CASSAVA–WHEAT COMPOSITE FLOUR PROCESSING AND BREAD-MAKING

A PRACTITIONER'S WORKBOOK

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
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TAAT Technologies for African Agricultural Transformation
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CVCD PROJECT

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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.

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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

The manual combines the science and art of bread-making 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 Adegoke, Idris 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.

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CONTENTS

PREFACE

Bread is more than food—it is sustenance, culture, and livelihood for millions across Africa. Yet, in a region where wheat is largely imported, reliance on foreign flour puts bakers, businesses, and national economies at the mercy of fluctuating global prices. At the same time, cassava—a crop grown widely and abundantly across the continent—offers an underutilized, cost-effective, and locally sourced alternative.

Cassava–wheat composite flour processing and bread-making: A practitioner's workbook was developed to bridge a critical gap: how to incorporate high-quality cassava flour into wheat flour for bread-making without compromising on quality, profitability, or consumer satisfaction. It is grounded in both science and practice, drawing on years of research, collaboration with bakers, and engagement with national food policymakers. It aims at improving food security and self-reliance.

The goal of the workbook is simple: to empower bakers with the knowledge and skills to confidently adopt bread-making cassava–wheat composite flour in their production. This resource supports practical training delivered through national extension systems, and serves as a stand-alone guide for self-learners and bakery entrepreneurs.

Each module of the workbook is designed to be hands-on and actionable, covering everything from ingredient assessment and recipe adaptation to troubleshooting, scaling, and business planning. Whether you are a small-scale baker or managing a growing enterprise, we hope you will find that the workbook's contents support innovation, efficiency, and sustainability in your practice.

Ultimately, this workbook is about local solutions for local challenges. We believe that every loaf of cassava–wheat bread is not just a product of innovation, but a statement of confidence in African agriculture and industry.

We are grateful to the many collaborators—researchers, field practitioners, and bakers—whose contributions helped to shape this practical and forward-looking resource.

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

BACKGROUND

Numerous African countries are promoting—even mandating—the use of high-quality cassava flour in bread-making to reduce foreign exchange expenditure on importing wheat flour, support local cassava production, and enhance national food security.

Wheat flour is expensive. Very little is grown in sub-Saharan Africa, so the cost to millers, bakers, and the national economy is dictated by changes in international supply and trade prices on the open market.

Meanwhile, cassava root is comparatively cheap—it is grown across much of the continent, so available locally, and processing into high-quality unfermented bread-making flour is well within the capabilities of African food processors.

For bakers, adopting up to 10% cassava flour substitution in bread-making is highly advantageous. Up to 10% substitution means that bakers can keep using their own tried-and-tested bread recipes. With proper production, more loaves can be made from the same amount of flour, increasing the return on investment (ROI) in the bakery business. With the right techniques, a baker will maintain the quality of the products on which they have built their reputation. Considering the broader social–political–economic climate, every baker will be supporting government policies, local farmers, and local processors, and will also be helping their customers if they pass on some of the cost savings to them.

This workbook is designed to support training by IITA experts and delivered through national extension services. It is also a stand-alone guide that empowers those who are unable to attend such training.

With this workbook, you will be able to:

- Learn about bread-making with composite cassava–wheat flour
- Gain an introduction to modern bakery equipment and machinery, and see how that can be integrated in your bakery
- Make the financial business case for adopting 5–10% substitution of cassava flour in bread- and pastry-making.

MODULE 1: INTRODUCTION

1.1 INTRODUCTION AND CONTEXT

Why cassava–wheat composite flour?

Wheat flour is expensive. For example, the Democratic Republic of the Congo (DRC) spends an average of US$87 million annually on wheat imports, most of it for bread production. Recent reports also indicate ongoing price volatility, with wholesale prices ranging from US$0.67 to US$1.34 per kilogram in 2025, impacted by global supply–demand dynamics and trade tensions. The DRC's heavy reliance on wheat imports poses economic and supply risks. Supply chain vulnerabilities, infrastructure gaps, high taxation, limited credit access, and bureaucratic inefficiencies further complicate consistent wheat availability and cost control. Moreover, dependence on wheat sourced mainly from Europe (including Ukraine) and the Russian Federation exposes the economy to geopolitical risks.

Various African governments have adopted policies to promote the use of bread-making cassava flour (BCF) to reduce wheat import costs, support local cassava production, and enhance national food security.

Benefits for bakers

In addition to cost savings, BCF substitution of 10% of the wheat flour in bread-making results in production increases, in terms of more loaves from the same amount of flour and better return on investment (ROI) in raw materials. With the techniques detailed in this workbook, bakers will maintain the quality of their products. Overall, bakers will be supporting national development while improving their business's performance.

1.2 INTRODUCTION TO CASSAVA FLOUR

Bread-making cassava flour (also known as high-quality cassava flour, HQCF) is made from freshly harvested, wholesome cassava roots. To be accurately labeled BCF or HQCF, roots must have been correctly processed to dry flour within 24 hours of harvest and possess specific quality characteristics (see section 2.3).

In terms of a food product, bread containing BCF has a number of nutritional qualities and health benefits:

- it enhances dietary fiber content, serving as a prebiotic that supports digestive health
- it produces a lower glycemic response than 100% wheat bread, making it a viable option for individuals managing their blood sugar levels
- it has a lower fat content, contributing to healthier dietary choices.

However, the nutritional impact depends on cassava variety and processing method. For example, some varieties of cassava have vitamin A precursors that can be converted to retinol in the body and so improve human health.

KEY MESSAGES

Direct business benefits for bakers

- **Cost savings and increased production:** Substituting 10% BCF for wheat flour reduces raw material costs while producing more loaves from the same amount of flour, improving return on investment.
- **Quality maintenance with proven techniques:** Bakers can adopt BCF substitution while maintaining product quality and preserving their market reputation using the techniques in this workbook.
- **No recipe overhaul required:** Up to 10% substitution allows bakers to continue using their tried-and-tested bread recipes with minimal adjustment.

Customer and community value

- **Health benefits create market differentiation:** BCF bread offers higher dietary fiber and lower glycemic response—providing competitive advantages.
- **Supporting local value chains:** Using locally-sourced cassava flour supports regional farmers and processors while aligning with government food security policies.

Quality assurance essentials

- **Processing standards matter:** High-quality cassava flour (HQCF/BCF) must be processed from fresh, wholesome cassava roots within 24 hours of harvest to meet quality specifications for bread-making.

MODULE 2:

WORKPLACE SAFETY, INGREDIENTS, QUALITY ASSESSMENT, AND STORAGE

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 very prone to picking up contamination from the environment, including workers. Yet, local bakeries in Africa are generally characterized by poor hygiene. This module covers the practical hygiene and safety procedures that need to be implemented in all bakery settings.

2.1 WORKPLACE SAFETY

Keep floors dry and clean to prevent slips.

Install an air extractor to reduce dust and maintain good air quality (humidity and temperature).

Store cleaning materials properly—for example, well away from the work areas, ingredient store, and products. Ideally, keep cleaning solutions and chemicals in a lockable cupboard (and keep the cupboard locked when the cleaning chemicals are not in use).

Fire safety measures: Fire extinguishers must be placed in an accessible location where all staff can reach them. All staff must be trained how to use them and know where the emergency exits are. Encourage staff to exit the building swiftly but without running in the case of fire.

First aid kit: A first aid kit must be placed in an accessible location where all staff can reach it, and all staff should be taught basic responses to minor cuts and burns. Ideally, two members of staff should be trained as qualified first aiders.

2.2 PERSONNEL SAFETY AND FOOD-SAFETY PRACTICES

Protect personnel, ingredients, and products

Staff should:

- **Not work if they are feeling unwell**, as they could pass their germs onto colleagues and/or customers. It is very easy for a bakery to lose a hard-earned reputation through a lack of attention to personnel hygiene and safety!
- Wear clean, not damaged, and not too loose clothing. Loose clothing may get caught in machinery or drag items off worktables onto the floor, thus spoiling and wasting them.
- Wear protective clothing (see next subsection).
- Wash their hands thoroughly, including under fingernails, and frequently, especially:
  - at the start of the work day
  - before and after handling raw ingredients
  - before and after each stage in the production process
  - after removing gloves
  - after visiting the toilet
  - at the end of the working day.
- Use clean gloves when handling raw ingredients and bakery products. **Never handle bread with bare hands!**

Protective clothing

Aprons both protect clothing from spills, splashes, and other mishaps, and protect ingredients and products from any contaminants on clothing.

Closed shoes provide better protection of feet should anything fall, spill, or splash on them (especially hot items) or if something is kicked while walking around the bakery.

Hair coverings (usually hairnets) both prevent contamination of ingredients and products from shed hairs and hair-borne foreign matter, and keep long hair out of harm's way (e.g., protected from open flames, moving machinery parts).

Gloves are possibly the single most important piece of protective clothing. In a food context, they are primarily designed to protect raw ingredients and food products from hand-borne germs and dirt. They also protect the wearer from inadvertent contamination from ingredients such as raw eggs that can easily spread spoilage microorganisms in the bakery. While handwashing is essential, it is still best practice to handle finished products with gloved hands to prevent contamination.

2.3 FLOUR QUALITY TESTING METHODS

Flour quality is critical for good baking outcomes. Flour that fails any of the quality tests will result in substandard or contaminated bread.

Tests for wheat flour strength

Water mixing

1. Place a flour sample in your palm
2. Add a small amount of water
3. Mix with one finger.

Compression test

1. Place a flour sample in your palm
2. Compress with four fingers
3. Open your hand
4. Rub the flour between your fingers.

For **wheat flour**, observe:

- High-gluten flour forms a hard, viscous mass
- The more viscous the mass the greater the strength
- Bread flour falls apart after squeezing.

Visual checks

- Color:
  - Wheat flour should be creamy white.
  - BCF should be white, although it may be yellow if it is made from a biofortified cassava variety.
- Check for foreign matter, impurities, insects, insect body parts.
- Evaluate texture and fineness: rub a teaspoon of flour between your fingers—flour should feel smooth and dry, not gritty or damp.

Sensory and physical tests

Odor assessment

- Smell the flour directly
- "Scald" a sample of flour with hot water at about 65 °C
  - Wheat flour should have a neutral odor
  - BCF should be odorless, with no off-odors
  - Do not use any flour that smells bad, stale, musty, or sour.

Taste test

- Taste the flour directly
- "Scald" a sample of flour with hot water at about 65 °C
  - Wheat flour has a distinctive, subtle taste: mild, nutty, and slightly buttery
  - BCF should be tasteless, with no sour taste or off-flavors.

Moisture content check (Figure 2.1)

1. Place a sample of flour in your palm
2. Compress with four fingers
3. Open your hand
   - Well-dried flour leaves a nonsticky trace and does not stick to the hand.

Simple float test for impurities (Figure 2.2)

1. Fill a glass with clean water
2. Add flour (1 part flour to 4 parts water)
3. Stir vigorously
   - Fibrous materials (including bran) float, dirt and sand sink.

Simple chemical tests

Purity check for chalk adulteration

- Add dilute hydrochloric acid (HCl) to a sample of flour
  - bubbles indicate contamination with chalk
  - do *not* use any flour contaminated with chalk.

pH testing for BCF quality

- Use pH strips or a pH meter
  - ideal pH is in the range 5.8–7.0.

2.4 QUALITY TESTING OF OTHER BAKING INGREDIENTS

Sugar

- Look at the sugar (visual inspection) for proper granulation, color consistency, absence of lumps, foreign matter, or excessive moisture (Figure 2.3)
  - fine granules are required for dough-making.

Figure 2.1. Hand compression test for flour moisture content: (a) compress with fingers; (b) good moisture level, wheat flour; (c) good moisture level, BCF.

Figure 2.2. Test for impurities in flour.

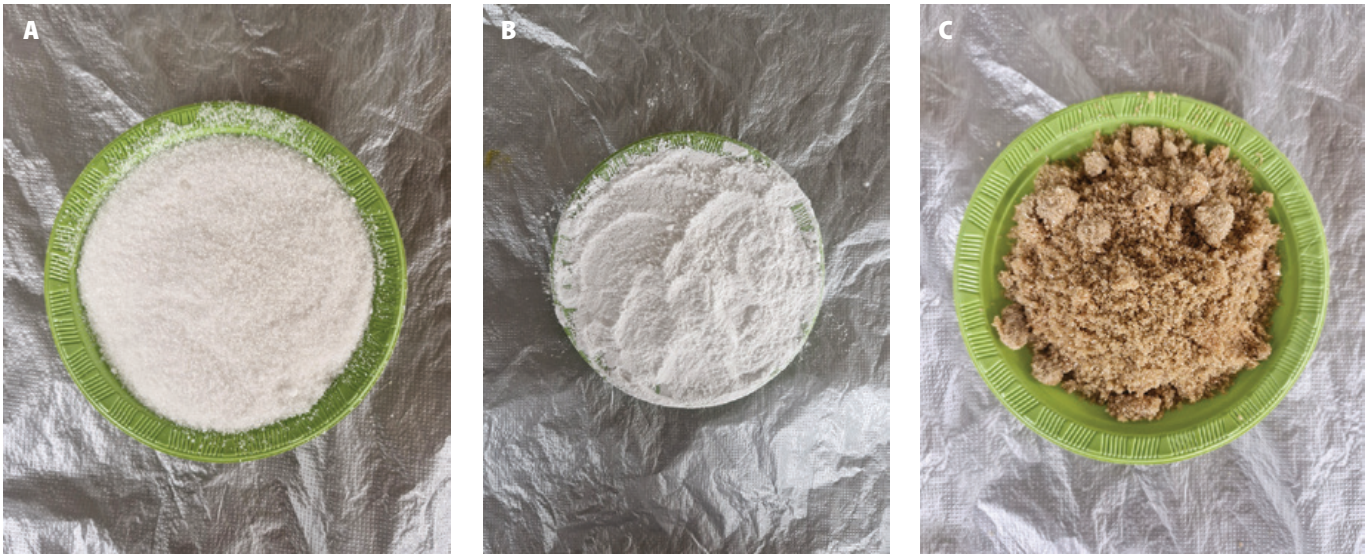

Figure 2.3. Sugar types: (a) regular granulated; (b) superfine granulated; (c) brown.

Eggs—freshness tests

The primary concern with eggs is how fresh they are.

The international "scare" contaminant is *Salmonella*, but this is rendered harmless by the baking process. However, you need to handle raw eggs appropriately to avoid self-contamination (see section 2.5).

Float test in water

- Place the egg in a wide glass or bowl containing cold water
  - A good quality egg will sink to the bottom of the glass of water (Figure 2.4)
  - Discard rotten eggs; do not use them.

Shell integrity and sound test

- Check the shell by eye for cracks
  - Do not use cracked eggs.
- Hold the egg to your ear and shake gently (Figure 2.5)
  - Sloshing indicates the egg is not fresh, but may still be edible—do another test.

Quality assessment after breaking

- Break the egg, without breaking the yolk, carefully pour the albumen onto a saucer or small plate (Figure 2.6)
  - The albumen should be firm
  - Do not use the egg if it spreads thinly.

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

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

Figure 2.4. Egg freshness floatation test.

Figure 2.5. Shake egg beside ear to hear if it "sloshes".

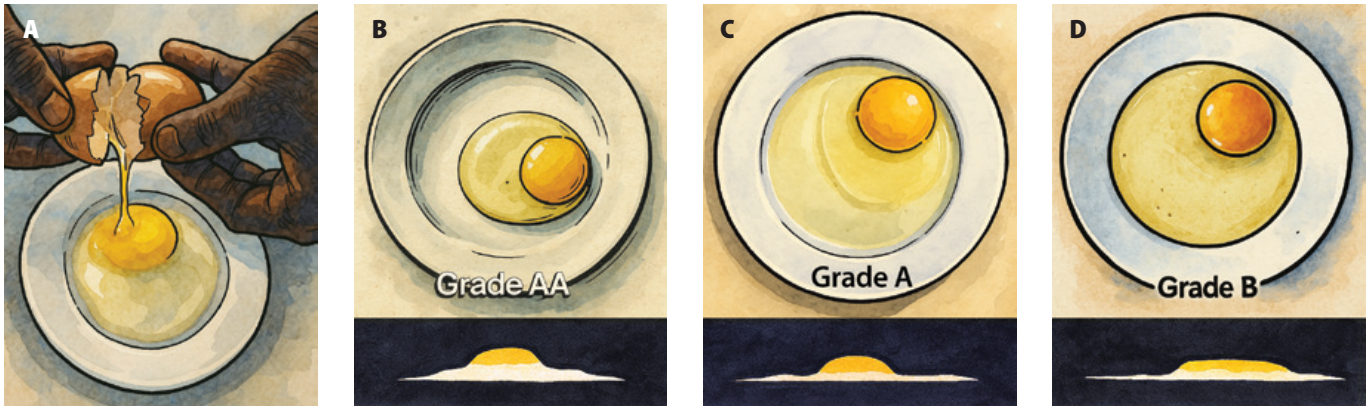

Figure 2.6. Break-out egg freshness test: (a) break egg onto a plate without breaking the yolk; (b) grade AA (fresh) egg; (c) grade A (ageing but edible) egg; (d) grade B (old, not to be used) egg.

2.5 STORAGE AND HANDLING

Storage requirements and environmental controls

Temperature control and monitoring

- Most ingredients should be stored in a cool, dry place
- Maintain dry conditions and good ventilation, which are important for humidity/moisture control
- Use clean, sealed, food-grade containers, clean storage areas regularly, and regularly inspect storage areas to prevent pest intrusion
- Stack and space ingredients appropriately—do not stack ingredients (especially flour) on the floor but on plastic or wooden pallets; leave space for easy inspection and collection adopting first-in, first-out (FIFO) principle
- Keep different ingredients separate from each other
- If not used daily, eggs need to be kept in a refrigerator (about 4°C)
- 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*
- Keep ingredients separate from ready-to-use products
- FIFO system—to ensure all ingredients are used by their best before dates:
  - keep oldest stock at the front of the shelves
  - after checking best before dates, place incoming stock behind older stock.

Handling ingredients and products

- Use clean equipment (scoops, bowls, tongs) for handling ingredients and products
- Prevent cross-contamination:
  - keep raw materials (e.g., eggs) separate from other ingredients and finished products
  - use only designated equipment for each part of the process and clean it thoroughly before use, between uses, and after use
  - maintain a clear workflow—in other words, separate the tasks in the process and ideally have a separate workspace for each task.

2.6 DOCUMENTATION AND RECORD-KEEPING

Record-keeping is important for quality control, traceability, and business management (including proof of compliance).

Maintain the following types of records:

- daily quality check forms for ingredients (with a pass/fail column)
- storage temperature logs (for refrigerators/freezers if used, or ambient temperature checks)
- basic inventory tracking (to support FIFO and reordering)
- cleaning logs (see section 3.6)
- problem reporting (issues with ingredients or storage and corrective actions taken).

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 BCF 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

(continued)

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

Figure 2.7. Ingredient quality checklist.

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.

Figure 2.8. Temperature recording log.

Date (DD/MM/YYYY)	Item	Opening stock (kg or L)	Quantity received (kg or L)	Quantity used (kg or L)	Closing stock (kg or L)	Reorder point
/ /	Cassava flour	150	100	50	200	50
/ /	Wheat flour	500	350	315	535	150
/ /	Yeast					
/ /	Salt					
/ /	Sugar					
/ /	Baking powder					
/ /	Vegetable oil					

Figure 2.9. Inventory tracking template with example data.

KEY MESSAGES

Business protection through hygiene and safety

- **Hygiene failures destroy businesses:** Poor hygiene leads to foodborne illness, product spoilage, customer complaints, and business closure—yet local African bakeries are generally characterized by poor hygiene practices.
- **Worker safety equals operational continuity:** Dry floors, proper ventilation, accessible fire extinguishers and first aid kits, and trained staff prevent accidents that disrupt production and create liability.
- **Protective equipment is nonnegotiable:** Clean aprons, closed shoes, hair coverings, and gloves protect both workers and products—never handle bread with bare hands.

Quality control prevents waste and losses

- **Simple flour tests prevent production failures:** Visual checks, odor and taste tests, moisture compression tests, and float tests for impurities identify substandard flour before it ruins batches.
- **BCF quality specifications:** White color (or yellow for biofortified varieties), odorless with no off-odors, tasteless with no sour taste, pH range 5.8–7.0, and no impurities.
- **Wheat flour strength testing:** Water mixing and compression tests reveal gluten content—high-gluten flour forms a hard, viscous mass indicating proper bread-making strength.
- **Ingredient freshness matters:** Simple tests for eggs (float test, shell integrity, break-out assessment) and visual checks for sugar, baking powder, and other ingredients prevent product defects.

Storage and handling protect investments

- **Poor yeast storage ruins bread quality:** Store yeast at manufacturer's recommended temperature (refrigerated in hot bakery environments) and respect expiry dates—substandard storage is a common cause of poor bread volume in local bakeries.
- **FIFO system prevents waste:** First-in-first-out inventory rotation ensures all ingredients are used before their best before dates, keeping oldest stock at front of shelves.
- **Separation prevents cross-contamination:** Keep raw materials (especially eggs) separate from other ingredients and finished products using designated equipment and clear workflow.

Documentation protects and improves business

- **Records provide proof and traceability:** Daily quality check forms, storage temperature logs, inventory tracking, cleaning logs, and problem reports support quality control, business management, and compliance.

MODULE 3: PRODUCTION FUNDAMENTALS

3.1 INTRODUCTION TO COMPOSITE FLOUR BLENDING, "CASSAVA BREAD", AND DOUGH

Blending BCF into wheat flour

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

Mixing BCF with commercial wheat flour at the bakery level leads to appropriate gluten content adjustment, ensuring quality loaves with good volume. Note, however, that factory blending by wheat millers produces a better, well-blended composite flour than bakery-level mixing.

Quality of source wheat flour and BCF

- The moisture content of BCF must be considered before mixing with wheat flour to ensure the composite flour maintains acceptable overall moisture levels. Low moisture prevents microbial growth and extends shelf life.
- Color:
  - BCF is generally white—a good match for (bleached) wheat flour and therefore not affecting the final product color
  - If yellow biofortified BCF is used, the resulting composite flour will be cream-colored to pale yellow.
- BCF particle size must closely match wheat flour specifications—uniform particle size ensures proper distribution throughout the blend.
- pH directly affects yeast activity and fermentation: optimal pH range is 5.8–7.0 for proper yeast function—lower or higher pH values may reduce bread quality.
- High ash content gives darker flour, which can impair the overall color of the composite flour.
- BCF must have a cyanide content below maximum recommended limits (i.e., 10 ppm)—ensure your supplier does regular tests to ensure food safety compliance. The final blended or composite flour will have very minute cyanide content.
- Ensure wheat flour and BCF are of the right quality (see section 2.3).

Blending process points

- Sift the flours (wheat and BCF) to ensure regular particle size.
- Measure quantities carefully to ensure weight-for-weight replacement at required substitution level (e.g., 5%, 10%).
- Add the flours by turn (i.e., some wheat flour, some BCF, some wheat flour, etc.) into a clean mixing (blending) bowl or machine.
- Mix (blend) the flours thoroughly.
- In the wheat milling or blending factory, it is advisable to mix the BCF and wheat flour at the predetermined ratio after the grinding and separation stages. This way, composite flours of tailored characteristics can be produced for different baked products. Final sieving may then be carried out before packaging.
- Other permitted additives may be added as well.
- Some bread regulations mandate the addition of micronutrients to composite flour (fortifications).

Recipes for bread-making

The essential ingredients of bread are flour, yeast, salt, and water. Most bakers develop their own preferred recipe and use it consistently.

"Enhanced" bread products may also have other ingredients, including sugar, baking powder, colorant, flavoring, improver, and fat/vegetable oil.

One very good thing about substituting up to 10% of the wheat flour with BCF is that **there is no need to change the recipe**. Other than the BCF–wheat flour substitution, keep the same amounts of the other ingredients.

While each baker will likely have their own tried-and-tested bread recipe that they want to maintain, Table 3.1 presents two example recipes.

Table 3.1. Example recipes for basic and "enhanced" cassava–wheat composite-flour breads.

INGREDIENT	BASIC RECIPE	"ENHANCED" RECIPE
Wheat flour (kg)	45	45
BCF (kg)	5	5
Yeast (g)	300	900
Salt (g)	4305	60
Water (liters)	25	30
Sugar (g)	–	80
Baking powder (g)	–	50
Colorant (g)	–	25
Vegetable oil (liters)	–	1

The roles of the ingredients in dough formation and bread-making

- Flour contributes to bread structure and texture (through gluten, and wheat and cassava starches)
- Water hydrates the flour and other ingredients to produce dough
- Yeast activity creates a rise
- Salt enhances yeast activity and taste
- Sugar acts as food for yeast activity and affects browning
- Fat (e.g., vegetable oil) provides texture and affects shelf life
- Baking powder produces carbon dioxide contributing to rise; it can supplement the role of yeast, creating gas (and therefore rise) quicker than the biological process—this is especially useful in pastry and cake products that do not use yeast.

3.2 WATER MANAGEMENT IN COMPOSITE FLOUR

Always add water gradually. This is especially important with untested recipes or when testing a recipe under different environmental conditions (temperature, humidity, etc.).

- Start mixing slowly while gradually adding water.
- Be aware of water absorption by the dry ingredients (especially the flour) and know the visual cues for correct hydration.
- Increase mixing speed (vigor if by hand) slowly as the dough develops.
- Be prepared to use less or more water than stated in the recipe according to the behavior of the dough and the initial moisture content of the flour.

Figure 3.1 depicts normal, under- and over-hydrated dough.

Figure 3.1. Dough hydration: (a) normal; (b)–(c) underhydration; (d) overhydration.

SCIENCE BEHIND THE PRACTICE

The key to successful bread-making with composite cassava–wheat flour is the correct alignment of the different-sized starch granules from the wheat and cassava flours during mixing. This is achieved by adding the water slowly and mixing gradually (slow to fast). The larger starch granules in BCF make the dough harder to work with—they present greater resistance to mixing.

3.3 MIXING AND KNEADING

While mixing by hand (or with a paddle for large batches) can provide perfect bread, the use of electric mixing machines can save valuable time and boost your bakery's capacity.

Vertical mixer

- The commonest type of mixer.
- Also known as a "planetary" mixer, as the beater spins on its axis to reach all parts of the stationary bowl (like a planet orbits around the sun).

Spiral mixer

- Dough hook and mixing bowl move in opposite directions, automatically scraping dough from the bowl surface during mixing.

Using electric mixers

- Use a clean mixer (clean before use if necessary)
- Follow the manufacturer's instructions
- Keep hands and tools away from the moving parts during operation
- Electric mixers have the advantage of precise control of speed
- Disconnect from the power supply after use
- Clean the mixer after each use.

Kneading

- Kneading is an essential part of the broader mixing process
- It distributes the ingredients evenly through the dough
- It develops the viscoelastic dough matrix (gluten network)
- Modern mechanical (electric) mixers also perform the kneading.

Dough quality assessment

- Conduct windowpane test (see Box page 14)
- Check temperature
- Assess texture.

3.4 FERMENTATION MANAGEMENT

Assess fermentation as it is happening

Check:

- Volume increase (Figure 3.2)
  - Check the dough expansion relative to its starting volume
  - The volume of a well-fermented dough usually doubles—a sign that enough gas is being produced by yeast activity
- Texture changes
  - During fermentation, the dough's texture evolves from dense to more airy and elastic.
  - In the early stages, dough appears firm and less pliable; as fermentation progresses, it becomes softer, smoother, and more extensible due to gluten development and gas formation
- Aroma development
  - Fermenting dough develops a noticeable, distinctive aromatic profile (smell)
  - Early on, the smell might be mild and yeasty; as fermentation progresses, it becomes more complex, with hints of sweetness, alcohol, and subtle sour notes arising from yeast and bacterial activity
- Poke test at different stages

  This test helps monitor the fermentation process by pressing a finger gently into the dough.
  - Early stage: The dough springs back quickly and firmly, indicating underfermentation
  - Optimal stage: The indentation springs back slowly but incompletely, suggesting ideal fermentation and readiness for baking
  - Overfermented stage: The dough does not spring back or may deflate, indicating that gas has escaped and the dough structure is weakening.

WINDOWPANE TEST

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, about 4.3 cm in diameter)
- Let it rest for 5 minutes to relax the gluten.

Step 2: Stretching technique

- Slowly stretch it by pulling outward from the center
- Use fingertips to carefully thin the center
- Continue until the dough forms a thin membrane (window).

Step 3: Assessment

Properly developed dough:

- Creates a thin, translucent membrane (window) when stretched
- Stretches without immediately breaking
- Holds shape without tearing
- Shows elasticity (i.e., shrinks back 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 in wheat flour):

- The membrane (window) 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 if the gluten content was not properly balanced during the milling operations
- It should still form a stable membrane (window) without tearing.

Remember

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

Fermentation temperature and time

Temperature

- Temperature affects fermentation rate:
  - The ideal temperature range for fermentation is 20–30 °C.
  - At high temperature (e.g., > 30 °C), fermentation is sped up, but may stop quickly—dough becomes difficult to handle, and bread quality is lost (poor texture, reduced volume, potentially sour taste, and poor aroma).
  - At low temperatures (e.g., 10–19 °C), fermentation times extend considerably, with full fermentation requiring a much longer time, 3–6 hours.
  - At refrigeration temperatures (i.e., 4 °C), fermentation is slowed further—full fermentation takes 8–12 hours.
  - At freezing temperatures (< 0 °C), fermentation stops altogether.

Production planning

- Use slow fermentation to aid scheduling in daily production.

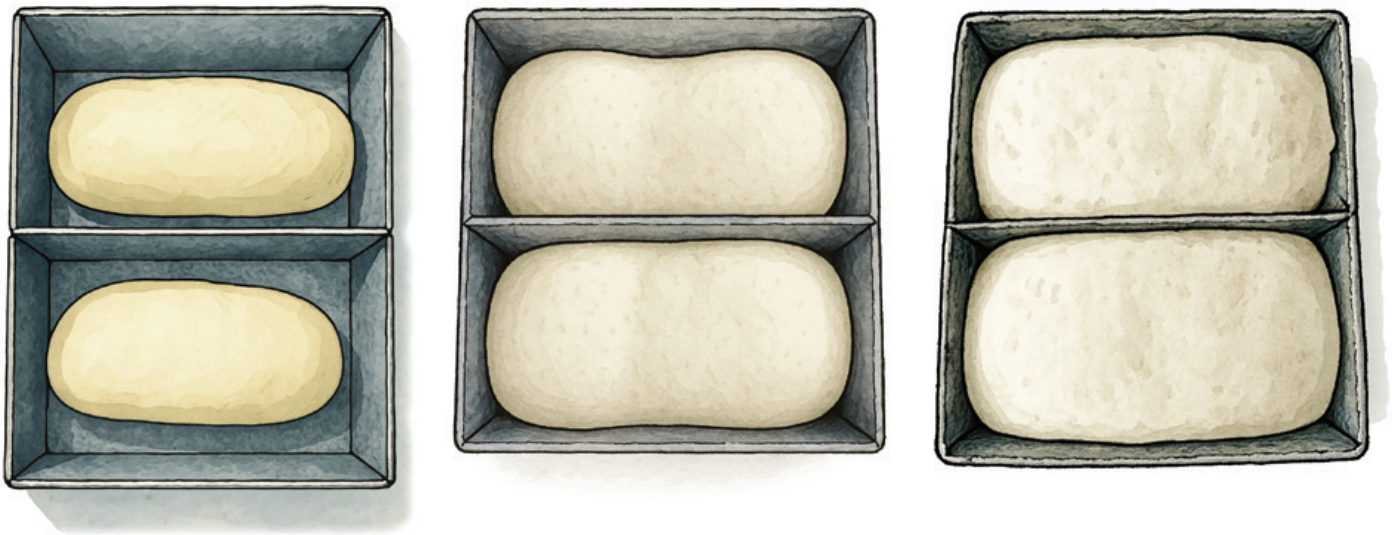

Figure 3.2. Volume increases through fermentation stages.

SCIENTIFIC EXPLANATION

High temperatures initially stimulate the yeast, causing rapid carbon dioxide production and dough expansion. However, this can use up available sugar too quickly, leading to insufficient flavor development and yeast death (as temperatures approach 40–45 °C). Rapid fermentation also compromises dough structure development, as the gluten network has insufficient time to form properly, resulting in bread with poor texture and reduced volume. In addition, high temperatures accelerate enzyme activity, potentially causing excessive starch breakdown and creating overly sticky, difficult-to-handle dough. The accelerated process also increases the risk of overfermentation, leading to a collapsed dough structure, excessive sourness, and poor final bread quality.

USING LOW TEMPERATURES

The extended fermentation timeline can provide certain advantages when properly managed. The slower fermentation allows more complete flavor development through extended enzymatic activity, often producing bread with superior taste complexity. The gradual process also permits better gluten network development, potentially yielding improved texture and crumb structure.

USING SLOW FERMENTATION

Advanced preparation of dough

1. Prepare as many batches of dough as required for staggered production times
2. Retard or delay fermentation through refrigeration (4° C)—at these temperatures, full fermentation will take 8–12 hours
3. If necessary and available, freezing the dough stops fermentation altogether.

Notes on retarding dough

- Refrigeration slows yeast activity but does not completely stop it
- Cold dough needs 30–45 minutes to return to room temperature
- Label batches clearly with mixing time and time of refrigeration.
- In case any challenges arise to continuing the baking process, freezing the dough will stop the fermentation and help to preserve the batch until baking becomes possible.

3.5 BAKING PROCESS

Oven operation

- Properly preheat the oven to the required temperature (200 °C for Nigerian/British bread and 230–273 °C for baguette)
- Load the oven correctly—handle dough with care to avoid dropping, do not bang it on the oven surface
- Monitor during baking (likely 15 minutes)
- Be safe around the oven(s)—ovens are hot:
  - Be aware of hot-air blast upon door opening for loading and unloading—stand to the side out of the main blast path
  - Use suitable (heat-resistant) oven gloves when loading and unloading.

Product quality assessment

Visual indicators

External

- Even color distribution without dark spots or pale patches
- Attractive surface finish that appeals to consumers
- Good glaze or sheen, especially on leavening breads, which indicates proper baking
- Smooth, well-formed shape appropriate to the bread type
- Even surface without cracks, tears, or irregularities
- Proper scoring marks, where applicable
- Clean appearance free from flour residue or baking debris.

Internal

- A variety of bubble sizes throughout the crumb
- Light, airy texture with good volume
- Even crumb structure without large holes or dense areas
- Slightly glossy interior finish (though not every bread should appear wet inside)
- Proper elasticity—the bread should spring back when pressed gently with a finger.

Sensory qualities

Aroma and flavor

Quality bread must have distinctive, appealing aroma and flavor characteristics:

- Evaluate bread aroma before and after breaking it open: the aroma should be noticeable before taking a bite—good bread has an inviting aroma
- Taste:
  - Clean, pleasant taste without sourness or staleness
  - Appropriate flavor intensity for the bread type
  - No bland or flat taste that lacks character.

Texture

- Chew: feels soft and pleasant in the mouth—neither too chewy nor too brittle
- Has appropriate moisture content—not dry or overly moist
- Has good bite characteristics that make eating it enjoyable
- Has consistent texture throughout the loaf
- A major quality of baked foods with cassava–wheat composite flour is that the bread or biscuit does not stick to the palate or teeth, unlike 100% wheat bread—it leaves the mouth clean.

3.6 CLEANING AND MAINTENANCE

Standard cleaning and sanitization procedures and schedules

Rule 1: Disassemble and thoroughly clean all surfaces that come in contact with dough after each shift.

Rule 2: Read the manual to ensure you are completely disassembling all parts of the machine.

Rule 3: Use approved and correct cleaning agents.

Rule 4: Perform a deep cleaning of the equipment at least once a month to sanitize any crevices that might get neglected during routine daily cleaning.

Rule 5: Stock spare parts that undergo significant wear and tear.

Rule 6: Follow a disciplined sanitation schedule and ensure all waste is disposed of properly.

Rule 7: Remember that all bread-making equipment is designed with efficiency and cleanliness in mind; do not break the chain.

Facility cleaning procedures

Daily cleaning required for:

- Bakery area
- Make-up room
- Display areas
- Utensils
- Display cases.

DAILY CLEANING SCHEDULE

	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Cleaning materials		
Date:								*Only use cleaning materials stated below*		
All areas										
Floors								Clean water, disinfectant		
Walls										
Windows/screens										
Store										
Shelves										
Ingredient containers										
Pallets										
Blending										
Work surface										
Mixing box/mixer										
Tools/equipment										
Mixing and kneading										
Work surface										
Mixers										
Utensils										
Equipment										
Fermentation										
Fermentation cabinet outside and inside, including shelves										
Utensils and tools										
Baking										
Ovens outside and inside, including shelves										
Utensils and tools										
– Baking pans										
– Baking trays										
– Oil containers and brushes										
– Baking trolleys/racks										
– Other utensils and tools										
Heat-resistant gloves										
Finishing										
Work surfaces										
Cooling racks outside and inside, including shelves and trays										
Cooling coverings										
Tools/utensils										
Pre-dispatch storage										
Pallets										
Shelves/baskets										
Forklift (if appropriate)										
Display										
Display cabinet outside and inside										
Utensils (tongs, etc.)										
Report any issues to the supervisor or manager										

Figure 3.3. Bakery cleaning schedule template with daily tasks.

Hygiene for bakery surroundings

The environment of bread bakeries is prone to serious infrastructure deterioration, inadequate waste disposal, and other environmental hazards. These hazards pose risks to the bakery staff, the bread consumers, and the bakery neighborhood.

Bakery management must ensure a hygienic environment for bread production by preventing contamination, pest infestations, and environmental hazards. The plan should apply to all nonfood-contact areas surrounding the bakery, including external compound and walkways, waste disposal and refuse areas, drainage systems, firewood depot (if applicable), raw material and bread loading and unloading bays, staff entrances and changing areas, external walls, doors, windows, and vents. There should be cleaning staff to carry out the cleaning activities, a quality assurance officer or bakery supervisor to verify the effectiveness of the cleaning, and access to maintenance technicians to repair cracks, drains, and structural defects. Appropriate cleaning chemicals and tools must be provided. Some of the hazards that require adequate attention include biological, chemical, and physical hazards such as pests (including rodents and insects), chemical residues, waste spills, dust, wood pieces, charcoal, ash from wood ovens, bottles, metal pieces, nylon, broken plastic, and broken glass.

It is recommended that cleaning tools be color-coded and dedicated to external use. Chemicals must be food-grade approved and labeled. Waste bins must always be covered, emptied, and cleaned daily. Waste must not be allowed to accumulate near production areas, and cleaning is to be conducted outside production hours to avoid food contamination.

WEEKLY/DAILY CLEANING SCHEDULE

	Activity	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**	**Sat**	**Sun**	**Cleaning materials and tools**		
Date:									*Use the cleaning materials and tools recommended below according to the bakery's size*		
Area:											
All areas											
Compound and walkways	Weed, sweep, and wash								Clean water, disinfectant	Weeder, sweeper machine, brush, hose, cutlass/machete, hoe, rake, shovel, wheelbarrow, etc.	
Wood storage area	Weed, sweep, and stack wood neatly										
Fuel (diesel, petrol) storage area	Sweep; wet-clean floor, wall, and container surfaces								Detergent, disinfectant		
Generator area											
Waste bins	Clean by scrubbing and disinfecting										
Drains to remove debris	Clean and flush								Detergent		
Loading area	Dry sweep								No chemicals		
Doors and walls	Wipe with a damp cloth								Detergent (mild)		
External structures, including old, unused machines	Cleaning										
Report any issues to the supervisor or manager											

Figure 3.4. Bread bakery external environment cleaning schedule template with weekly or daily tasks.

KEY MESSAGES

Composite flour blending essentials

- **Factory blending is superior:** Wheat millers produce better-blended composite flour than bakery-level mixing, but proper bakery blending techniques ensure quality loaves with good volume.
- **No recipe change needed:** Substituting up to 10% BCF for wheat flour allows bakers to maintain their tried-and-tested recipes—only the water ratio might change, other ingredients remain the same.
- **Quality specifications for blending:** BCF must match wheat flour particle size, have a pH of 5.8–7.0 for proper yeast function, maintain low moisture content, and have cyanide below 10 ppm for food safety.

Water management is critical

- **Gradual water addition prevents failures:** The amount of water required by composite flour blending may differ from that of 100% wheat flour. Always add water slowly while mixing, especially with untested recipes or different environmental conditions—BCF's bigger starch granules create greater mixing resistance.
- **Visual cues guide hydration:** Learn to recognize normal, underhydrated, and overhydrated dough by appearance—adjust water amounts as necessary.

Mixing, kneading, and dough development

- **Electric mixers boost capacity:** Vertical (planetary) and spiral mixers save valuable time compared with hand mixing, with precise speed control and automatic scraping.
- **Windowpane test ensures quality:** This simple test determines proper gluten development—composite flour dough may be slightly less translucent than 100% wheat dough but should still form a stable membrane without tearing.
- **Proper kneading distributes ingredients evenly:** Kneading develops the viscoelastic gluten network essential for bread structure, with composite flour typically requiring longer kneading time.

Fermentation control determines the outcome

- **Temperature dictates fermentation speed:** Ideal range is 20–30 °C; temperatures above 30 °C speed fermentation but compromise quality, while 4–7 °C slows it to 8–12 hours—useful for production scheduling.
- **Poke test monitors fermentation stages:** Early stage springs back quickly (underfermented); optimal stage springs back slowly and incompletely (ready); overfermented dough does not spring back or deflates.
- **Retarding enables flexible scheduling:** Refrigerate prepared dough batches to slow fermentation, allowing staggered production times—cold dough needs 30–45 minutes to return to room temperature.

Baking and quality assessment

- **Proper preheating and loading matter:** Preheat ovens to 200 °C / 230–273 °C, handle dough carefully during loading, and use heat-resistant gloves while standing aside from the hot-air blast. Baking time is approximately 15 minutes.
- **Visual indicators confirm quality:** External—even color, attractive surface, good glaze, smooth shape. Internal—variety of bubble sizes, light airy texture, even crumb structure, proper elasticity when pressed.
- **Composite flour delivers unique benefit:** Cassava–wheat bread does not stick to the palate or teeth unlike 100% wheat bread—it leaves the mouth clean, a major quality advantage.

Cleaning and maintenance protect the investment

- **Daily cleaning prevents contamination:** All surfaces in contact with dough must be thoroughly cleaned after each shift, while the bakery area, make-up room, display areas, utensils, and display cases require daily cleaning.
- **Equipment maintenance follows strict rules:** Disassemble all parts per the manufacturer's manual, use approved cleaning agents, perform deep sanitization of crevices monthly, stock spare parts for worn items, and follow disciplined schedules.
- **Area around the bakery needs to be kept clean:** Weed, sweep, wash, and disinfect all external areas as appropriate. Keep storage areas (fuel, wood, waste) tidy.

MODULE 4:
ADAPTATION TECHNIQUES

4.1 RECIPE SCALING AND ADAPTATION

Understanding scaling principles

The principal rules of scaling are:

- The **proportions** of the dry ingredients (and any oil) in your recipe remain the same
- You may need **more or less water** (proportionally) compared with the original recipe batch size
- Mixing and kneading times may change
- Always monitor progress when testing a tried-and-tested recipe at a different scale and adjust as necessary.

Basic scaling calculations

- If you wish to double the batch size, multiply the weight or volume of all dry ingredients by 2.
- If you wish to make a batch two-thirds of your standard recipe, multiply the weight or volume of all dry ingredients by two-thirds.
- The same idea applies to any batch size: proportions of dry ingredients remain the same.

Quality control in scaling

- Assess and ensure dough consistency
- Adjust hydration (amount of water) to maintain dough consistency
- Verify product weight
  - If you have doubled the recipe, you should obtain double the number of loaves of the standard size and similar quality.

4.2 ADAPTATION TO VARIABILITY IN ENVIRONMENTAL CONDITIONS

Temperature effects (fermentation)

- Dough behaves differently at different temperatures—this is due to the activity of yeast at different ambient temperatures. Yeast optimum temperature is 20–30 °C.
- Adjust water temperature as necessary—this depends on the method adopted by the baker. There are also yeast formulations (types) that function at cold temperatures and those that function at elevated temperatures.
- Adapt fermentation time, if necessary, depending on yeast type and ambient temperature.

Table 4.1. Examples of scaling a basic recipe.

INGREDIENT	BASIC RECIPE	SCALING UP (DOUBLE)	SCALING DOWN (TWO-THIRDS)
Wheat flour (kg)	9	18	6
BCF (kg)	1	2	0.7
Yeast (g)	104	208	69
Salt (g)	101	202	67
Water (liters)	5.5	Have a little more than 11 L available	Have about 4 L available

Note:
- for scaling up, all dry ingredients are increased by the same ratio
- for scaling down, all dry ingredients are reduced by the same ratio
- proportions of dry ingredients remain the same, whatever the batch size
- water requirement will change depending on batch size, so always have a little more than the exact proportion available, but monitor the hydration and dough consistency through mixing and kneading, adjusting the amount of water as necessary.

Monitoring for adaptation to weather conditions

- Measure and record temperature
- Record any water temperature adjustments and their effects on the process
- Note any modifications to fermentation timing.

4.3 INTEGRATING TRADITIONAL METHODS WITH MODERN MACHINERY

The tools and equipment used will depend on the context of the bakery. Over time, a baker may choose to adopt more modern machinery.

"Upgrade" one part of the process at a time—but carefully choose which parts of the process to mechanize and when to upgrade them.

- Weighing
- Mixing and kneading
- Dough handling (dividing, sheeting, molding)
- Fermenting/proofing
- Baking (oven)
- Cooling
- Slicing
- Packaging
- Labeling, including speciality ingredients, allergens, and weight.

4.4 RECORD-KEEPING

Record-keeping is important for quality control, traceability, and business management (including proof of compliance).

Maintain records for:

- Weights and measures
- Ingredient usage tracking, including fortificants or micronutrients used and quantities
- Production parameters (variations, adjustments for environmental reasons, daily production volumes by bread type)
- Ambient, proofing, and baking temperature monitoring
- Product quality check results (see section 3.5 subsection "Product quality assessment")
- Problems arising (see section 5.3).

INGREDIENT QUALITY TESTING RECORD SHEET			
Date:		**Time:**	
Tester (name):		**Signature/initials:**	
Ingredient	**Test**	**Result**	**Pass / Fail**
Wheat flour	Strength (water mixing)		
	Strength (compression)		
	Moisture (compression)		
	Impurities		
	Chalk (HCl)		
	Color		
	Odor/smell		
	Taste		
BCF	Moisture (compression)		
	Impurities		
	Chalk (HCl)		
	Color		
	Odor/smell		
	Taste		
Sugar	Type		
	Impurities (visual)		
Yeast	Viability		
Eggs	Flotation		
	Sound		
	Visual (for cracks)		
	Break-out		
	Odor/smell		
Others			
Supervisor (name):		**Signature & date:**	

Figure 4.1. Ingredient quality testing record sheet.

BATCH TRACKING

Batch ID:		**Date:**		**Time (start):**	
Ingredients*	Recipe	Actual	Initials	Time	
Wheat flour					
BCF					
Yeast					
Salt					
Water					
Sugar					
Baking powder					
Vegetable oil					
Colorant					
Other additives (specify)					
Process parameters					
Ambient temp.					
Mixing time (h:min)					
Fermentation temp.					
Fermentation time					
Baking temp.					
Baking time					
Quality control					
External					
Internal					
Aroma					
Taste					
Specific tests (specify)					
Supervisor:		**Initials:**		**Time (end):**	

* Recipe details should be included in this column as part of the prepared form, prior to printing; "actual" is the actual weights and volumes used for the batch; "initials" are the initials of the baker who completes the form; "time" is for the baker to record the actual, precise timings of steps in the process.

Figure 4.2. Batch tracking for recipe, production parameters, and product quality control.

KEY MESSAGES

Recipe scaling fundamentals

- **Proportions stay constant:** When scaling recipes up or down, all dry ingredients and oil maintain the same proportions—only water requirements may change based on batch size and dough consistency.
- **Simple scaling calculations:** Double all dry ingredients to double batch size; multiply by two-thirds to reduce batch size by one-third—the same principle applies to any scaling ratio.
- **Monitor and adjust water:** Always have slightly more water available than the calculated proportion, but add gradually while monitoring hydration and dough consistency throughout mixing and kneading.
- **Quality control confirms success:** If you have doubled the recipe, you should obtain double the number of standard-size loaves with similar quality—verify product weight and consistency.

Environmental adaptation for consistent results

- **Temperature drives fermentation behavior:** Yeast optimum is 20–30 °C; dough behaves differently at various ambient temperatures, requiring adjustments to water temperature and fermentation timing.
- **Document environmental adaptations:** Record temperature measurements, water temperature adjustments, and fermentation timing modifications to build knowledge for future production under similar conditions.
- **Different yeast types for different conditions:** It may be possible to select yeast formulations designed for cold temperatures or elevated temperatures based on your bakery environment.

Strategic mechanization planning

- **Upgrade strategically, not all at once:** Carefully choose which processes to mechanize and when—weighing, mixing/kneading, dough handling, fermenting/proofing, baking, cooling, slicing, packaging, or labeling.
- **One process at a time:** Upgrading incrementally allows better adaptation and avoids overwhelming operational changes or excessive capital outlay.

Record-keeping builds knowledge and protects business

- **Track production parameters:** Document ingredient usage (including fortificants/micronutrients), variations and adjustments for environmental reasons, daily production volumes by bread type, and all temperature monitoring.
- **Quality control records demonstrate compliance:** Product quality checks and batch tracking provide proof of quality standards and support traceability requirements.
- **Problem documentation prevents recurrence:** Recording problems and their solutions builds institutional knowledge for preventing future issues (see Module 5).

MODULE 5: TROUBLESHOOTING COMMON ISSUES

5.1 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:
   - 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.

5.2 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.

  Solutions:

  - Ensure regular cleaning and sanitization of equipment and surfaces.
  - Enforce strict personal hygiene protocols for all staff including handwashing and protective clothing.
  - Train staff on contamination risks and prevention.

Table 5.1. Symptoms and likely causes

SYMPTOM (PROBLEM)	LIKELY CAUSE(S)
Dense/heavy texture	• Flour strength • Inadequate hydration • Yeast viability • Underfermentation / underproofing • 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: underbaked • Dark: overbaked • 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

- Use proper storage and handling practices for raw materials.

Recipe problems

- Water quality
  - Contaminated water
  - Unhygienic water storage facility.

  Solutions:

  - Use filtered or treated water
  - Clean and cover water storage tanks regularly to prevent contamination.
- Quality of flour and other ingredients
  - Improper ingredient handling
  - Poor storage facility
  - Nonadherence to FIFO principles.

  Solutions:

  - Store ingredients in cool, dry places
  - Implement FIFO inventory to avoid use of expired ingredients
  - Train staff on proper ingredient handling to prevent cross-contamination.

Dough problems

- Water absorption issues:
  - Underhydrated (dry, tough)
  - Overhydrated (sticky, slack).

  Solutions:

  - Adjust water quantity based on flour type and ambient humidity
  - If the dough is too dry/tough, add small amounts of water incrementally
  - If the dough is sticky/slack, reduce water or add more flour gradually.
- Mixing problems:
  - Undermixed (poor gluten development)
  - Overmixed (broken gluten structure).

  Solutions:

  - Mix dough until gluten network develops, but do not overmix (to avoid gluten breakage)
  - Use consistent mixing times and monitor dough texture.

Fermentation issues

- Nonviable or poorly performing yeast as a result of storage in a hot environment or storage beyond expiry date (see Module 2 section 2.5 "Storage requirements and environmental controls")
- Temperature:
  - Too cold (slow fermentation)
  - Too warm (over-fermentation)
- Timing:
  - Underfermented (dense structure)
  - Overfermented (collapsed structure).

  Solutions:

  - Store yeast in cool, dry places and check expiry dates.
  - Maintain dough fermentation temperature between 20 and 30 °C.
  - Adjust fermentation time based on temperature and dough behavior: shorter in warm temperatures, longer when cold.
  - Aim for light, airy dough to prevent density or collapse.

Baking problems

- Ingredient-related issues:
  - Water imbalance (slack, raw-like, wet interior)
  - Inactive yeast (faint aroma, dense, poor volume).

  Solutions:

  - Balance water addition carefully to avoid wet or raw interiors.
  - Use fresh yeast and ensure it is active for proper rise.
- Temperature-related issues:
  - Underbaked (pale crust, doughy interior)
  - Uneven baking (uncooked loaves, overcooked loaves)
  - Overbaked (dark crust, dry interior).

  Solutions:

  - Bake at recommended temperatures (typically 200 °C for Nigerian/British bread and 230–273 °C for baguette) for the right times.
  - Use ovens with good heat distribution or rotate trays to prevent uneven baking.
  - Monitor baking time to avoid over- or underbaking.
- Shape problems:
  - Irregular rise
  - Burst crusts
  - Poor volume.

  Solutions:

  - Ensure proper dough fermentation for even rise
  - Avoid overproofing, which can cause bursts
  - Use correct dough handling techniques to maintain good volume and shape.

Adopting these solutions can greatly improve bread quality, safety, and consistency in baking operations.

5.3 PROBLEM DOCUMENTATION AND PREVENTION

Record-keeping for troubleshooting

- Document (see Figure 6.3):
  - Problem description
  - Observed causes
  - Corrective actions taken
  - Results achieved
- Use records to prevent recurring issues.

Problem-prevention strategies

- Ingredient quality and storage conditions (especially egg and yeast storage temperatures)
- Quality control checkpoints (see sections 2.3 and 2.4)
- Monitoring critical parameters
- Staff training on quality standards
- Adhering to the manufacturer's recommended equipment maintenance schedule.

KEY MESSAGES

Systematic problem identification saves time and money

- **Symptoms reveal causes:** Dense texture, poor volume, uneven crumb, irregular shape, color variations, and abnormal odor indicate specific ingredient or process failures—symptoms guide diagnosis.
- **Production records pinpoint problems:** Check ingredient quality tests and process parameters in documented records to identify likely causes before wasting materials on trial batches.
- **Test solutions methodically:** Rerun recipes with quality-checked fresh ingredients or adjust specific process parameters, then document results, especially successful solutions, for future reference.

Hygiene failures create costly problems

- **Contamination destroys product and reputation:** Poor environmental and personnel hygiene leads to bread contamination and poor aesthetic appeal—enforce strict handwashing, protective clothing, and regular cleaning protocols.
- **Water quality matters:** Contaminated water or unhygienic storage tanks compromise entire batches—use filtered or treated water, and clean storage tanks and their covers regularly.
- **FIFO prevents ingredient failures:** Proper storage in cool, dry places and first-in-first-out inventory management avoid the use of expired ingredients that cause production failures.

Dough problems have clear solutions

- **Hydration adjustments rescue batches:** Underhydrated dough (dry, tough) needs incremental water addition; overhydrated dough (sticky, slack) needs water reduction or gradual addition of extra flour.
- **Mixing time affects structure:** Undermixing causes poor gluten development; overmixing breaks gluten structure—use consistent times and monitor dough texture.

Fermentation control prevents waste

- **Yeast storage is critical:** Nonviable or poorly performing yeast from hot storage or expired stock causes dense bread and poor volume—always store yeast in cool, dry places and check expiry dates regularly and before use.
- **Temperature and timing are interconnected:** Maintain 20–30 °C fermentation temperature; adjust timing based on conditions—shorter in warm temperatures, longer when cold—to achieve light, airy dough.
- **Under- and overfermentation have distinct symptoms:** Underfermented dough produces dense structure; overfermented dough collapses—aim for doubled volume with proper spring-back in poke test.

Baking problems need immediate correction

- **Temperature issues create visible defects:** Underbaked bread has a pale crust and doughy interior; overbaked bread has a dark crust and dry interior—bake at appropriate temperature (200 °C / 230–273 °C) and monitor timing carefully.
- **Uneven baking wastes product:** Use ovens with good heat distribution or rotate trays to prevent uncooked and overcooked loaves in the same batch.
- **Shape problems signal process failures:** Irregular rise, burst crusts, and poor volume indicate fermentation or handling issues—ensure proper proofing and dough handling techniques.

Documentation prevents recurrence

- **Keeping records of problems builds expertise:** Document problem description, observed causes, corrective actions, and results achieved—use records to prevent recurring issues and train staff.
- **Prevention strategies protect profits:** Regular ingredient quality checks, critical parameter monitoring, staff training on quality standards, and adherence to equipment maintenance schedules prevent problems before they occur.

MODULE 6:
BUSINESS AND COMPLIANCE

6.1 COST ANALYSIS AND PRICING

Production cost

- Closely monitor production and record all cost items (per Figure 6.1)
- Calculate costs for one batch, including:
  - Raw materials
  - Labor
  - Utilities
  - Equipment depreciation
  - Taxes and rebates
- Calculate costs for 100% wheat flour bread and composite-flour bread production
- Compare production costs, calculate and document savings achieved
- Compare production costs over time, including for different volumes
- Calculate actual cost savings in cash and percentage terms.

Price-setting

- Use total costs per batch from the previous subsection
- Determine appropriate profit margins
- Set product prices considering (and balancing):
  - Production costs
  - Market rates
  - Customer purchasing power
  - Taxes and rebates
  - Competition.
- Consider running promotions for new products—lower prices (potentially selling at a slight loss to gain market traction).

Financial record-keeping

Use simple templates to record:

- Daily costs
- Sales volumes
- Revenue
- Profit and ROI calculations.
  - ROI = Total benefit (revenue) ÷ Total cost
  - Profit = ROI – 1

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		

Figure 6.1. Cost tracking template with example data.

Date			Amount (US$)
Ingredients used			
Wheat flour	kg	× US$[1]	
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		

Figure 6.2. Daily cost tracking

Note: [1] Or local currency.

6.2 SUPPLIER AND INVENTORY MANAGEMENT

Supplier evaluation

- Assess supplier(s) using:
  - Quality consistency tracking (per Module 2)
  - Delivery reliability records
  - Price stability history
  - Payment terms comparison
- Document supplier performance
- Develop a strategy to work with local suppliers:
  - Relationship-building
  - Your assessment (from above)
  - Develop basic contract terms
  - Handling quality disputes—whether to feed back to the supplier or change supplier in case of problems
- You will likely invest time to work with the supplier if you have developed a good working relationship with them over time
- You are perhaps more likely to move away from a local supplier who lets you down in the early stages of the relationship or repeatedly lets you down later on
- Supply chain risk assessment, for example:
  - Alternative suppliers/supply routes.

Supplier management practice

- Maintain records on your suppliers
- Create one file per supplier
- Set quality specifications
- Develop ordering schedules
- Plan contingency supplies/alternative suppliers
- Pay attention to raw material traceability
- Establish template agreements to work with suppliers.

6.3 FOOD SAFETY AND COMPLIANCE

Daily safety checks

Document daily health-and-safety compliance (per sections 2.1 and 2.2) and food safety actions (sections 2.5 and 3.6):

- Personnel hygiene verification
- Equipment safety and cleaning checks (see Figure 6.3)
- Water quality (potable)
- Temperature monitoring
- Product handling assessment
- Environmental sanitation.

Compliance documentation

Compliance with general health and safety, and food safety requires documentation of:

- Cleaning schedules (see Figure 3.3)
- Temperature logs (see Figure 2.8)
- Quality checks (see Figure 4.1)
- Problem reports (see Figure 6.4)
- Packaging and labeling (with details) (see next subsection)
- Product traceability records
- Customer feedback forms
- Market requirement checklist (related to national and possibly regional standards).

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.

Figure 6.3. Sample equipment safety and hygiene compliance form template.

Label template: Cassava–wheat composite bread

The package must be legibly and indelibly marked with:

- Product name ("Cassava–wheat composite 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.

Date:		Time:	
Problem reported by:			
Problem identified:			
Diagnosis / Identified cause(s):			
Corrective action taken:			
Corrective action taken by (name):		Date/time:	
Results of corrective action:			
Verified by Supervisor (name):		Date:	Time:
Form to be filed once problem resolved and signed off by supervisor			

Figure 6.4. Problem reporting template.

6.4 BUSINESS PLANNING

Production planning

Using your own bakery data:

- Calculate or set daily production targets
- Plan ingredient requirements
- Schedule staff duties
- Document production flow
- Determine seasonal variations in demand (e.g., festivals, holidays)
- Schedule equipment maintenance/replacement
- Plan staff training.

Financial planning

Financial planning requires detailed:

- Monthly cost projections: Estimates of the expected expenses for a business or project for each month, used to plan and control spending.
- Revenue forecasting: Predicting future income or sales over a specific period based on historical data, market trends, and business activities.
- Cash flow planning: Managing the timing and amounts of cash inflows and outflows to ensure sufficient liquidity to meet ongoing financial obligations.
- Basic bookkeeping (in–out cash flows): Recording daily financial transactions, particularly money coming in and going out, to track financial health and support accounting.
- Market research: Gathering and analyzing information about customers, competitors, and market conditions to inform business decisions.
- A marketing plan: A strategic document outlining marketing goals, target audience, tactics, budget, and timelines to promote products or services.
- Competition analysis: Assessing competitors' strengths, weaknesses, strategies, and market position to identify opportunities and threats.
- Customer feedback analysis: Collecting and evaluating customers' opinions and experiences to improve products, services, and customer satisfaction.

6.5 IMPLEMENTATION PLANNING

Develop:

- Action steps for the bakery
- A timeline for changes
- A detailed list of resources needed
- A follow-up plan
- A mentorship arrangement (if desired and feasible)
- Technical support contacts
- Peer learning opportunities
- A list of future training needs.

KEY MESSAGES

Cost tracking proves BCF profitability

- **Detailed cost monitoring quantifies savings:** Track all production costs per batch (raw materials, labor, utilities, equipment depreciation, taxes/rebates) to calculate and document actual cash and percentage savings from BCF substitution.
- **Comparative costing demonstrates value:** Calculate costs for 100% wheat flour bread versus composite-flour bread production, comparing costs over time and at different volumes to show concrete financial benefits.
- **ROI calculations guide pricing:** Use total costs per batch, determine profit margins, and set prices balancing production costs, market rates, customer purchasing power, and competition—consider promotions at lower prices to gain market traction.

Supplier management protects quality and supply

- **Supplier evaluation prevents disruptions:** Track quality consistency, delivery reliability, price stability, and payment terms to assess supplier performance and develop strategic local supplier relationships.
- **Documentation supports decisions:** Maintain one file per supplier with quality specifications, ordering schedules, and contingency plans—invest time with reliable suppliers but move away from those who repeatedly disappoint.
- **Traceability and contracts provide security:** Establish template agreements, pay attention to raw material traceability, and plan alternative suppliers to mitigate supply chain risks.

Compliance documentation protects business operations

- **Daily safety checks prevent closures:** Document personnel hygiene verification, equipment safety and cleaning, water quality, temperature monitoring, product handling, and environmental sanitation daily.
- **Required records demonstrate compliance:** Maintain cleaning schedules, temperature logs, quality checks, problem reports, packaging and labeling details, product traceability records, customer feedback, and market requirement checklists.
- **Proper labeling is mandatory:** Packages must show product name ("Cassava–wheat composite bread"), manufacturer details, brand, manufacture date, ingredients list, lot ID, best before date, net weight, storage instructions, and disposal instructions.

Business planning ensures sustainability

- **Production planning optimizes resources:** Use bakery data to set daily targets, plan ingredient requirements, schedule staff duties, document production flow, determine seasonal variations, and plan equipment maintenance and training.
- **Financial planning requires multiple tools:** Develop monthly cost projections, revenue forecasting, cash-flow planning, basic bookkeeping, market research, marketing plans, competition analysis, and customer feedback analysis.

Implementation planning drives adoption

- **Structured transition reduces risk:** Develop action steps, timelines for changes, detailed resource lists, and follow-up plans to successfully integrate BCF into operations.
- **Support networks accelerate success:** Establish mentorship arrangements, maintain technical support contacts, identify peer learning opportunities, and plan future training needs to continuously improve operations.

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