause 1: _____

   Solution: _____

   Cause 2: _____

   Solution: _____

   Cause 3: _____

   Solution: _____

   Cause 4: _____

   Solution: _____

6. **Analysis:** Explain why the cooling step is important for bread quality and what problems might occur if bread is packaged before complete cooling.

   Importance: _____

   Problems if packaged too early: _____

7. **Comparison:** What is the main way that working with composite flour is likely to differ from working with 100% wheat flour, and explain how bakers should adapt their techniques.

   Difference: _____

   Adaptation: _____

See Appendix F for answers.

MODULE 6:
QUALITY ASSESSMENT AND TESTING METHODS

LEARNING OBJECTIVES

By the end of this module, you will know how to:

- Perform simple quality assessments of flours using visual, physical, and sensory methods
- Test the quality and freshness of other baking ingredients, including yeast, eggs, sugar, and salt
- Evaluate finished bread products against established quality criteria
- Identify and solve common quality problems in ingredients and products
- Apply simple testing methods in any bakery setting
- Use quality assessment to protect a business and control costs.

Quality assessment is the first defense against poor products and customer complaints. These skills protect business reputation, ensure customer satisfaction, and help control costs by preventing waste.

6.1 TESTING FLOUR QUALITY

Flour is the most important ingredient. These tests help avoid costly mistakes and ensure consistent results.

Physical testing methods

Test for flour strength

Water mixing test:

1. Place the flour sample in your palm
2. Add a few drops of water
3. Mix with one finger
4. Observe the result.

Compression test:

1. Place flour in your palm, compress with four fingers
2. Open your hand and observe
3. Rub flour between fingers.

Results interpretation:

- **Bread flour:** Feels slightly coarse, falls apart after squeezing, creamy white color
- **BCF:** Should not form a viscous mass (no gluten), feels smooth and fine
- **Cassava–wheat composite flour:** Forms a soft, viscous mass that stretches.

Test for moisture content

1. Use completely dry hands
2. Compress the flour sample in your palm
3. Open your palm and observe.

Results:

- **Good flour:** Non-sticky trace, does not stick to the palm
- **Problem flour:** Sticky, clumps together—indicates excess moisture leading to spoilage.

Test for contamination

Water separation method:

1. Mix flour with water (1:4 ratio)
2. Stir vigorously, let settle
3. Observe separation.

Results:

- **Fibrous materials:** Float (bran, plant matter)
- **Heavy contaminants:** Sink (sand, dirt)
- **Clean flour:** Mixes evenly with minimal foreign matter.

Sensory testing methods

Odor assessment

1. Smell directly or with wafting
2. Scald with hot water (about 65 °C) to enhance odor.

Results:

- **Fresh wheat flour:** Neutral, slightly nutty
- **Fresh BCF:** Completely odorless
- **Problems:** Stale, musty, sour, or fermented smells—discard immediately.

Taste and color evaluation

1. Taste directly
2. Scald (1 part flour to 2 parts hot water, 65 °C) and taste
3. Visual assessment

Results:

- **Wheat flour:** Mild, nutty flavor; creamy white color
- **BCF:** Tasteless; white (or cream/yellow if biofortified)
- **Problems:** Bitter, sour tastes; dark spots, uneven coloring.

BCF-specific considerations

Critical quality points unique to BCF:

- Complete absence of odor (any smell indicates a problem)
- Fine, uniform texture (should feel smooth)
- Proper color (white unless biofortified)
- Free-flowing properties (no caking).

Business note: BCF quality varies more between the processors than wheat flour between the millers. Develop relationships with reliable processors.

6.2 EVALUATING OTHER INGREDIENTS

Yeast viability test

1. Mix 1 teaspoon of sugar in ¼ cup of warm water
2. Add a small amount of yeast
3. Wait 5–10 minutes
4. Observe bubbles.

Results:

- **Good yeast:** Many vigorous bubbles
- **Weak yeast:** Few small bubbles—replace
- **Dead yeast:** No bubbles—will ruin the entire batch.

Egg freshness tests

Flotation test (quickest)

1. Place the egg into a bowl or a large glass of cool water

Results:

- **Fresh:** Lies flat on the bottom of the container
- **Aging:** Stands upright but touches bottom—use it soon
- **Old:** Floats—do not use (safety risk).

Sound test

1. Hold to the ear and shake gently

Result:

- Sloshing indicates ageing—perform another test to confirm.

Break-out test (most reliable)

1. Break an egg (without damaging the yolk) onto a plate

Results:

- **Fresh:** Stays compact, yolk stands high, thick white
- **Aging:** Spreads more, yolk flattens
- **Bad:** Spreads widely, off-color or smell.

Safety note: When in doubt about egg quality, discard. One bad egg can contaminate the entire batch.

Sugar and salt assessment

Sugar: Check for consistent color, no lumps or foreign matter, uniform crystals.

Salt: Should be clean, white, free-flowing; use iodized salt per DRC standards.

Other minor ingredients (e.g., baking powder, colorant, vegetable oil)

- Do a visual check for impurities, proper appearance, and packaging integrity.

6.3 FINAL PRODUCT EVALUATION

Visual assessment

Crust quality

- Golden brown to light golden color range
- Even distribution, no dark spots or pale areas
- Smooth surface without cracks.

Shape and volume

- Uniform shape appropriate to bread type
- Good volume development (well-risen appearance)
- Consistent size within batches.

Internal structure

Cut bread with a sharp knife and examine:

- **Air pockets:** Variety of bubble sizes distributed evenly
- **Color:** Uniform throughout
- **Texture:** Springs back when pressed gently
- **Appearance:** Slightly glossy interior.

Sensory evaluation

- **Texture:** Spongy
- **Aroma:** Pleasant bread smell, no off-odors
- **Flavor:** Good bread flavor, not bland.

Composite flour bread expectations

Positive differences from BCF inclusion

- Often slightly denser texture
- Better digestibility
- Lower fat content
- Lower costs with maintained quality.

6.4 TROUBLESHOOTING COMMON QUALITY PROBLEMS

See Module 11.

KEY TAKEAWAYS

- **Systematic testing prevents costly failures** and protects business reputation.
- **Simple methods work effectively** using basic equipment and trained senses.
- **Each ingredient needs specific tests** to identify different quality problems.
- **Early detection saves money** by preventing batch failures.
- **Documentation supports improvement** and regulatory compliance.
- **Quality skills develop with practice**—use these tests daily to build expertise.

Self-assessment questions

1. **Multiple choice:** When testing flour strength, what indicates good quality composite cassava–wheat flour?
   (a) Mixture stays powdery (b) Forms soft, viscous mass (c) Becomes watery (d) Changes color.

2. **True/False:** BCF should form a viscous mass when mixed with water.

3. **Short answer:** List the three signs of a fresh egg in the break-out test.

   1. _____

   2. _____

   3. _____

4. **Problem-solving:** Your yeast test shows only few small bubbles. What does this mean and what should you do?

   Meaning: _____

   Action: _____

5. **Application:** Flour feels sticky when compressed. What problem does this indicate? Give two potential consequences.

   Problem: _____

   Consequence 1: _____

   Consequence 2: _____

6. **Analysis:** Name two positive differences you expect in bread made with 10% BCF versus 100% wheat flour.

   Difference 1: _____

   Difference 2: _____

7. **Business application:** List three quality tests you would perform for each batch and why each protects your business.

   Test 1: _____ Protection: _____

   Test 2: _____ Protection: _____

   Test 3: _____ Protection: _____

See Appendix F for answers.

MODULE 7:
EQUIPMENT AND PRODUCTION METHODS

LEARNING OBJECTIVES

By the end of this module, you will know how to:

- Identify and describe essential cassava processing and bakery equipment for BCF and bread production
- Operate key equipment safely and effectively
- Plan production workflow using available equipment efficiently
- Adapt bread-making techniques to work with different types of equipment
- Follow proper equipment operation procedures for consistent results.

The design and construction of a cassava processing factory or establishing a bakery building are outside the scope of this module.

Understanding your equipment is essential for consistent bread production and business success. Whether working with traditional tools or modern machinery, proper operation ensures quality results, reduces costs, and protects your investment. This module covers the equipment you will encounter in cassava processing plants and bakeries across Africa, from basic hand tools to industrial machines.

7.1 CASSAVA PROCESSING EQUIPMENT

Cassava graters

A cassava grater, also known as a cassava grating machine, is used to pulverize or grind peeled, washed cassava roots into a fine mash. All the food contact surfaces of a grater are made of stainless steel. It can be powered by an electric motor or a diesel/petrol (gasoline) engine.

The cassava is fed into the machine through the hopper onto the rotating grating drum, which is made of a rough-surface stainless steel sheet wound around the drum. The high-speed rotating rough surface grates the cassava into cassava mash or pulp.

Cassava dewatering press

The function of a press is to reduce the moisture content of cassava mash, making it easier to handle and dry further. By pressing out the water, cyanide is also eliminated.

Screw/hydraulic jack press

Commonly used in cottage or community cassava processing units.

The screw press consists of a ram that is driven up and down by a screw and a shaft. The top and bottom platforms are attached by a double or single screw that can make them closer or move them further apart.

By placing bagged cassava mash between the two platforms and moving them toward each other, a compression force is exerted that squeezes the water out of the wet cassava mash.

Hydraulic press

A press can generate the compression force using a hydraulic lifting jack. This form of press is most commonly used for dewatering grated cassava at cottage and small- and medium-sized enterprise (SME) levels.

Plate-and-frame filter press

Used in large-scale cassava processing plants.

The cassava mash is loaded onto the plate-and-frame filter press, where force is applied to squeeze the water out.

Compared with the hydraulic press, the plate-and-frame filter press has a larger processing capacity and higher dehydration efficiency.

Cassava processors should choose an appropriate dewatering machine based on their cassava flour processing scale. A hydraulic press can fully meet the needs of small-scale automated cassava flour production. For a large cassava flour processing plant, a high-efficiency plate-and-frame filter press can improve overall efficiency by completing the dewatering process.

Cassava dryers

Drying is a preservation procedure that reduces the moisture content of food components, increasing their shelf life.

Drying is the most important process in transforming cassava roots into value-added products. Dryers turn pressed cassava mash into a floury or powdery product.

There are several types of mechanical dryers.

Flash dryer

Among the various dryers, flash dryers have the shortest drying time and are the most commonly used drying technique for BCF.

Principle: Cassava particles are rapidly dried by suspending them in a stream of very hot air for a very short time.

Process:

1. Cassava granules or grits (pressed cassava mash) are fed into the dryer after being pulverized
2. Hot air is introduced, drying the particles almost instantly
3. Dried cassava grits are separated from the wet airflow via a cyclone and collected.

Advantages: High drying speed (a few seconds), suitable for large-scale production, retains product quality and color.

Cabinet dryer

Principle: Cassava products are dried in enclosed compartments with heated air circulation.

Process:

1. Products are placed on trays inside a cabinet
2. Hot air circulates within the cabinet to dry the products
3. Temperature and airflow are controlled for uniform drying.

Advantages: Compact, easy to operate, and ideal for small-scale processing.

Rotary dryer

Principle: Cassava products are dried as they tumble inside a rotating drum.

Process:

1. Wet cassava grits are fed into a rotating cylindrical drum
2. Hot air is passed through the drum, drying the product as it moves
3. The rotation ensures uniform exposure to heat.

Advantages: Handles large volumes and is suitable for granular cassava products.

Tunnel dryer

Principle: Cassava products are dried as they pass through a long tunnel with controlled airflow and temperature.

Process:

1. Products are placed on trays or conveyors
2. Hot air is passed along the tunnel as the grits move through
3. Continuous drying ensures efficiency.

Advantages: Suitable for large-scale operations and continuous drying, saves time.

Cassava mill

Milling BCF involves grinding the dried cassava grits into fine flour. A hammer mill or other suitable milling machine is used to grind the dried grits into a fine powder.

A hammer mill is the most commonly used for BCF. It is a single-passage-type mill that has sets of hammers (generally rectangular pieces of hardened steel) evenly spaced and attached to a shaft that rotates at high -speed, using a powerful electric motor inside a grinding chamber. The dried BCF grits are fed by gravity into the milling chamber and crushed or shattered by repeated hammer impacts, collisions with the chamber walls, and particle–particle impacts. The flour passes through the framed mesh beneath the chamber once its particle size is smaller than the mesh aperture size. The desired fineness of flour determines the aperture size of the mesh to be selected for the machine.

The particle size of the product is influenced by:

- Screen or mesh aperture size
- Rotation speed of the motor
- Flow rate of incoming material (load)
- Design and arrangement of hammers
- Hardness or resistance to breakage of the material being milled
- Power rating of the electric motor.

7.2 ESSENTIAL SMALL TOOLS AND UTENSILS FOR BAKERIES

Every bakery needs basic tools for measuring, mixing, and handling ingredients and bread products. These tools form the foundation of bread production, regardless of a bakery's size.

Weighing and measuring equipment

Digital weighing scale

- Essential for accurate ingredient measurement—accuracy is critical for consistent results
- Choose scales appropriate for batch sizes
- Calibrate regularly per manufacturer's instructions.

Measuring containers

- Various sizes for liquids and dry ingredients
- Stainless steel or food-grade plastic preferred.

Hand tools and utensils

Dough scraper

- Used for scraping dough and cutting portions into different sizes.

Dough scorer

- Sharp surgical blade for scoring bread at an angle before baking
- Creates decorative patterns during baking.

Sieves

- Manual aluminum (or plastic) sieves separate coarser materials from finer flour particles
- Size of mesh depends on flour type:
  - Whole grain flour: coarse mesh to retain bran and nutritious components
  - BCF and wheat flour: fine mesh for smooth texture.

Pastry brushes

- Apply glazes, coatings, or washes to bread/pastry surfaces
- Keep separate brushes for different applications.

Long-handled wooden spatulas and paddles

- Handle dough and move products safely.

Work surfaces and containers

Work tables

- **Stainless steel:** The best material—hygienic, maintains surface smoothness, globally used for food-contact surfaces.
- **Aluminum:** Hygienic and easy to clean. Not suitable if the dough is cut on the surface with a knife, as it is prone to scoring and can contaminate the dough.
  - Environmental and personnel hygiene standards are major issues in traditional settings.
- **Wooden tops:** Maple wood is ideal—nonporous, hygienic, poor heat conductor.
  - Wood allows dough to be at the required temperature and rarely causes dough to stick to the surface.
- **Alternative materials:** Granite or marble where stainless steel or aluminum are unavailable or costly.
- **Avoid iron:** Can react with dough, causing discoloration and contaminating the bread with iron (heavy metal) residue.

Plastic basins

- Medium size for bread processing
- Use for ingredient preparation and dough handling.

Wooden trays

- Product handling and transport
- Various sizes for different applications.

Baking trays and pans

- Available in aluminum, stainless steel, or nonstick (Teflon-coated)
- Range of sizes for different bread types
- Proper selection affects baking results.

7.3 MIXING EQUIPMENT

Proper mixing develops gluten structure and ensures uniform distribution of ingredients. Equipment ranges from traditional hand methods to sophisticated machines.

Traditional methods

Hand mixing in wooden boxes

- Large wooden containers are used in traditional bakeries (bigger bakeries use mechanical mixers)
- Requires physical strength but provides good dough control
- Low cost and readily available
- Suitable for small- to medium-sized batches
- See Module 5, section 5.3, "Step 2" for procedure.

Mechanical mixers

Vertical (planetary) mixers

- Beater spins on its axis while rotating around inside a stationary bowl (like a planet orbiting the sun)
- Reaches all parts of the bowl.

Spiral mixers

- Dough hook and bowl move in opposite directions
- Provides automatic bowl scraping during mixing
- Equipped with two speeds: slow and high
- Most bread recipes require specific speeds for optimal gluten development.

Equipment operation and maintenance

Safety and operation

- Follow manufacturer's instructions for safe operation
- Ensure proper training for all equipment operators
- Use recommended voltage and electrical specifications
- Maintain equipment according to manufacturer's guidelines.

Cleaning requirements

- Refer to Module 3, sections 3.4 and 3.5 for detailed cleaning schedules and sanitization requirements.

7.4 DOUGH HANDLING EQUIPMENT

Specialized equipment helps shape and portion dough efficiently, particularly in larger bakery operations.

Dough dividers

- Divide dough into equal sizes and portions
- Can shape portions into round balls automatically
- Mostly used in large bakeries
- Improve portion consistency and production efficiency.

Dough sheeters

- Roll portions of dough into sheets of uniform thickness
- Canvas conveyor belt feeds dough through an adjustable pair of rollers
- Multiple passes through rollers create thinner sheets, with the operator decreasing roller spacing after each pass
- Useful for specific bread types and production requirements.

Dough molders

- Roll and form dough pieces for standard loaves, baguettes, and rolls
- Eliminate the need for manual shaping operations
- Improve product consistency and production speed.

Equipment operation

- Follow manufacturer's instructions for setup and operation
- Ensure proper maintenance by qualified personnel
- Use only approved lubricants and cleaning procedures.

7.5 FERMENTATION EQUIPMENT

Controlling the fermentation environment ensures consistent bread quality and production timing. For details of fermentation monitoring and control, see Module 5, section 5.3, "Step 3."

Proofing cabinets

- Control temperature and humidity for optimal yeast activity
- Available in electric, gas, and pressure steam models
- Warmth and humidity activate yeast and increase CO_2 production.

Retarder proofers

- Control rate of proofing for flexible production scheduling
- This allows shaping of bread in the evening while baking occurs later as required
- Programmable to have bread ready for baking at specified times
- Can freeze shaped bread to stop yeast function, bring dough to cold (not frozen) temperature, then raise to proper proofing conditions.

7.6 BAKING EQUIPMENT

Ovens transform raw dough into finished bread by applying controlled heat. Different oven types suit different production needs and available resources.

Traditional artisanal (wood-fired brick) ovens

- Common throughout Africa
- Use wood or charcoal fuel
- Independent of electrical supply requirements.

Modern oven types

Deck ovens

- Large, enclosed baking chambers with one or more shelves (decks)
- Use gas or electricity for heating
- Forced hot-air circulation spreads heat uniformly around the chamber

- Suitable for bread, pizza, pastries, and other baked products requiring even cooking
- Provide consistent, reliable baking results.

Rack ovens

- Large ovens that accommodate entire racks of sheet pans
- Standard racks hold 15–20 pans
- Ovens hold 1–4 racks simultaneously
- Available in gas and electric models
- Equipped with steam injection systems
- Suitable for high-volume production.

Mechanical (revolving) ovens

- Dough is in motion during baking
- The mechanism operates like a Ferris wheel
- Eliminates hot spots through continuous rotation
- Can be equipped with steam injectors
- Especially useful for high-volume operations.

Convection ovens

- Contain fans that circulate air and distribute heat rapidly
- Foods cook more quickly at lower temperatures due to forced air
- Strong airflow may distort items made with batters or soft doughs
- Airflow may also blow baking parchment off sheet pans
- Thus, not as versatile for bread applications as other oven types.

7.7 FINISHING AND AUXILIARY EQUIPMENT

Equipment for final processing steps ensures professional presentation and efficient production.

Bread slicers

Tabletop slicers

- Slice one loaf at a time
- Work with single-phase power supplies
- Used by hot bread shops and small bakeries.

Gravity slicers

- Slice up to 20 loaves per minute
- Require three-phase power supply
- Used by larger commercial bakeries
- Automated operation for high-volume production.

Storage considerations

- Display cases need to be kept clean and covered at all times
- Appropriate temperature to be maintained for different products
- Follow time limits for perishable products (Module 3, section 3.5)
- Adopt the FIFO approach to product storage and sales
- If possible, date-timestamp packaging with best-before date.

7.8 PRODUCTION WORKFLOW AND EQUIPMENT ADAPTATION

Efficient production requires coordinating equipment use with bread-making timing and adapting to available resources.

Workflow optimization

Production scheduling considerations

- Plan around natural fermentation timing (1.5–3 hours typical, but determined by early trials on site and with bread types produced)
- Use fermentation time for complementary activities such as ingredient preparation
- Coordinate equipment cleaning between production batches
- Schedule baking during optimal times (cooler hours in hot climates).

Equipment coordination

- While dough ferments, carry out quality assessment or discuss results
- Build in time for proper cleaning and preparation between batches
- Consider local conditions when scheduling operations.

Adapting to available equipment

Working with traditional equipment

- Hand mixing in wooden boxes produces quality results with proper technique
- Natural fermentation works well in tropical environments
- Wood-fired ovens create excellent bread when properly managed
- Focus on technique mastery rather than equipment dependence.

Equipment alternatives

When modern equipment is unavailable:

- Manual mixing methods for dough development
- Natural temperature control for fermentation
- Traditional ovens for baking operations
- Simple tools substituting specialized equipment functions.

Scaling considerations

- Small-scale operations: emphasize essential tools and technique development
- Medium-scale operations: selective equipment upgrades for greatest efficiency gains
- Large-scale operations: systematic equipment integration for workflow optimization.

Resource management

Making effective use of available equipment

- Understand the principles that apply regardless of equipment level (Module 5, section 5.3)
- Develop skills transferable across different equipment types
- Maintain quality standards with available resources
- Plan for systematic equipment improvements based on production needs.

Local adaptation strategies

- Source equipment appropriate for local conditions and power supply
- Consider fuel availability and costs for different oven types
- Plan maintenance support for chosen equipment types
- Train staff on equipment specific to the operation.

KEY TAKEAWAYS

- **Equipment serves bread-making principles:** Understanding fundamental bread-making processes enables effective use of any equipment level, from traditional tools to modern machinery.
- **Traditional methods produce quality results:** Hand mixing in wooden boxes, fermenting at ambient temperature, and baking in wood-fired ovens (all commonly used in Africa) can produce excellent bread when proper techniques are applied.
- **Composite flour requires mixing adaptations:** Different starch granule sizes in cassava–wheat blends need graduated mixing speeds for optimal ingredient distribution.
- **Workflow coordination maximizes efficiency:** Timing equipment use around fermentation periods and cleaning requirements optimizes production and reduces waste.
- **Equipment operation requires proper training:** Following manufacturer guidelines and ensuring adequate training prevents accidents and maintains consistent performance.
- **Cleaning and maintenance procedures are essential:** Refer to Module 3 (section 3.4) guidelines for equipment sanitation and follow manufacturer recommendations for maintenance.

Self-assessment questions

1. **Multiple choice:** Which type of mixer provides automatic bowl scraping during operation?
   (a) Vertical mixer (b) Spiral mixer (c) Hand mixer (d) Planetary mixer

2. **True/False:** Metal (iron-based) work surfaces are recommended for bread-making because they are easy to clean.

3. **Application:** You are setting up a small bakery in an area with unreliable electricity. Describe your equipment approach and explain two advantages of your strategy.

   Equipment approach: _____

   Advantage 1: _____

   Advantage 2: _____

4. **Problem-solving:** A baker using composite flour reports uneven mixing results. Based on the mixing principles in this module, what adjustment should they make and why?

   Adjustment: _____

   Reason: _____

5. **Analysis:** Compare the natural fermentation approach used in many African bakeries with mechanical proofing cabinets. List one advantage of each method.

   Natural method advantage: _____

   Mechanical proofing advantage: _____

See Appendix F for answers.

MODULE 8:
RECIPE DEVELOPMENT AND ADAPTATION

LEARNING OBJECTIVES

By the end of this module, you will know how to:

- Apply proven recipes for composite cassava–wheat bread production
- Scale recipes accurately for different production volumes
- Adapt recipes for local ingredients and conditions
- Calculate ingredient costs and optimize profitability
- Document recipe modifications for consistent results.

Recipe development with composite flour requires systematic approaches to ensure consistent quality while managing costs effectively. This module provides practical guidance for adapting and scaling recipes based on proven formulations from DRC bakeries.

8.1 EXAMPLE RECIPES FOR COMPOSITE CASSAVA–WHEAT BREAD (DRC)

Two proven recipes from DRC demonstrate successful 10% BCF inclusion levels that meet regulatory requirements for baguette-type French bread while maintaining product quality.

Recipe 1: Basic composite bread (for DRC baguette)

For 50 kg total flour:

- Wheat flour: 45 kg
- BCF: 5 kg (10% inclusion)
- Yeast: 300 g
- Salt: 43.5 g
- Water: 25 L.

Recipe 2: Enhanced composite bread

For 50 kg total flour:

- Wheat flour: 45 kg
- BCF: 5 kg (10% inclusion)
- Yeast: 900 g
- Salt: 60 g
- Water: 30 L
- Sugar: 80 g
- Baking powder: 50 g
- Colorant: 25 g
- Vegetable oil: 1 L.

Recipe selection considerations

- Recipe 1: Lower cost, basic formulation suitable for everyday bread
- Recipe 2: Enhanced formulation with improved texture and shelf life
- Both recipes exceed DRC regulatory requirements (10% BCF inclusion cf. 5%)
- Both produce bread that consumers accept and purchase.

8.2 SCALING RECIPES FOR DIFFERENT BATCH SIZES

Basic scaling principles

1. **Maintain proportions:** All ingredients scale proportionally to flour weight, except water
2. **Check equipment capacity:** Ensure mixing and baking equipment can handle scaled quantities.

Practical scaling example

To halve Recipe 1 from 50 kg flour to 25 kg flour:

- Wheat flour: 45 kg ÷ 2 = 22.5 kg
- BCF: 5 kg ÷ 2 = 2.5 kg
- Yeast: 300 g ÷ 2 = 150 g
- Salt: 43.5 g ÷ 2 = 21.75 g (round to 22 g for practical measurement)
- Water: 25 L ÷ 2 = 12.5 L.

Common scaling factors

Based on the DRC bakery experience, recipes can be scaled up or down by dividing or multiplying all ingredients by the same factor.

8.3 WATER ABSORPTION AND MIXING CONSIDERATIONS

Water absorption basics

Composite flour may require different water levels from 100% wheat flour as a result of:

- Different starch structures in cassava and wheat
- Different protein content (proportion) affecting gluten development
- Local flour quality variations.

Practical approach

1. **Start with recipe amounts:** Use proven recipe ratios as a starting point
2. **Add water gradually:** Monitor dough consistency during mixing
3. **Assess dough feel:** Proper dough should be smooth and slightly tacky but not sticky (see also Module 5, section 5.3, "Step 2")
4. **Document adjustments:** Record successful water levels for future batches.

See Module 5, section 5.5, for detailed water absorption principles and mixing techniques.

8.4 ADJUSTING FOR LOCAL CONDITIONS AND INGREDIENTS

Environmental factors

Temperature and humidity effects:

- Hot climates: May need slightly more water because of faster evaporation
- Cool climates: May require longer fermentation times
- Humidity: Affects flour moisture content and dough hydration needs.

Practical adaptation: DRC bakers report fermentation times ranging from 1 to 3 hours, depending on local conditions and the type of fermentation adopted (cold water or warm water for mixing).

Ingredient substitutions

Composite flour and BCF quality variations:

- It is in cassava processors' interests to adhere to millers' quality requirements for BCF. Millers need to set BCF quality requirements prior to purchase to avoid wide variations in the quality of the composite flour they produce.
- Different processors may produce BCF with different characteristics resulting from differences in the physicochemical properties of the cassava varieties used for processing the BCF and the adequacy of processing methods. Thus, millers must adhere to their quality requirements when procuring BCF for blending. Differences in BCF quality may result in millers producing composite flour with different characteristics depending on their quality criteria for BCF purchase.
- Both millers and bakers should test small batches when changing flour suppliers.
- Bakers should adjust water levels based on flour absorption properties.

Local ingredient availability:

- Sugar types: Granulated sugar preferred, but local alternatives may work
- Salt: Prefer iodized salt (per DRC standards)
- Yeast: Fresh, dry active, or instant yeast are all suitable with proper use.

Cost optimization strategies

Ingredient cost management:

- Bakers should source composite flour (or BCF) from reliable local processors for consistent pricing

- Buy ingredients in appropriate quantities to balance cost and freshness
- Track ingredient costs per kg of finished bread.

Profitability calculation example: Based on experience in Nigeria, 10% BCF inclusion typically reduced flour costs by 5.4%, contributing to overall operational cost savings of 4.1%.

8.5 FERMENTATION TIMING AND TEMPERATURE CONTROL

Temperature management

Optimal range: 20–30 °C, achievable in most tropical environments without specialized equipment.

Natural fermentation approach:

- Cover dough with clean cloth
- Monitor dough development visually
- Expect at least doubling in size over 1–3 hours.

Quality indicators

- Dough fills the bread pan (i.e., at least doubles in size)
- Springs back slowly when lightly pressed
- No over-fermentation signs (sourness, collapse).

See Module 5, section 5.3, "Step 3" for detailed fermentation monitoring techniques.

8.6 DOCUMENTATION AND CONSISTENCY

Recipe record-keeping

Essential documentation for each batch (at the start of testing a new variation of a recipe, the baker does not know whether it will be a successful batch, so they should record the details and later retain those for the successful batches):

- Ingredient quantities: Exact weights and measures used
- Environmental conditions: Temperature, humidity if known
- Timing: Mixing and kneading duration, fermentation time, baking time
- Results: Bread quality, customer feedback, costs.

Cost tracking template

Simple daily record:

Total ingredient cost per batch	
Number of loaves produced	
Cost per loaf	
Selling price	

Recipe improvement process

1. **Test small batches** when making changes
2. **Change one variable** (ingredient, temperature, timing) at a time
3. **Document results** systematically
4. **Implement successful changes** in full production
5. **Train staff** on updated procedures.

KEY TAKEAWAYS

- **Proven recipes provide reliable starting points:** DRC formulations demonstrate successful 10% BCF inclusion with commercial viability.
- **Systematic scaling maintains quality:** Proportional ingredient scaling ensures consistent results across different batch sizes.
- **Local adaptation requires testing:** Environmental conditions and ingredient variations need systematic adjustment and documentation.
- **Cost tracking supports profitability:** Recording ingredient costs and yields enables informed business decisions.
- **Documentation enables consistency:** Detailed records of successful formulations support reliable reproduction and staff training.
- **Small-batch testing reduces risk:** Testing modifications on small batches prevents large-scale failures and waste.

Self-assessment questions

1. **Multiple choice:** When scaling a recipe from 50 kg to 25 kg total flour, how much yeast would you use if the original recipe calls for 600 g?
   (a) 600 g (b) 300 g (c) 150 g (d) 1200 g

2. **True/False:** Composite flour always requires exactly the same water absorption as the original recipe indicates.

3. **Short answer:** List three environmental factors that might require recipe adjustments in your local area.

   1. _____

   2. _____

   3. _____

4. **Application:** You want to produce 200 loaves using Recipe 1, but your standard batch produces 150 loaves. Calculate the scaling factor and the amount of wheat flour needed.

   Scaling factor: _____

   Wheat flour needed: _____

5. **Problem-solving:** A baker reports that bread made from Recipe 2 is not rising properly in their location. List three possible causes and solutions.

   Cause 1: _____

   Solution: _____

   Cause 2: _____

   Solution: _____

   Cause 3: _____

   Solution: _____

6. **Analysis:** Explain why documentation is important for recipe development and list two specific pieces of information you should record for each successful batch.

   Why important: _____

   Information 1: _____

   Information 2: _____

See Appendix F for answers.

MODULE 9:
BUSINESS AND ECONOMIC CONSIDERATIONS

LEARNING OBJECTIVES

By the end of this module, you will know how to:

- Calculate and interpret cost–benefit analysis for BCF adoption in bakery operations
- Estimate investment requirements for establishing bakery operations using composite flour
- Apply pricing strategies that maximize profitability while remaining competitive
- Maintain essential business records for financial management and regulatory compliance
- Identify market opportunities and develop customer education strategies
- Evaluate and manage supplier relationships for consistent BCF supply
- Implement business practices that support regulatory compliance and quality standards.

This chapter is based on the premise of establishing a bakery to use composite cassava–wheat flour in bread-making and pastries. The underlying principles can also be applied to establishing a cassava processing plant to make BCF.

Understanding the business aspects of composite-flour bread production is essential for success in the growing cassava flour industry. This module provides practical tools for making informed financial decisions, managing operations profitably, and building sustainable businesses that contribute to local economic development.

9.1 COST–BENEFIT ANALYSIS OF USING BCF

Understanding the financial impact

The adoption of bread-making cassava flour creates measurable financial benefits for bakery operations. Evidence from major cassava-producing countries demonstrates consistent cost savings and improved profitability when BCF is properly integrated into bread production.

Key cost components (example costs)

Flour costs

In traditional bread production, wheat flour represents the largest single expense:

- 100% wheat flour operations: 82.9% of operational costs
- 10% BCF composite flour operations: Flour costs reduced to approximately 81.8% of operational costs
- Net flour cost savings: Typically 5.3% reduction in flour expenses.

Operational cost structure

Based on analysis of small to medium-sized bakery operations:

Fixed costs (approximately 90% of start-up budget):

- Production infrastructure and equipment: 67%
- Electricity generator: 16%
- Other fixed costs (administration, maintenance, marketing): 7.6%

PROFITABILITY CALCULATION EXAMPLE

Case study: Nigerian bakery operations

Daily production using 350 kg of flour (315 kg wheat flour + 35 kg BCF).

Revenue calculation:

- Large bread: 528 loaves × US$1.19 = US$628.32
- Small bread: 602 loaves × US$0.40 = US$240.80
- Total daily revenue: US$869.12

Cost calculation:

- Wheat flour (315 kg): US$289.80
- BCF (35 kg): US$15.05
- Other ingredients and operations (including depreciation on machinery): US$71.19
- Total daily cost: US$376.04

Profitability analysis:

- Total daily revenue: US$869.12
- Total daily costs: US$376.04
- Net daily profit: US$493.08
- Return on investment (ROI): 2.31

ROI interpretation: Every US$1.00 invested generated US$1.31 in profit.

Comparative analysis

100% wheat flour vs. 10% BCF inclusion:

- BCF operation produced 70 more loaves daily (1130 vs. 1060)
- Net benefit increased from US$427.15 to US$493.08 daily
- ROI improved from 2.09 to 2.31
- Cost per kg of flour decreased while revenue per kg increased.

Variable costs (approximately 10% of start-up budget):

- Raw materials: 1.9%
- Wages: 5.3%
- Utilities and packaging: 1.3%
- Other: 1.2%.

Business implications

Immediate benefits:

- Reduced raw material costs through lower-priced BCF
- Increased production volume from same flour quantity
- Improved profit margins on each loaf produced.

Strategic advantages:

- Reduced dependence on volatile wheat import prices
- Support for government policies promoting local agriculture
- Market differentiation through local content and nutritional benefits.

9.2 INVESTMENT REQUIREMENTS FOR BAKERY OPERATIONS (EXAMPLE COSTS)

Start-up cost structure

Building costs are not in the scope of this section.

Essential equipment investment (excluding building)

Major equipment (approximately 90% of equipment costs):

- Diesel/electric oven: 52% of total equipment investment
- Delivery vehicle (pedal tricycle): 11%
- Dough mixer: 19%
- Baking pans and trays: 3.7%
- Other equipment: 14%.

Sample investment breakdown for a small-scale bakery

- Production infrastructure: US$8950
- Generator: US$2150
- Other fixed costs: US$1010
- Variable costs: US$1280
- Total first-month costs: US$13 390 (excluding building).

Equipment considerations

Oven selection (largest single investment)

- Economic life span: 20 years
- Daily depreciation cost: Approximately US$1.32
- Available types: Diesel, electric, wood-fired (see section 7.6).

Production capacity planning

- Standard operation: Two production shifts (late night and early morning)

Working capital requirements

Monthly operational needs

- Raw materials inventory
- Staff wages
- Utility costs
- Packaging materials
- Maintenance reserves.

Cash flow considerations

- Daily sales provide working capital for the next day's production
- Maintain ingredient inventory for 7–14 days production
- Plan for seasonal variations in demand and ingredient availability.

9.3 PRICING STRATEGIES AND PROFITABILITY CALCULATIONS

Profitability analysis framework

Key performance indicators from case studies

- Revenue per loaf by bread type
- Cost per kg of flour used: US$1.07 (composite) vs. US$1.12 (wheat only)
- Net benefit per kg of flour: US$1.41 (composite) vs. US$1.22 (wheat only)
- Return on investment ratio: 2.31 (composite) vs. 2.09 (wheat only).

Pricing based on documented performance

DRC bakery pricing examples:

- US$15 per 100 loaves bread: 82–87 g finished weight
- US$25 per 100 loaves bread: 115–160 g finished weight
- US$50 per 100 loaves bread: 197–312 g finished weight.

Nigerian case study pricing:

- Large bread: US$1.19 per loaf
- Small bread: US$0.40 per loaf.

Cost calculation methodology

Production cost analysis

Based on 10% BCF inclusion producing 1130 loaves daily:

- Total daily cost: US$376.04
- Cost per loaf: US$0.33 average
- Total (gross) revenue per loaf: US$0.77 average
- Profit margin: 131%.

Break-even considerations

The break-even point is where revenue exactly matches costs—this means selling enough loaves to cover daily costs.

- Fixed costs (equipment depreciation): US$3.37 daily
- Variable costs (ingredients, labor): US$372.67 daily
- Minimum daily sales needed: US$376.04.

9.4 RECORD-KEEPING AND FINANCIAL MANAGEMENT

Essential business records

Daily production tracking

- Ingredient quantities used
- Product output by type and size
- Quality control checks performed
- Production problems and solutions.

Financial documentation

- Daily sales revenue by product type
- Ingredient costs and supplier information
- Equipment maintenance and operating expenses
- Staff wages and other labor costs.

Simple record-keeping templates

Daily cost tracking

Template for keeping track of costs:

Date			Amount (US$)
Ingredients used			
Wheat flour	kg	× US$	
BCF	kg	× US$	
Other ingredients			
Total ingredient cost			
Production			
No. loaves produced			
Cost per loaf			
Selling price			
Profit per loaf			
Day's profit	No. loaves × Profit per loaf		

Monthly profitability review

- Average daily revenue
- Average daily costs
- Monthly profit trend
- ROI calculation
- Supplier performance evaluation.

Inventory management

First-in-first-out (FIFO) system:

- Use older stock before newer purchases—place incoming stock behind current supplies or rotate stacks (clearly labeled by best before date)
- Track expiration dates systematically
- Minimize waste through proper rotation.

Stock level monitoring

- Maintain adequate raw material supplies
- Avoid over-stocking perishable ingredients
- Plan purchases based on production forecasts.

9.5 MARKET OPPORTUNITIES AND CUSTOMER EDUCATION

Benefits documented from case studies

Documented consumer benefits

- Enhanced nutritional profile through increased dietary fiber content
- Research indicates cassava-based bread may produce different glycemic responses compared with 100% wheat bread (cassava has a lower glycemic index [GI] than wheat, but individual responses vary)
- Improved digestibility
- Potential cost savings when production efficiencies are passed on to consumers.

Economic impact evidence

- Support for local cassava farmers through industrial demand
- Contribution to national food security through import substitution
- Foreign exchange savings: reduced imports of wheat.

Market positioning based on documented advantages

Quality demonstration opportunities

- Product quality maintained with 10% BCF inclusion based on successful DRC bakery operations
- Consumer acceptance documented through successful sales in 12 DRC bakeries
- Consistent bread characteristics: good taste, considerable weight, good texture.

Business differentiation

- Alignment with government policies requiring minimum BCF inclusion
- Demonstrated profitability improvements for bakery operations
- Local content supporting community economic development.

9.6 SUPPLY CHAIN MANAGEMENT AND SUPPLIER RELATIONSHIPS

BCF supplier evaluation based on quality requirements

Critical supplier criteria

- Adherence to BCF processing timeline (24 hours from harvest to drying)
- Consistent achievement of quality specifications (Module 2, section 2.2):
- Moisture content ≤ 10%
- pH 5.8–7.0 for optimal yeast performance
- Particle size 250 µm (or national standard if finer)
- Cyanide content ≤ 10 ppm.

Documented supply challenges

In a case study of Nigerian millers, common BCF quality issues included:

- Inconsistent moisture content above acceptable limits
- Irregular particle size affecting flour blending
- Dark coloration
- Low pH levels affecting yeast performance
- Microbial loads above permissible limits
- Traceability problems with unbranded, unlabeled supplies.

Supply management strategies

Quality control approach

- Implement ingredient quality testing procedures (Module 6, sections 6.1 and 6.2)
- Maintain supplier documentation for traceability
- Use first-in-first-out (FIFO) inventory management
- Document quality issues and corrective actions.

Supplier development

Nigeria's experience shows progress in expanding medium- and large-scale BCF processors to meet standards. Similar development approaches include:

- Supporting processor training on quality standards
- Sharing feedback on product quality issues
- Collaborating on capacity-building initiatives.

9.7 REGULATORY COMPLIANCE AND BUSINESS IMPLEMENTATION

Business compliance framework

Legal requirements

- Business registration and licensing per local regulations
- Food safety and health department approvals and certifications
- Tax registration and reporting obligations
- Employment law compliance for staff management.

Quality system implementation

- Document procedures for meeting standards requirements (Module 4)
- Establish regular testing and monitoring protocols
- Maintain traceability records for ingredient sourcing
- Implement corrective action procedures for quality issues.

Documentation for compliance

Required business records

- Supplier qualification and approval documentation
- Ingredient purchase records with traceability information
- Production records showing compliance with inclusion requirements
- Quality testing results and corrective actions.

Financial compliance

- Accurate cost accounting for tax purposes
- Proper wage and employment records
- Equipment depreciation calculations for financial reporting
- Sales documentation for regulatory and tax requirements.

Business development support

Professional consultation

- Consider hiring specialists (accountant, technical/operations manager) to monitor business operations (technical and financial)
- Seek advice on revenue structure optimization
- Conduct regular profitability ratio analysis
- Perform break-even analysis for business planning.

Continuous improvement

- Regularly review cost structure and profitability
- Benchmark against industry performance standards
- Conduct investment planning for equipment upgrades and expansion
- Market analysis for growth opportunities.

KEY TAKEAWAYS

- **Financial benefits are measurable:** BCF adoption typically reduces flour costs (e.g., by 5.3% in our generalized case study) and increases daily production volume, improving overall profitability with ROI increasing from 2.09 to 2.31 in documented case studies.
- **Investment planning requires a systematic approach:** Major equipment (ovens) represents 47% of investment, with total start-up costs around US$13 390 excluding buildings, thus careful financial planning is essential.
- **Record-keeping supports business success:** Daily tracking of costs, production, and sales enables informed decision-making and demonstrates regulatory compliance.
- **Market opportunities exist across customer segments:** Health-conscious consumers, cost-conscious families, and supporters of local agriculture represent growing markets for composite-flour products.
- **Supplier relationships are critical:** Developing partnerships with reliable BCF processors ensures consistent quality and supply while managing costs effectively.
- **Compliance integration supports sustainability:** Meeting regulatory requirements while maintaining profitability requires systematic documentation and quality management systems.
- **Business skills complement technical skills:** Success requires mastering both bread-making techniques and business management fundamentals, including pricing, record-keeping, and customer relations.

Self-assessment questions

1. **Calculation:** A bakery produces 400 loaves daily using 250 kg of flour (225 kg wheat + 25 kg BCF). If wheat flour costs US$0.92/kg and BCF costs US$0.43/kg, calculate the daily flour cost and compare it with 100% wheat flour cost.

   Composite flour cost: US$ _____

   100% wheat flour cost: US$ _____

   Daily savings: US$ _____

2. **Multiple choice:** In the standardized case study, what was the ROI for bakery operations using 10% BCF inclusion?
   (a) 2.09 (b) 2.15 (c) 2.31 (d) 2.35

3. **Short answer:** List three key customer segments that represent market opportunities for composite flour bread.

   1. _____

   2. _____

   3. _____

4. **Application:** A new bakery wants to price its composite-flour bread competitively. The production cost per loaf is US$0.40, and the bakery wants a 50% profit margin. Market research shows competitors pricing similar bread at US$0.65–0.70. What pricing strategy would you recommend and why?

   Recommended price: US$ _____

   Strategy reasoning: _____

5. **True/False:** The largest equipment investment for a new bakery is typically the dough mixer.

6. **Problem-solving:** A baker reports inconsistent BCF quality from their supplier, which is affecting bread quality. List four steps they should take to address this supply chain issue.

   Step 1: _____

   Step 2: _____

   Step 3: _____

   Step 4: _____

7. **Analysis:** Explain why maintaining daily production and cost records is important for both business success and regulatory compliance.

   Business importance: _____

   Regulatory importance: _____

See Appendix F for answers.

MODULE 10:
PRACTICAL APPLICATIONS AND CASE STUDIES

10.1 CASE STUDIES FROM SUCCESSFUL BAKERIES

In general, there are two types of bakery in DRC—artisanal (traditional) and mechanical or industrial (with electricity) bakeries. The equipment used is very similar, except that the majority of that used in traditional bakeries is made of wood, while that used in industrial bakeries is made of food-grade metals. The key equipment comprises: weighing scales, trolley, kneader, dough cutter, baking trays, cutter, and earthenware or mechanical baking oven.

The principal ingredients used are wheat flour, water, yeast, and salt. Though some bakers add additives (e.g., improver, colorant) to enhance flavor or color or to make their bread unique. Some bakers have recently (since 2023) started using BCF in DRC (many bakers in Nigeria have been using BCF for much longer). The baking process involves weighing the ingredients, mixing (all dry ingredients, i.e., flour, salt, and yeast are mixed together before adding water), kneading, fermentation/proofing (about 3 hours), cutting into required shapes and sizes, baking (temperature: 230–273 °C; time: 15 minutes for baguette-type French bread), and cooling.

10.2 COMMON CHALLENGES AND SOLUTIONS

Challenges

- **Limited knowledge and training:** Bakers and pastry producers lack experience and training in using HQCF in bread-making.
- **Quality issues of HQCF:** Most cassava processors lack knowledge of GMP and GHP. Also, poor processing techniques, such as sun-drying, lead to low-quality bread-making cassava flour with impurities, unpleasant odors, and color problems.
- **Supply chain and logistics:** Inconsistent supply, availability, and quality of HQCF hamper continuous use in bread production.
- **Production costs:** High costs related to machinery, fuel, transportation, and labor increase the price of HQCF, limiting its competitive edge.
- **Cassava diseases:** Crop diseases such as cassava brown streak disease threaten the availability of cassava roots for flour production.

Solutions

- **Training and sensitization:** Conducting training programs for bakers and pastry makers to improve skills and awareness about HQCF usage and its benefits.
- **Improved processing technology:** Adopting modern cassava flour processing methods, especially the use of mechanical drying to ensure high-quality flour.
- **Government policy and enforcement:** Introducing and enforcing policies to promote HQCF use in bread-making, with mandates on substitution rates (e.g., 5–10% bread-making cassava flour in wheat flour).
- **Market development and linkages:** Creating market linkages between farmers, processors, and end-users to ensure steady supply and demand.
- **Research and innovation:** Universities and research centers developing improved cassava varieties, addressing crop diseases, and innovating processing techniques.
- **Economic incentives:** Supporting cassava farmers and processors with credit access, subsidies, and infrastructure improvements.
- **Public awareness campaigns:** Educating consumers about the health, economic, and environmental benefits of cassava flour to increase acceptance.

10.3 PRODUCT DIVERSIFICATION OPPORTUNITIES

Utilization of HQCF in baking is not limited to bread but extends to a broad portfolio of bakery items such as cakes, muffins, tortillas, and pizza crusts, as well as cooking applications, enabling diverse product development opportunities. Bread-making cassava flour can serve as an all-purpose flour substitute for baking and confectionary, offering versatility for various recipes. It is also suitable as a thickening agent in sauces, gravies, and soups—hence, expanding its use in cooking beyond baking. The gluten-free nature of HQCF opens up product diversification opportunities for gluten-sensitive consumers or those seeking allergen-free options.

Product diversification opportunities in HQCF utilization for baking include a wide variety of bakery and related products beyond just bread. Examples include the following.

- **Buns:** HQCF can partially or fully substitute wheat flour to create buns with good crust and crumb texture.
- **Biscuits:** HQCF can be used for making biscuits without wheat flour, delivering a gluten-free option with good texture.
- **Cakes and brownies:** 100% HQCF performs well in cakes and brownies, allowing for moisture retention and a desirable texture.
- **Muffins and pancakes:** 100% HQCF is suitable for gluten-free muffins and pancakes, providing a light, fine texture.
- **Tortillas and pizza crusts:** HQCF can be used to create gluten-free tortillas and pizza crusts with acceptable structure and taste.

10.4 BUILDING CUSTOMER ACCEPTANCE

Building customer acceptance for bread-making cassava flour baked products requires a systematic blend of education, quality improvement, marketing, and consumer engagement. Some ways to achieve this include the following.

- **Product quality and sensory appeal:** This involves improving the texture, taste, aroma, and appearance of HQCF baked goods. Sensory studies have shown that favorable texture and moistness are key attributes consumers associate positively with HQCF products.
- **Consumer education and awareness:** Many consumers are not aware of the benefits of using HQCF for baking and confectionary. Awareness campaigns explaining its nutritional and socioeconomic benefits, gluten-free nature, and environmental benefits can shift consumer perceptions positively.
- **Sampling and demonstrations:** Offering in-store tastings and baking demonstrations significantly increases customers' willingness to buy by enabling them to experience the product first-hand, reducing hesitancy due to unfamiliarity.
- **Effective marketing and branding:** Use social media platforms to visually showcase the appeal of HQCF baked products through high-quality images, videos, and user-generated content.
- **Loyalty programs and incentives:** Designing and implementing discount offers, loyalty rewards, and special promotions to encourage repeat purchases and foster long-term customer relationships.

MODULE 11: TROUBLESHOOTING AND PROBLEM-SOLVING

LEARNING OBJECTIVES

By the end of this module, you will know how to:

- Diagnose and solve production problems

11.1 PROBLEM ANALYSIS

Problem identification

Common problems (symptoms):

- Dense/heavy texture
- Poor volume
- Uneven crumb
- Irregular shape
- Color variations
- Abnormal odor.

Systematic problem-solving

1. The symptoms are often an indication of the cause.
2. Check production records for likely causes (see Table 11.1 and subsections 11.2–11.4):
   - Ingredient quality
   - Relevant process parameters
3. Test possible solutions:
   - Rerun the recipe with quality-checked fresh ingredients
   - Adjust process parameter(s)
4. Document results, especially successful solutions.

11.2 COMMON PRODUCTION ISSUES AND SOLUTIONS

Raw material and product (bread) contamination issues

- Poor environmental and personnel hygiene leading to bread contamination and poor aesthetic appeal.

Recipe problems

- Water quality:
  - Contaminated water
  - Unhygienic water storage facility
- Quality of flour and other ingredients:
  - Improper ingredient handling
  - Poor storage facility
  - Non-adherence to FIFO principles.

Dough problems

- Water absorption issues:
  - Under-hydrated (dry, tough)
  - Over-hydrated (sticky, slack)
- Mixing problems:
  - Under-mixed (poor gluten development)
  - Over-mixed (broken gluten structure).

Table 11.1. Symptoms and likely causes

SYMPTOM (PROBLEM)	LIKELY CAUSE(S)
Dense/heavy texture	■ Flour strength ■ Inadequate hydration ■ Yeast viability ■ Under-proofing / under-fermentation ■ Improper kneading
Poor volume	■ Poor yeast activity ■ Baking issue ■ Excessive water
Uneven crumb	■ Flour quality ■ Poor mixing ■ Too high a baking temperature
Irregular shape	■ Damaged pan ■ Baking issue ■ Molding defect ■ Improper handling before oven baking
Color variations: crust	■ Pale: under-baked ■ Dark: over-baked ■ Uneven heat distribution in the oven
Color variations: inside	■ Mixing ■ Flour quality ■ Additives used ■ Baking temperature
Abnormal odor / flavor	■ Individual ingredient flavors (especially flour, additive, or oil) ■ Bad fermentation/proofing ■ Storage conditions ■ Equipment cleanliness

Fermentation issues

- Non-viable or poorly performing yeast as a result of storage in a hot environment or storage beyond expiry date (see Module 3, section 3.2, "Storage requirements")
- Temperature:
  - Too cold (slow fermentation)
  - Too warm (over-fermentation)
- Timing:
  - Under-proofed (dense structure)
  - Over-proofed (collapsed structure).

Baking problems

- Ingredient-related issues:
  - Water imbalance (slack, raw-like, wet interior)
  - Inactive yeast (faint aroma, dense, poor volume)
- Temperature-related issues:
  - Under-baked (pale crust, doughy interior)
  - Uneven baking (uncooked loaves, overcooked loaves)
  - Over-baked (dark crust, dry interior)
- Shape problems:
  - Irregular rise
  - Burst crusts
  - Poor volume.

11.3 DOCUMENTATION AND PROBLEM PREVENTION

Once a baker has identified their preferred recipe, determined the production parameters for the "perfect" bread, and (literally) sold it to their customers, it is important to maintain product quality to maintain customer trust and therefore income stream.

Documentation of ingredient supplies, ingredient use, and production parameters is vital to enable systematic diagnosis of any problems that may arise.

Documentation for business improvement

Daily records:

- Date, ingredients tested, problems identified, actions taken
- Adherence to recipe
- Refrigeration, ambient, fermentation, and baking temperatures
- Store, ambient, and cooling-area humidity
- Production figures (output)
- Product quality test results.

Monthly review: Analyze trends, calculate quality-related costs, evaluate suppliers.

Regulatory support: Quality documentation supports standards compliance (Module 4) and traceability requirements.

Record-keeping for troubleshooting

- Document:
  - Problem description
  - Observed causes
  - Corrective actions taken
  - Results achieved
- Use records to prevent recurring issues.

Problem-prevention strategies

- Ingredient quality and storage conditions (especially yeast storage temperature)
- Quality control checkpoints (see sections 6.1, 6.2, 6.3)
- Monitoring critical parameters
- Staff training on quality standards
- Adhering to the manufacturer's recommended equipment maintenance schedule.

11.4 EQUIPMENT MALFUNCTIONS AND REPAIRS

Typically, if equipment or machinery fails, bakers call in private technicians to diagnose and repair per manufacturer's instructions.

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APPENDIX A: INDUSTRIAL BLENDING PROCESS

The addition of BCF into wheat flour during the industrial milling process requires precise control and monitoring. At flour mills, the two flours are conveyed in separate systems and combined at a carefully controlled micro-dosing point.

Blending procedure:

1. **Separate conveyance:** BCF and wheat flour are transported in dedicated conveyor systems
2. **Quality filtration:** The BCF conveyor opens into a holding bin equipped with a mesh screen that traps extraneous material
3. **Controlled dosing:** The holding bin feeder opens into the wheat flour conveyor at a regulated speed to deliver the desired substitution level (typically 5% or 10%)
4. **Homogenization:** The composite flour is cycloned through sets of sifters
5. **Bleaching treatment:** The blended flour may pass through bleaching mechanisms
6. **Final blending:** The composite flour enters a blender to ensure complete homogeneity
7. **Fortification:** During final blending, the flour may be fortified with premixed vitamins, oxidizing agents, and enzymes
8. **Packaging:** The finished composite flour is conveyed for packaging and warehousing.

Critical blending parameters

These essential quality parameters directly impact final product performance.

Moisture content management

- BCF moisture content must be lower than that of the wheat flour
- This ensures the composite flour maintains acceptable overall moisture levels
- Low moisture prevents microbial growth and extends shelf life.

Color compatibility

- For many millers, bakers, and consumers, BCF color needs to closely match wheat flour to ensure visual homogeneity
- White BCF (from white-fleshed cassava) provides the best color matching
- While yellow BCF (from biofortified cassava) may affect final product appearance, some may consider this an acceptable trade-off for the nutritional benefit of the biofortification.

Particle size uniformity

- BCF particle size must closely match that of the wheat flour
- Uniform particle size ensures proper distribution throughout the blend.

pH control considerations

- pH directly affects yeast activity and fermentation performance
- Optimal pH range is 5.8–7.0 for proper yeast function
- Lower or higher pH values may negatively impact bread quality.

Ash content implications

- Higher ash content results in a darker flour appearance
- This can impair the overall color of the composite flour
- Monitor ash levels to maintain visual quality standards.

Cyanide safety requirements

- BCF cyanide content must remain below maximum recommended limits (i.e., 10 ppm)
- Regular testing ensures food safety compliance
- Proper BCF processing is essential for achieving safe cyanide levels.

Microbiological quality

- Aflatoxin contamination is a critical concern for millers
- BCF must undergo rigorous testing before blending
- Reject contaminated BCF batches to prevent quality issues.

Fermentation odor control

- BCF must be completely odorless
- Any odors will be carried into the composite flour
- Reject BCF batches with detectable odors.

Miller challenges and solutions

Based on the experience of millers in Nigeria.

Quality consistency issues

Many small-capacity BCF processors cannot produce large volumes of uniform-quality flour. Common problems include:

- Inconsistent moisture content (often above acceptable limits)
- Irregular or rough particle size distribution
- Dark color affecting the final product appearance
- Low pH values impacting yeast performance
- Excessive microbial loads.

Traceability and inventory management

- BCF supplies often lack proper labeling
- Missing manufacturing dates and batch numbers complicate stock rotation, making first-in-first-out (FIFO) procedures difficult to implement
- Quality control tracking becomes challenging.

Solutions in progress

Nigeria's experience shows successful approaches:

- Expanding medium- and large-scale BCF processing capacity
- Implementing standardized quality control systems
- Developing consistent supply chains for uniform-quality BCF
- Training BCF processors in quality management.

Millers' responsibilities to bakers (bakers' requirements and millers' responses)

Bakers have specific performance needs that millers must address through proper flour processing (Table A1).

Table A1. Some of the baking qualities of mutual interest to bakers and millers.

BAKER'S INTEREST	HOW THE WHEAT FLOUR MILLING FACTORY ACHIEVES THIS
Bread flour that yields more loaves	Ensure optimal starch damage and tempering during flour milling
High dough spring or loaf volume	Use good-quality wheat grains and appropriate flour treatment with enzyme and oxidizing agents
Factory-blended bread flour containing cassava	BCF and wheat should be blended by a wheat flour miller and sold directly to bakers. Millers need to use flour improvers to enhance bread volume at the bakery Mixing BCF with commercial wheat flour at the bakery leads to gluten content reduction, affecting the bread volume
Good crumb color and structure	Ensure efficient extraction of bran and shaft—not too low or too high. At the bakery level, excessive addition of improver should be avoided
Elastic and extensible dough and with good stability during proofing	Use good-quality wheat grains with high protein (gluten) content when manufacturing bread-making composite cassava–wheat flour. The composite flour *must* contain not less than 7% gluten content Mixing BCF with commercial wheat flour by bakers leads to a reduction of the gluten content of the factory-made flour, affecting the bread volume

APPENDIX B: QUALITY CONTROL CHECKLISTS

Daily quality check procedures: Ingredient quality checklist

INGREDIENT QUALITY CHECKLIST FROM PURCHASE THROUGH STORAGE AND USE

Phase 1: Ingredient procurement and receipt

1. Supplier verification and ingredient receipt

Critical control point: Verify ingredients from approved suppliers with proper documentation

- Check supplier approval status and certifications
- Verify ingredient expiry dates and best before dates
- Confirm proper packaging and transport conditions
- Maintain purchase invoices for full traceability
- Ensure chilled products maintained at ≤4°C

2. Bread-making cassava flour (BCF) quality assessment

Critical control point: Systematic evaluation of BF quality parameters

- Visual inspection: white color (or yellow if biofortified), fine texture
- Odor assessment: must be completely odorless
- Moisture content verification: ≤12%
- Particle size consistency: 90-98% through specified mesh
- pH range compliance: 5.5-7.0 (East African) / 4.0-4.5 (DRC)

3. Wheat flour quality verification

Critical control point: Comprehensive wheat flour assessment

- Gluten strength evaluation using water mixing test
- Moisture content assessment: ≤13-15.5% depending on standard
- Physical contamination: check using water separation
- Color consistency: characteristic creamy white
- Protein content verification: minimum levels per standard

4. Supporting ingredient quality checks

Critical control point: Comprehensive evaluation of all baking ingredients

- Yeast viability testing using sugar syrup bubble test
- Egg freshness assessment: flotation, sound, and break-out tests
- Sugar granulation consistency and purity verification
- Salt purity and moisture content evaluation
- Oil/fat quality and storage condition assessment

Phase 2: Ingredient storage and inventory management

5. Temperature-controlled storage compliance

Critical control point: Systematic temperature monitoring and control

- Chilled products maintained at ≤4°C with continuous monitoring
- Dry goods stored in cool, dry conditions with humidity control
- Temperature logs maintained for all storage areas
- Automated alerts for temperatures outside specified ranges
- Regular calibration of temperature monitoring equipment

6. First-in-first-out (FIFO) inventory control

Critical control point: Systematic inventory rotation protocols

- Clear labeling with receipt and expiry dates
- Structured storage arrangement supporting FIFO
- Regular stock rotation audits and verification
- Immediate removal of expired or compromised ingredients
- Documentation of inventory movements and usage

7. Cross-contamination prevention protocols

Critical control point: Comprehensive contamination control measures

- Dedicated storage areas for different ingredient types
- Food-grade packaging with secure sealing
- Elevated storage on pallets with accessible inspection areas
- Integrated pest control monitoring and management
- Regular cleaning and sanitization schedules

Cleaning schedules:
Cleaning schedule template with daily tasks

DAILY CLEANING SCHEDULE

	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Cleaning materials		
Date:								*Only use the cleaning materials stated below*		
Area:										
Peeling										
Knives										
Basins/buckets										
Flooring								Clean water	Disinfectant	
Washing										
Tiles										
Flooring										
Basins/buckets										
Grating										
Tiles										
Flooring										
Basins/buckets										
Pressing										
Tiles										
Flooring										
Basins/buckets										
Pressing machine										
Hydraulic jack										
Bags/sacks										
Drying										
Flooring										
Flash dryer feed unit										
Flash dryer discharge unit										
Bagging and storage										
Packaging/bags										
Basins/buckets										
Flooring										
Pallets										
Report any issues to the supervisor or manager										

Hygiene monitoring:
Sample safety and hygiene compliance form template

Equipment name: _____ Serial number/ID: _____

Date: _____ Inspector name: _____

Pre-operation safety check:

Physical condition

- Equipment is free from visible damage
- All guards and safety devices are in place
- Emergency stop button functions correctly
- Electrical cords and plugs are intact
- Moving parts are properly secured

Operational safety

- Equipment operates smoothly without unusual noise
- All controls function as intended
- Warning labels are visible and legible
- Adequate workspace around equipment
- Proper ventilation in operating area

Hygiene compliance:

Cleanliness status

- All surfaces that contact dough are clean
- No visible residue from previous use
- Equipment free from dust and debris
- Surrounding area is clean and organized
- No signs of pest activity

Sanitation verification

- Equipment disassembled per manufacturer guidelines
- Approved cleaning agents used
- All parts thoroughly cleaned and dried
- Deep cleaning performed (if monthly schedule)
- Cleaning documented in logbook

Staff compliance:

Operator verification

- Operator trained on this equipment
- Wearing appropriate protective equipment
- Following proper hygiene protocols
- Aware of emergency procedures
- Training records on file

Corrective actions required:

Issue identified: _____

Action taken: _____

Follow-up needed: _____ Yes _____ No

Target completion date: _____

Certification:

I certify that this equipment has been inspected according to established safety and hygiene protocols.

Inspector signature: _____ Date: _____

Supervisor review: _____ Date: _____

Next scheduled inspection: _____

This form must be completed daily before first use and filed according to facility record-keeping procedures.

APPENDIX C: CALCULATION WORKSHEETS

Recipe scaling calculations:
Recipe scaling worksheet for cassava–wheat composite flour bread

Recipe information:

Recipe name: _____

Current batch size: _____ kg total flour Current yield: _____ loaves

New batch calculation:

Desired batch size: _____ kg total flour

Scaling factor calculation:

$$\frac{\text{Desired flour (kg):}\ _____}{\text{Current flour (kg):}} = _____ \text{ (scaling factor)}$$

Expected yield: _____ loaves

Ingredient quantities:

Ingredient	*Current quantity*	*Calculation (current quantity × scaling factor)*	*New quantity*
Wheat flour (kg)	_____	_____ × _____ =	_____
Bread-making cassava flour (BCF) (kg)	_____	_____ × _____ =	_____
Total flour (kg)	_____	_____ × _____ =	_____
Yeast (g)	_____	_____ × _____ =	_____
Salt (g)	_____	_____ × _____ =	_____
Sugar (g)	_____	_____ × _____ =	_____
Fat/oil (L or kg)	_____	_____ × _____ =	_____
Water (L)*	_____	_____ × _____ =	_____
Other:	_____	_____ × _____ =	_____

** Remember to have more than the calculated amount of (clean) water available, but be prepared to use less or more than calculated amount to obtain correct dough hydration and consistency.*

Production notes (original recipe):

Mixing time: _____ minutes Fermentation time: _____ hours

Baking temperature: _____ °C Baking time: _____ minutes

Dough piece weight: _____ g per loaf

Quality check:

- All ingredients measured accurately
- BCF meets quality standards (white, odorless, fine texture)
- Proper mixing achieved
- Target dough consistency reached
- Expected yield achieved

Notes: _____

_____

Date: _____ Baker: _____

Remember: When using 10% BCF substitution, maintain all other ingredient proportions from your standard recipe.

Cost analysis templates: Cost tracking template with example data

Date (DD/MM/YYYY)	Item	Quantity	Unit cost (US$)	Total cost (US$)	Remarks
/ /	Cassava flour	50 kg	0.43	21.50	
/ /	Wheat flour	315 kg	0.92	289.80	
/ /	Yeast	0.35 kg	3.96	1.39	
/ /	Packaging (bags)	100 pcs	1.32	1.32	
/ /	Electricity	–	–	0.82	
/ /	Labor	–	–	3.85	
Total cost for date:			318.68		

Profitability assessment: Revenue and profit margin calculation template with example data

Date (DD/MM/YYYY)	Product	Units sold	Price per unit (US$)	Total revenue (US$)	Total cost (US$)	Net profit (US$)	Profit margin (%)
/ /	Cassava bread	528	1.19	628.32	318.68	309.64	49.3%
/ /	Small bread	602	0.40	240.80	150.25	90.55	37.6%
Total/day		1130		869.12	468.93	400.19	46.0%

APPENDIX D: TROUBLESHOOTING

Troubleshooting quick reference: Troubleshooting cassava processing equipment

ISSUE	POSSIBLE CAUSE	SOLUTION
Cassava graters		
Low output	Dull blades	Sharpen or replace blades
Machine vibrates excessively	Unbalanced drum or loose fittings	Rebalance drum, tighten parts
Clogged hopper	Feeding too fast or wet tubers	Slow feed rate, drain tubers
Motor overheating	Prolonged use or overload	Allow to cool, reduce load
Cassava dewatering press		
Low pressure	Hydraulic fluid low or leak	Refill or repair system
Incomplete pressing	Overload or short cycle	Reduce load, extend cycle time
Leaking water tray	Blocked drain or damaged tray	Clear drain or repair tray
Loud operation	Worn mechanical parts	Inspect and replace parts
Cassava dryers		
Low drying efficiency	High moisture in input or low heat	Check feedstock, adjust temperature
Blocked pipes	Product build-up	Stop operation and clean pipes
Overheated product	High temperature	Reduce furnace heat setting
No product output	Cyclone clogged	Inspect and clean cyclone
Cassava mill		
Uneven flour size	Damage to the mesh	Repair mesh/use appropriate mesh size
Motor overload	Overfeeding or hard material	Reduce feed rate
Excessive noise	Loose hammers or bearings	Tighten or replace components
Poor output	Blocked screen or blunt hammers	Clean or replace parts

APPENDIX E: REGULATORY COMPLIANCE

Label templates: Cassava–wheat composite bread

The package must be legibly and indelibly marked with:

- Product name ("Cassava bread")
- Name and physical address of manufacturer/distributor
- Brand or trade name
- Date of manufacture
- List of ingredients
- Lot identification number
- Best before date
- Net weight in metric units
- Storage instructions
- Declaration of flavoring agents/spices used
- Instructions for package disposal.

For nonretail packages, information may be provided in accompanying documentation, but the product name, lot ID, and manufacturer details must appear on the actual package.

Documentation templates: Temperature recording log

Area: _____ Date(s): _____

Target temperature range: _____ Recording frequency: _____

TEMPERATURE READINGS

Date	Time	Temperature recorded	Out of range?	Recorder's initials	Comments/ Actions taken

Supervisor name: _____ Signature: _____ Date: _____

☐ Data entered into IT system/database

This form should be completed according to facility hygiene and safety protocols. Store completed forms according to record retention policy.

APPENDIX F: SELF-ASSESSMENT ANSWERS

Module 1

1. (b) 24 hours.
2. Possible answers include: white/odorless/tasteless, fine texture, controlled moisture (≤ 12%), neutral pH, processed within 24 hours, free from foreign matter.
3. False—BCF typically costs less than wheat flour.
4. Possible benefits: reduced flour costs, increased bread output per batch, enhanced nutritional profile, market differentiation, support for local agriculture.
5. Composite flour is a blend of BCF and wheat flour that maintains bread quality while reducing import dependence and supporting local cassava production. Governments promote it to save foreign exchange, support local farmers, and improve food security.
6. Recovery rate means that 100 kg of fresh cassava roots produces about 25 kg of BCF. This is important for planning raw material needs, calculating costs, and determining the scale of processing operations needed.

Module 2

1. (b) 12–18 months after planting.
2. Possible answers: Moisture content (≤ 10%—prevents spoilage and maintains flow properties); pH level (5.8–7.0—ensures proper yeast activity); particle size (250 µm—enables proper blending with wheat flour); cyanide content (≤ 10 ppm—ensures food safety).
3. False—BCF should be completely odorless; any sour smell indicates fermentation and quality problems.
4. Problem: Processing timeline exceeded, likely fermentation occurred.
   Action: Reject the batch and source BCF from reliable supplier with proper processing controls.
5. Possible answers: Moisture-proof packaging, dry storage environment, proper ventilation, FIFO inventory management, pest control, temperature control, off-ground storage.
6. Too large flour particles: Poor blending with wheat flour, uneven distribution in dough, potential gritty texture in bread.

Module 3

1. (c) Clean equipment only when visibly dirty
   Correct answer explanation: Equipment must be cleaned after each shift regardless of visible dirt, as contamination may not be visible.
2. False—You must never handle bread products with bare hands. Always use clean gloves when handling bread products.
3. Possible answers include: Before starting work, after visiting the toilet, before handling raw materials and bread, after handling eggs and before contact with other food, after touching face/hair/clothes, after handling cleaning materials, before handling ready-to-eat products.
4. Storage: Store eggs at cool temperature until needed. If storing at room temperature, use current batch daily and replenish stocks daily. Ensure eggshells are not cracked—discard cracked eggs.
   Preparation: Keep raw eggs separate from other food, especially cooked and ready-to-eat food. When pooling eggs, pool only the required quantity, use all the pooled liquid egg on the same day, and do not top up with new eggs. Wash hands, utensils, and surfaces thoroughly after handling eggs.
5. Action: Remove the bread from display immediately and discard it.
   Reason: Bread with perishable fillings should not be displayed beyond 4 hours at room temperature because of food safety risks. After 5 hours, the product is no longer safe for consumption.
6. Keeping invoices allows you to trace ingredients back to their suppliers if food safety problems occur. This helps identify the source of contamination, enables quick removal of affected products, and demonstrates to regulators that you have proper traceability systems in place. It also helps track expiration dates and supplier performance.

Module 4

1. (c) DRC national, East African regional, and Kenyan national standards—Since DRC joined the East African Community in 2022, exports within the region must meet regional standards plus both national requirements.
2. False—Particle size requirements vary significantly: International (600–1200 µm), continental (95% through 250 µm), regional (90% through 250 µm).
3. Any five of these required pieces of information for East African composite flour labels:
   - product name: "Cassava–wheat composite flour"
   - percentage substitution of wheat with cassava (e.g., "10% cassava flour")
   - ingredient list in descending order by weight
   - "Human food" statement
   - name and physical address of manufacturer/packer/distributor
   - net weight
   - manufacturing date
   - best before date
   - storage instructions
   - lot identification.
4. Inclusion level: 10%
   Reason: To access both markets with a single product formulation, use the higher requirement. This avoids the complexity and cost of producing separate products for different markets.
5. Three ways to promote standards compliance as marketing advantage:
   - Display certificates or compliance statements prominently in the bakery and on packaging
   - Use marketing messages such as "Meets international quality standards" or "Exceeds national safety requirements"
   - Provide transparency through facility tours or quality documentation that customers can review.

Module 5

1. (b) Uniform distribution
   Explanation: Uniform distribution ensures consistent bread quality and prevents uneven areas that could affect texture, appearance, and baking performance.
2. Possible answers: distributes ingredients uniformly throughout the dough, begins gluten development through mechanical action, incorporates air that contributes to final bread texture, creates foundation for fermentation, enables proper hydration of flour proteins and starches.
3. False—Composite flour contains two different types of starch (cassava and wheat) that absorb water differently, often requiring adjustment of water levels during initial recipe trials.
4. Action: Add water gradually in small amounts while continuing to mix until proper dough consistency is achieved.
   Reason: Cassava flour absorbs water differently than wheat flour, and the dual starch system may require more water than standard recipes. Gradual addition prevents over-hydration.
5.

Possible cause	*Solution*
Poor yeast quality	Test yeast viability before use
Incorrect fermentation temperature	Maintain 20–30 °C temperature range
Insufficient water in dough	Adjust water absorption for composite flour requirements
Poor BCF quality affecting pH	Check BCF quality against standards (Module 2, section 2.2)
Over-mixing damaging gluten	Adjust mixing time and process
Contaminated ingredients	Perform quality checks on all ingredients before use and only use those that pass
Incorrect ingredient ratios	Recheck and re-run recipe; recheck scaling calculations

6. Importance: Cooling allows internal structure to set completely, reduces internal temperature for safe handling, and prevents condensation that could make the crust go soggy.
   Problems if packaged too early: Condensation inside packaging making bread soggy, continued internal cooking affecting texture, potential mold growth from trapped moisture, poor slicing characteristics.
7. Difference: Water absorption requirements may vary due to dual starch system (cassava and wheat starches).
   Adaptation: Start with standard water amounts but be prepared to adjust while gradually mixing. Document successful formulations for future use.

Module 6

1. (b) Forms soft, viscous mass
   Explanation: High gluten wheat flour will form a hard, viscous mass when mixed with water due to the gluten proteins. The more viscous the mass, the stronger the flour and the better it is for bread-making.
2. False
   Explanation: BCF contains no gluten-forming proteins, so it should not form a viscous mass. It should feel smooth and fine but will not develop the stretchy, elastic properties of wheat flour.
3. Any three of the following:
   - Stays compact when broken onto plate
   - Yolk stands high and round
   - White is thick (not thin or watery)
   - No off-odors
   - Uniform color
   - Yolk does not break easily.
4. Meaning: Yeast is weak/losing viability
   Action: Replace with fresh yeast before production
   Explanation: Few bubbles indicate the yeast is still alive but weak. It may cause poor fermentation and inconsistent results, so it is better to replace it.
5. Problem: Excess moisture content.
   Consequences: Spoilage/mold growth, poor baking performance/quality issues, shorter shelf life, caking problems, equipment difficulties
6. Any two of: Better digestibility, enhanced fiber content, lower production costs.
7. Any three of:
   - Flour odor test—Prevents batch failures from spoiled flour
   - Flour moisture test—Ensures you use good-quality flour only (quality control)
   - Yeast viability test—Ensures bread will rise properly
   - Egg freshness test—Prevents food safety issues and off-flavors
   - Visual ingredient inspection—Quality control
   - Finished product evaluation—Quality control.

Module 7

1. (b) Spiral mixer—Spiral mixers have the dough hook and bowl moving in opposite directions, providing automatic bowl scraping during operation.
2. False—Stainless steel, aluminum, or hard wood are preferred over iron for work surfaces because iron can react with dough and cause discoloration. Wood is a poor heat conductor, does not affect dough temperature, and dough rarely sticks to wooden surfaces.
3. Equipment approach: Focus on wood-fired ovens, hand mixing in wooden boxes, and manual tools.
   Advantage 1: Independent of electrical supply, ensuring consistent production.
   Advantage 2: Lower operating costs using locally available fuel sources.
4. Adjustment: Use graduated mixing speeds, starting slow and gradually increasing.
   Reason: Composite flour contains different starch granule sizes that require progressive speed increases to allow proper alignment of small and large granules from cassava and wheat.

5. Natural method advantage: Achieves optimal temperature (20–30 °C) without equipment investment in tropical climates.
   Mechanical proofing advantage: Precise control of temperature and humidity for consistent results regardless of environmental conditions.

Module 8

1. (b) 300 g—When scaling from 50 kg to 25 kg (÷2), all ingredients are divided by 2:
   600 g ÷ 2 = 300 g.
2. False—Composite flour may require different water levels due to different starch structures in cassava and wheat flours.
   Water should be added gradually and adjusted based on dough consistency.
3. Possible answers include: Temperature (hot/cool climates), humidity levels, seasonal variations, altitude, local ingredient quality variations.
4. Scaling factor: 1.33 (200 ÷ 150 = 1.33)
   Wheat flour needed: 60 kg (45 kg × 1.33 = 59.85 kg, rounded to 60 kg).
5. Possible causes and solutions:
   - Cause 1: Poor yeast quality/viability, possibly as a result of storing at high ambient temperatures
     Solution: Test yeast viability before use; store yeast in a cool, dry environment
   - Cause 2: Temperature too low/high
     Solution: Maintain 20–30 °C fermentation temperature
   - Cause 3: Incorrect water absorption
     Solution: Adjust water levels for local flour characteristics.
6. Why important: Documentation enables consistent reproduction of successful recipes and helps identify what works under local conditions.
   Information 1: Exact ingredient quantities used
   Information 2: Environmental conditions (fermentation and baking temperatures, fermentation time, baking time).

Module 9

1. Calculation:
   - Composite flour cost: (225 kg × US$0.92) + (25 kg × US$0.43) = US$207 + US$10.75 = **US$217.75**
   - 100% wheat flour cost: 250 kg × US$0.92 = **US$230.00**
   - Daily savings: US$230.00 – US$217.75 = **US$12.25.**
2. (c) 2.31.
3. Based on documented benefits:
   - Health-conscious consumers (enhanced fiber content, digestive benefits)
   - Cost-conscious consumers (potential price benefits from production savings)
   - Supporters of local agriculture and food security (cassava farmer support, import reduction).
4. Based on indicated margin and market information:
   - Calculated price with 50% margin: US$0.40 × 1.50 = US$0.60
   - **Recommended price: US$0.60–0.65**
   - Strategy reasoning: Higher price falls within competitor range (US$0.65–0.70) while achieving desired margin, allowing competitive positioning while maintaining profitability.
5. False—The oven represents the largest equipment investment at about half of total equipment costs.
6. Based on documented quality challenges:
   - Step 1: Implement systematic ingredient quality testing using procedures in Module 6, sections 6.1 and 6.2
   - Step 2: Document specific quality issues and share feedback with supplier
   - Step 3: Evaluate alternative BCF suppliers to reduce single-source dependence
   - Step 4: Establish clear quality specifications and acceptance criteria in supplier agreements.
7. Reasons:
   - Business importance: Daily records enable cost control, profitability analysis, and informed pricing decisions. They support ROI calculations and identify cost-saving opportunities.
   - Regulatory importance: Records provide traceability for food safety compliance, demonstrate adherence to inclusion requirements, and support tax reporting and business licensing obligations.

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