How effective are laws and regulations in improving food safety and quality?

Research study report

March 2025

Nutrition Research Facility
Knowledge and Research for Nutrition

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Document information

Deliverable	RS 21.007 How effective are laws and regulations to improving food safety and quality?			
Work Package	WP2			
Nature	Report			
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Date of Delivery	**Contractual**		**Actual**	09/12/2024

Document history

Version	**Issue date**	**Stage**	**Changes**	**Contribution**
1.0	09/12/2024	First version		
1.1	14/12/2024		Review	Carl Lachat, Paolo Sarfatti
2.0	24/03/2025	2nd version	Revision	Arlène Alpha, CSRS, ILRI
3.0	27/03/2025			Paolo Sarfatti

Content

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List of Acronyms

Acronym	Description
AfCFTA	African Continental Free Trade Area
AU	African Union
Cirad	Centre de Coopération Internationale en Recherche Agronomique pour le Développement
CODINORM	Côte d'Ivoire Normalisation
COI	Conflicts of Interest
CSRS	Centre Suisse de Recherches Scientifiques in Côte d'Ivoire
DALYs	Disability-adjusted life years
DPVCQ	Direction de la Protection des Végétaux et du Contrôle Qualité
DSV	Direction des Services Vétérinaires
ECOWAS	Economic Community of West African States
EU	European Union
FERG	Foodborne Disease Burden Epidemiology Reference Group
HICs	High-Income Countries
ILRI	International Livestock Research Institute
KDB	Kenya Dairy Board
KEBS	Kenya Bureau of Standards
LMIC	Low- and Middle-Income Countries
MAG	Mesophilic Aerobic Germs
MRL	Maximum Residue Limits
MTE	Metallic Trace Elements
NRF	Nutrition Research Facility
PAH	Polycyclic Aromatic Hydrocarbons
SPS	Sanitary and Phytosanitary Measures
SRA	Sulphite-Reducing Anaerobes
SSA	Sub-Saharan Africa
STEC	Shiga Toxin-Producing Escherichia Coli
TC	Total Coliforms
THC	Thermotolerant Coliforms
UFC	Unité Formant Colonie
WAEMU	West African Economic and Monetary Union
WHO	World Health Organisation
WTO	World Trade Organisation

Executive summary

Background

Food safety is essential for nutrition as foodborne diseases and malnutrition are linked in a vicious cycle. Fresh fruits, vegetables and animal source foods are often contaminated in low- and middle-income countries (LMICs) by microbiological and chemical hazards due to inadequate hygiene practices and industrialised agri-food systems (pesticides, heavy metals, antimicrobial residues linked to resistance to antimicrobials). While laws and regulations are effective in high-income countries (HICs) to ensure public health, their effectiveness is questioned in LMICs given the high levels of contaminants in food, often exceeding statutory limits. Using an original analytical framework, which combines policy analysis and political economy of food chains, this research study aims to answer the question: how effective are laws and regulations in improving food safety and quality? The study focusses on fresh fruits and vegetables and processed fish in Côte d'Ivoire and milk in Kenya, which are of critical socioeconomic importance. The assessment of the food safety of these products gives a first indication of the effectiveness of the current laws and regulations in ensuring safe foods. Different aspects of the regulatory framework are then analysed to understand what the barriers to effectiveness are: the way laws and regulations are designed, issues of coordination in their implementation, and enforcement capacities.

Methods

Data collection and analysis consisted of i) an assessment of microbiological and chemical contaminations of the targeted products, ii) an analysis of the regulatory texts relevant for these products, and iii) a qualitative analysis of the main barriers to effective laws and regulations. The main microbiological and chemical hazards and safety risks were identified through a systematic literature review in Kenya and lab analyses in Côte d'Ivoire of 540 samples collected from markets in three communes of Abidjan. The regulatory texts were identified from a bibliographic search and through interviews with key informants. A stakeholder mapping was built to identify the main stakeholders and institutions involved in food safety, their roles and responsibilities, interests, influences and their interactions. The qualitative analysis consisted of 3 expert committees (research, private sector and public actors) and 30 key informant interviews in Côte d'Ivoire; one expert workshop, 10 focus group discussions, 11 key informant interviews and a multi-stakeholder workshop in Kenya.

Results

Microbiological and chemical contamination assessment

Hazard assessment in Côte d'Ivoire based on samples analyses

- All samples of fruits were highly contaminated with most of the germs counted (mesophilic aerobic germs (MAG), total coliforms (TC), thermotolerant coliforms (THC), yeasts and moulds (YM). Mango samples were the most contaminated with TC and the highest load of THC was observed on the surface of avocado.
- All samples of eggplant, okra and tomato and most samples of onions were contaminated with germs (MAG, TC, THC, YM), and some samples were contaminated with coagulase-positive *Staphylococcus aureus*, with okra having the highest contamination and some samples contaminated with *Escherichia coli*.
- All smoked sardine samples and most samples of braised carp, smoked mackerel and fried tuna contained MAG, TC, THC and YM, with loads in smoked sardine and mackerel above the national standards. These products were also contaminated with *E. coli* and coagulase-positive *S. aureus* above national standards.
- Avocado, eggplant and okra samples, and fish samples (especially fried tuna) contained mercury but below the European Union (EU) regulations. Arsenic was detected in some smoked sardine samples at very high concentration, above the Codex Alimentarius standard. Polycyclic aromatic hydrocarbons (PAHs) due to the

use of Hevea for drying and smoking were detected in most fish samples, with highest concentrations in smoked sardine and fried tuna, far above the national and EU regulations.

- 13 pesticide residues were detected in fresh fruits and vegetables samples, with chlorpyrifos methyl and deltamethrin in all onion samples and the highest concentrations in okra, but below the EU Maximum residue limits (MRLs), except fipronil in okra. Two pesticide residues were detected in fish, with deltamethrin content in smoked sardine and mackerel exceeding the Codex MRLs.
- The results of the risk assessment revealed that the probability of consuming fresh fruits and vegetables contaminated with coagulase-positive *E. coli* and *S. aureus* exists but remains low because the rate of samples contaminated with these pathogenic germs was low. For chemical contaminants, given that the frequency and quantities consumed of the foods that were contaminated above standards are low the hazard quotients were less than 1, meaning that the risk of the hazard manifesting is low. The contaminations are mainly due to inadequate conditions of production, storage, transportation, processing and distribution.

Hazard assessment in Kenya based on literature

- Most studies reported indicators of the presence of hazards rather than hazards themselves. There was no study assessing the impact of hazards on human health. Studies mostly reported on pathogens that are easy and inexpensive to detect but not necessarily most important for foodborne diseases while other hazards have a significant health burden (e.g. viruses) but are difficult to study remained neglected.
- The five most reported biological hazards were: *S. aureus*, *Pseudomonas* spp., *Shigella* spp., toxigenic *E. coli*, *Salmonella enterica,* the first being a typical indicator of poor, unhygienic handling of milk and dairy products, including the use of unhygienic water.
- Four types of chemical hazards were reported: aflatoxins, antimicrobial residues, hydrogen peroxide and formaldehyde (the latter two are deliberately added to milk to prevent spoilage).
- Most raw milk samples were contaminated but boiling reduces the risk of contamination; however, not all pathogens are killed in case of inadequate boiling or re-contamination, and bacterial toxins are reduced but not eliminated by boiling. Formal sector pasteurised milk is sometimes contaminated indicating a breakdown of quality control (due to re-contamination and/or failure in the pasteurisation process) and regulation. Although the level of contamination is lower than raw milk, the risk to human health may be higher as these products are considered to be safe (often drunk without boiling).
- While there is strong concern about aflatoxin and antimicrobial residues (AMR), they do not represent a high risk for human health (AMR, although an enormous public health problem, has little direct impact on human health following ingestion, and while the aflatoxin found in milk is a carcinogen “the dose makes the poison” and the levels present in milk are not sufficiently high to make it a priority hazard). Conversely, the most dangerous and frequent chemical hazards in milk globally, dioxins and heavy metals, were not studied.

Regulatory frameworks

In Côte d’Ivoire

- A series of general acts organise the institutional landscape, and specific acts exist related to animal and plant products. A National Food Safety Policy is under preparation, with a strong export focus.
- The institutional landscape includes different ministries responsible for specific aspects of food safety (Agriculture, Animal resources, Commerce and Industry, Health, Education): phytosanitary controls, sanitary inspection, sanitary policy, health certificates, training. Local authorities have also hygiene services in charge of controls.
- Laws and regulations for animal products are more updated than those for plant products. The most recent Decree that sets mandatory standards for a list of food items sold on the domestic market, mostly by

referring to Codex Alimentarius standards, does not include fresh fruits and vegetables. Existing Ivorian standards for these products are voluntary.

- While fresh fruits and vegetables for export are controlled by export companies (internal quality system), the Ministry of Agriculture at borders and importing countries, those for the domestic market are much less controlled.

In Kenya

- The country has a comprehensive set of policies, laws, regulations and institutions for milk safety, refined over decades and regularly updated. A National Food Safety Policy has been developed in 2013.
- However, there is lack of alignment between the growing body of regulations and the largely informal dairy sector being regulated.
- Several acts organise food safety in relation to milk production and products under different ministries: Health, Agriculture, Livestock and Fisheries, Commerce.
- The recent 2021 Dairy Industry Regulations are a set of regulations aiming at structuring the milk and dairy value chains, that require the formalisation of economic operators, licenses, payment of fees and traceability instruments. Milk must be pasteurised and refrigerated; farmers must be paid a guaranteed minimum price for their milk. The 2024 Dairy Industry Bill under discussion has a similar approach.

Actors of the targeted food chains

In Côte d'Ivoire

- Fruit chains have been historically promoted for export. Large intensive exploitations (e.g. dessert banana) or small-scale farmers (e.g. mango) often use certification to guarantee sustainable or organic production. When fruits from these exploitations are sold on domestic market (due to alterations), contamination may not be related to production but to subsequent stages of the value chains (storage, transportation, etc.).
- Vegetables are mostly grown by small-scale farmers for the domestic market using chemical pesticides.
- Processed fish is mostly produced for the domestic market by small-scale business operators from the informal sector (in majority women), using artisanal methods that are often unsafe.
- The standardisation process led by the national standardisation organisation is in principle inclusive. However, not all actors from the private sector are able to participate and standards mainly reflect the interests of those involved, i.e. formal enterprises, while informal operators are poorly considered.

In Kenya

- The milk sector is characterised by many stakeholders who are not well organised or coordinated, which makes it difficult to implement traceability and quality systems.
- Most milk is produced by smallholder farmers and handled through the informal markets, which do not fully comply with laws and regulations. The formal sector is supported by the government and benefits from a positive image, but also faces contamination challenges and has the means to escape compliance with laws and regulations. Semi-formal sector traders do not comply with all regulations but may comply with some.
- A few large processors dominate the market. They are easier to monitor and regulate, have a traceability system but lack of competitiveness with the informal sector means they operate at around 50% of capacity.
- Actors who supply most of the milk in Kenya and supply relatively more to more vulnerable populations (small farmers, informal traders) have low influence on food safety; those who supply less milk and who supply mainly to richer and less vulnerable people (formal large processors) have high influence and push for formalisation and pasteurisation.

Barriers to effectiveness of laws and regulations

In Côte d'Ivoire

- A lack of enforcement due to limited human, financial and logistical capacities from public authorities, which results in few controls, slowness of lab analyses, and a lack of communication to the general public.
- The absence of Ivorian mandatory standards and explicit reference to Codex Alimentarius standards for fresh fruits and vegetables in the current regulations.
- The lack of capacities of informal operators in the fish sector to comply with stringent mandatory food safety standards.
- The challenges in coordinating competent authorities due to perceived risk of competition, which could explain why the project of implementing a national food safety agency has failed and ended up with the creation of a coordination unit within a public laboratory.

In Kenya

- The lack of coordination and coherence of too many regulations and policies that are largely based on that of HICs and made in the absence or contradictory to evidence on the public health benefits for regulations and with little regard to the cost of compliance.
- The lack of enforcement due to lack of public resources and the large number of informal small businesses. Too many licences and cost of compliance haver perverse effects in incentivising actors to avoid compliance.
- Milk is not rewarded for quality and quality-based payment schemes have not been financially sustainable.
- Conflict of interest between profit motivation and cost of compliance.
- Competition between the formal sector which has the capacity to comply but also evade full compliance, and the informal sector which lacks capacity to be fully compliant and of benefits from compliance.

Discussion

The two countries feature similar challenges that are consistent with what is found in the literature:

- A low effectiveness of current laws and regulations to improving food safety and quality, as confirmed by the unsatisfactory quality of the targeted foods products.
- Weak state capacities to enforce laws and regulations.
- Lack of evidence on the health benefits of laws and regulations and lack of consideration of alternative options for obtaining public health benefits (e.g. boiling milk instead of pasteurising).
- A lack of coordination among food control institutions which tends to be addressed by efforts to set one single authority for intersectoral coordination.
- Difficulties for informal sector actors to comply with laws and regulations because of the costs of compliance. This reflects the lack of data on such costs and of inclusiveness of these actors and consideration of their specific constraints in the design of laws and regulations.

Conclusions and policy recommendations

Overall, the research study advocates for a new approach of food safety laws and regulations in Kenya and Côte d'Ivoire which focusses on the informal sector and the domestic market:

- Designing food safety laws and regulations in a more inclusive and gradual process (staircase rules and standards) adapted to the capacity of the informal sector. Laws and regulations should be based on health risk rather than presence of hazards as is the current approach. Regulatory impact assessment should be conducted to minimise burden of regulations and unwanted consequences.

- Using other policy instruments than laws and regulations, that could rely on public and private investment: delivery of infrastructures (low-carbon electricity, sanitation, waste disposal, storage, transportation); low-cost technological solutions (smoking ovens, innovative containers for milk, ICT for traceability, etc.) with improved access to finance for small-scale operators; incentives to reward quality; training; support of the structuration of food chain actors; sensitisation and education to food safety.

1 Introduction

1.1 Food safety, a major public health concern

Food safety is a major public health issue and **a growing political priority globally**. The burden of unsafe food in low- and middle-income countries (LMICs) is comparable to the global priority diseases such as malaria, HIV/AIDS, and tuberculosis. Its economic costs are estimated as more than 100 billion USD per year (Havelaar *et al*., 2015; Jaffee *et al*., 2019). However, investments in improving food safety globally are significantly inferior to the ones for these priority diseases. Foodborne diseases have only recently gained the attention of development institutes and initiatives (Grace, 2023; Grace *et al*., 2024). This increase in prominence can be explained by the fact that food safety contributes to several major global agendas: the development of prevention in public health, with a push to prevent the emergence and spread of communicable diseases (Le Moli *et al*., 2022); the One Health approach, that puts an emphasis on issues at the intersection of agriculture, health, and the environment; and the food system approach (FAO, 2023). The priority given to food safety is also reflected in the regional political agenda, particularly within the African Union (African Union, 2021).

The epidemiology of foodborne diseases is complex and not thoroughly documented. The most authoritative body in this domain is the Foodborne Disease Burden Epidemiology Reference Group (FERG), established in 2007, a technical advisory group that advises the World Health Organisation (WHO) on the methodology to estimate the burden of foodborne diseases[1]. This burden is difficult to quantify because few foodborne infections are identified, reported and analysed as causes of illness. The most common **bacterial infections** do not require hospital treatment but will likely become more severe with the rise of antimicrobial resistance. They can cause a wide range of pathologies, with diarrhoea as the most common illness, but can also have long-term health issues such as cancers. **Chemical contaminants**, on the other hand, have long-term and sometimes indirect effects, and it is difficult to trace a clear causal link between exposure to a pollutant and a disease, for example between a carcinogenic pesticide and cancer.

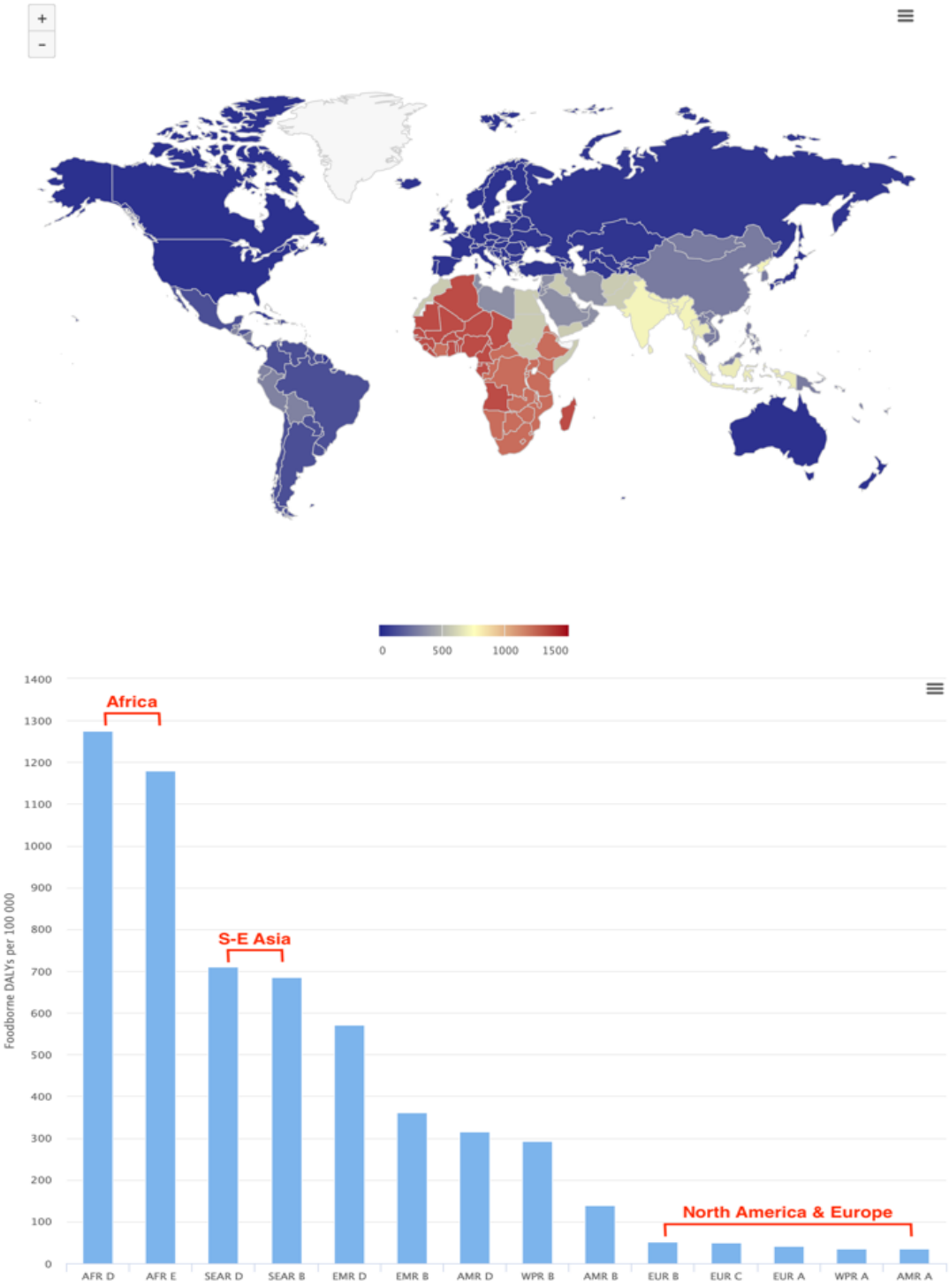
Hazards and contaminants can be found all along the food chains. They can be microbiological, related to inadequate hygiene practices, or increasingly chemical, due to the industrialisation of the agri-food systems in LMICs (pesticides, heavy metals, antimicrobial residues with the growing resistance to antibiotics, antifungals, etc.). Consumer traditional risk mitigation practices (such as boiling milk) that were effective to decrease microbiological contamination related to traditional agri-food systems are no longer adapted to emerging risks related to industrial agri-food systems (Figuié, 2019; HLPE, 2017).

Although the safety of food has emerged as an important public problem in high-income countries, **the burden is much higher in LMICs** (WHO, 2015), where food safety policies are significantly less developed. The loss of Disability-adjusted life years (DALYs) per 100 000 people is estimated to be between 35 and 50 for North America and Europe, 1200 for sub-Saharan Africa (25-35 times higher) and 700 for South-East Asia (15-20 times higher)[2].

[1] FERG - FoodborneDiseaseBurden.org

[2] Source: https://www.foodbornediseaseburden.org/ferg/estimates.

Figure 1. Estimation of foodborne DALYs (all pathogens combined) per 100 000 people



Source: Foodborne Disease Burden Epidemiology Reference Group, foodbornediseaseburden.org.

Unsafe foods also perpetuates a **vicious circle of foodborne diseases and malnutrition**, especially on children under 5 years of age: it increases their vulnerability to diseases from unsafe food, which weakens them and reinforces their malnutrition, with lasting impacts on their development (Havelaar *et al.*, 2015; HLPE, 2017). There is also evidence of an association between aflatoxin exposure in children and stunting (Gong, 2002; Rasheed *et al.*, 2021). While the consumption of food items such as **fresh fruits and vegetables and animal**

source foods (in moderation) are recommended for healthy diets, they may lead to foodborne diseases when they are contaminated by pathogenic bacteria or chemicals. Food safety concerns – real or perceived by consumers – might also negatively influence dietary behaviours as they may reduce consumption of these food items and increase consumption of starchy staples and ultra-processed foods (Liguori *et al*., 2022). Ensuring food safety is therefore critical to avoid such **trade-offs between safe and nutritious foods**.

1.2 Different dimensions of the effectiveness of food safety laws and regulations

This research study assesses the effectiveness of laws and regulations for food safety. This issue is important because most approaches by international organisations to improve food safety start by strengthening the framework of laws and regulations, which also tends to be the unique policy instrument for food safety. To assess the effectiveness of such policy instrument, we clarify below the different aspects of food safety (how food safety is framed), then unpack what effectiveness entails in this field, and we present the main rationale of laws and regulations.

Food safety is complex as it **includes several goals**. It is defined by the Commission of the Codex Alimentarius – the intergovernmental organisation founded jointly by FAO and WHO in 1961-1962 to set standards for food safety –, as the "*Assurance that food will not cause adverse health effects to the consumer when it is prepared and/or eaten according to its intended use*" (FAO and WHO, 2023). Internationally adopted food standards and related texts produced by the Codex Alimentarius *"aim at protecting consumers' health and ensuring fair practices in the food trade"*[3]. This illustrates that the goals associated with food safety are multiple: **public health**, the fluidity of **international trade**, and the **protection of countries** against the importation of pathogens.

The notion of effectiveness of laws and regulations can be conceptualised in different ways. A legal document cannot be effective in itself, but only as an instrument for the action of institutions, stakeholders, and individual actors. Laws and regulations are policy instruments that aim to steer actors' behaviour with rules and sanctions. A first possible understanding of their effectiveness is the level of **compliance** with what they prescribe. Furthermore, laws and regulations have a political legitimacy but always coexist with other normative systems among stakeholders and are potentially debated. As such, their effectiveness can also be understood as the level of **acceptance** and endorsement by stakeholders, which has a direct translation into political and economic costs. Finally, laws and regulations are set to reach a societal outcome, here the safety of food products to protect consumers' health. Their effectiveness has also to be assessed in the light of this outcome.

Following WHO and FAO recommendations, governments often seek to improve food safety by using laws and regulations that make standards mandatory. **Global standards set by the Codex Alimentarius** to regulate products and practices quality can be qualified as "maximalist" in the sense that their goal is to ensure food safety for consumers in all countries, regardless of their purchasing power and health issues. Although not mandatory - i.e. binding international treaties, the Codex standards carry an important legal value in international trade. Non-compliance with Codex standards can be used as an argument to lawfully restrict importations under the World Trade Organisation (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (SPS). In addition, in line with WHO and FAO recommendations, national regulatory frameworks are usually based on Codex standards. This approach has been **effective in high-income countries**, where the incidence of foodborne diseases is low. However, its **effectiveness is questioned in LMICs** given the persistent high level of foodborne diseases and of contaminants in food, often exceeding statutory limits. Consequently, there is a need to rethink the relationship between food safety laws and regulations on the one hand, their impact pathways and their embeddedness in broader policy strategies on the other hand.

[3] General Principles of the Codex Alimentarius | CODEXALIMENTARIUS FAO-WHO

This study aims to answer the research question: ***how effective are laws and regulations in improving food safety and quality?*** It will help fill research gap on the topic of food safety laws and regulations in LMICs by using **an original analytical framework, which combines policy analysis and political economy of food chains**. A legal approach focussing on the content of regulatory texts and on institutions responsible for enforcing the law, aimed to highlight the gaps and overlaps in the system, is useful but not sufficient. Understanding the effectiveness of laws and regulations requires a broader approach that encompasses not only the notion of enforcement, which is costly and hardly sustainable in isolation, but also notions of acceptability, adherence, commitment, legitimacy, knowledge, that express the ways the different stakeholders engage with the laws and regulations.

Policy analysis, understood as the sociology of policy processes, is well suited to this task. It highlights the **interplay of actors** involved in the design and implementation process of laws and regulations and their points of view on their own **interests**, by who and for whom the laws and regulations are drafted, and how stakeholders interact, align, or compete. Three phases in policy making are distinguished, not to present a linear process but to provide a structured approach for the analysis: i) **agenda setting**; ii) **formulation** of laws and regulation; iii) **compliance** with laws and regulations. This approach allows to question how food safety problems are identified and put into discussion for public action; how consultation with food chain actors is organised, who the most **influential** actors are; how intersectoral coordination is organised; and what the state capacities for enforcement and the dissemination of information are. By looking at the configuration of business operators in each food chain, political economy helps to understand the **capacity** of these actors to ensure compliance with laws and regulations, their resources, **motivations** and **incentives** to do so.

1.3 Diverse case studies in Côte d'Ivoire and Kenya

The study focusses on **fresh fruits and vegetables and processed fish in Côte d'Ivoire** and **milk in Kenya**. While rich in nutrients such as vitamins, minerals and fibres for fresh fruits and vegetables (Keatinge *et al.*, 2011; Schreinemachers *et al.*, 2018) and protein for animal-source foods, these products are the leading cause of FDB in sub-Saharan Africa (SSA) (Aworh, 2021; Grace, 2015). Pathogenic bacteria, viruses and chemical contaminants, such as pesticide residues, are the primary agents of foodborne diseases associated to fresh produce in SSA (Aworh, 2021). Fish is the main source of animal protein for the Ivorian population (Toe, 2018; Monney *et al.*, 2020; Dagnogo *et al.*, 2022) but may also be unsafe due to microbiological and chemical (e.g. heavy metals) contaminations. In Kenya, the consumption of milk is among the highest in Africa (Blackmore *et al.*, 2015). Raw milk is the most popular - because it is cheaper and more accessible than pasteurised milk - and offers significant nutritional value to poor consumers. However, milk is prone to contain or be contaminated with hazards and children are especially susceptible (Mutie *et al.*, 2024).

All targeted food chains have a critical socioeconomic importance in both countries. Côte d'Ivoire is a major exporter of fruits such as dessert banana and mango (Kouamé et Agnini, 2022; MINADER, 2017; PADFA, 2022). The vegetable chain is also important as an income-generating activity for almost 60% of women and youth in rural, urban and peri-urban areas (Bancal et Tano, 2019). Most business operators in the fresh fruits and vegetable and processed fish chains are small operators in the informal sector using traditional farming practices and artisanal processing methods. In Kenya, the dairy sector contributes about 12% to the agricultural GDP (4% of the national GDP) and similarly mostly comprises small-scale actors from the informal sector.

Based on case studies in Côte d'Ivoire and Kenya, this research study assesses the effectiveness of food safety laws and regulations by firstly assessing the level of microbiological and chemical contamination of the targeted products as an indicator of the capacity of laws and regulations to ensure safe foods and protect consumers' health. Secondly, the current food safety regulatory framework is analysed in the two countries. Thirdly, we identify the main barriers to its effectiveness and policy recommendations for improvements.

This present study is supported by the Nutrition Research Facility (NRF) within the Knowledge and Research for Nutrition project supported by the European Commission (2020-2026), which aims to provide improved knowledge and evidence for policy making processes in nutrition. The research question emerged from a **consultative process** organised by the NRF team with decision makers and other stakeholders involved in nutrition policy making in Anglophone East Africa and Francophone West Africa and the Sahel in April-June 2021. Among these countries, Cote d'Ivoire and Kenya were selected by the NRF team based on the interest expressed by the representatives of these countries during the consultations, and the wish of the NRF team to select both Francophone and Anglophone countries. The aim of the study is ultimately to provide insights to decision-makers on the effectiveness of laws and regulations to improve food safety and quality. The study was conducted by a multi-disciplinary research team (food sciences, microbiology, biochemistry, food technology, nutrition, sociology, political economy) involving Centre de Coopération Internationale de Recherche Cirad (coordinator), International Livestock Research Institute (ILRI) in Kenya and Centre Suisse de Recherches Scientifiques in Côte d'Ivoire (CSRS).

2 Methodology

The methods for data collection and analysis consisted in both countries of i) an assessment of microbiological and chemical contaminations of the targeted products; ii) an analysis of the regulatory texts relevant for these products, and iii) a qualitative analysis of the main barriers to effective food safety laws and regulations.

The method used to assess microbiological and chemical contaminations differs slightly between the two countries. In Kenya, a systematic literature review (details are provided in Annex 1) was conducted given the extensive literature on milk food safety. In Côte d'Ivoire, the literature on food safety in fresh fruits and vegetables was less abundant and research gaps existed regarding fish locally processed. Lab analyses were conducted to assess the safety of a selection of food items based on their significance in household food consumption: the top four most consumed fresh fruits (dessert banana, mango, orange, avocado), fresh vegetables (onion, eggplant, tomato, okra) and the top four most consumed processed fish (locally smoked sardines, smocked mackerel, braised carp, fried tuna - commonly named *garba*) in Abidjan[4].

The CSRS collected 540 samples of the targeted fresh fruits and vegetables and fish products (see the sampling protocol in Annex 2) on wholesale markets in three contrasted demographically and socioeconomically communes of Abidjan (Yopougon, Abobo and Adjamé)[5]. The most frequent varieties of fresh fruits and vegetables found on markets were collected (e.g. Kent variety – used for export but found in the domestic market when non-exported, and local variety for mango; Cavendish and Conakry varieties for dessert banana). Both microbiological and chemical contamination of the same matrices of fresh fruits and vegetables and processed fish was assessed. In the absence of Ivorian and Codex microbiological criteria for fresh fruits and vegetables, the Canadian standards were used. It was not possible to use the European standards because only

[4] The most consumed fresh fruits and vegetables in Abidjan were identified based on data from the Institut National de la Statistique (INS). (2022). *Enquête Harmonisée sur le Conditions de Vie des Ménages 2018-2019*. World Bank, Development Data Group. https://doi.org/10.48529/8WH3-BF40. We also used the statistical analyses run by Tomoé Bourdier (CIRAD) within the framework of the Project "Strengthening African Food Systems in the face of Food Insecurity and Climate Change" coordinated by CIRAD with the support of the ERA-NET Cofund FOSC No. 862555 (https://www.safoods.org/). The identification of the most consumed fish relied on CSRS knowledge, who has an extensive expertise in this sector.

[5] Exploratory surveys led to select wholesale markets rather than retail markets to ensure samples are most likely to be of local origin. However, consumers are used to buy their foods on these markets. In addition, the role of supermarkets is considered marginal in the distribution of fresh food products (Lançon et Boyer, 2019). Yopougon is the largest commune in Abidjan, with the highest population density, and its population is middle income. Abobo is the 3rd largest commune in Abidjan, with the 2nd highest population density, and its population represents the lowest income groups. Adjamé is a small commune with a low-income population and a large market where all socio-economic groups go to purchase foodstuffs.

the Canadian standards indicated values for all germs counted[6]. Existing Ivorian mandatory standards and Luxemburg standards were used for the microbiological analyses of fish samples. Chemical analyses used the European standards as the reference for most fresh fruits and vegetables in addition to the Codex 193-1995 standard in the absence of Ivorian criteria. Existing Ivorian microbiological and chemical criteria were used for the analysis of the fish samples. The health risk to consumer of consuming highly contaminated food was also estimated. Microbiological analyses using traditional bacteriological methods were carried out by the CSRS in their accredited lab infrastructures and. Chemical analyses (pesticide residues, heavy metals and polyaromatic hydrocarbons) were performed by an external accredited lab, ENVAL.

The regulatory texts were identified from a bibliographic search on Ministries' websites and legal texts databases (e.g. FAOLEX) and through the interviews with key informants. The analysis relied on a simple grid that includes their date, scope, the competent authority responsible, and the main objective. A stakeholder mapping was built to understand what the main institutions and stakeholders in the food safety system are, who is doing what, how the administration and private actors are organised for the compliance with laws and regulations.

The qualitative analysis was based on semi-structured interviews with key informants and consultative workshops. In Côte d'Ivoire, the method of collective expertise[7] for the consultative workshops was used in continuation with a previous study on food safety (Montet *et al*., 2017). Three expert committees were organised in April 2023 with the following experts: i) researchers (23 participants), ii) representatives of the private sector and technical and financial partners (16 participants), and iii) public actors from ministries and state agencies (17 participants). The objective of each expert committee was to collect information on the main safety risks associated with the consumption of fresh fruits and vegetables and fish, the relevant regulatory texts, the main barriers to their effectiveness and recommendations to overcome these barriers. These expert committees were complemented by 30 key informant interviews (KIIs) conducted from March to December 2023 to identify the main actors involved in the design and implementation of laws and regulations, to characterise their roles and understand their views on the main barriers and drivers of the effectiveness of laws and regulations.

In Kenya, a workshop with dairy experts was held on 12 February 2024 in Nairobi, which goal was to identify the stakeholders of the dairy value chains, their power, relationships, and strategies. A series of 11 KIIs and 10 focus group discussions with different stakeholders (producers, vendors, officials) were carried out from February to June 2024 in two counties (Nandi and Nairobi), which brought complementary information on the perceptions of the challenges and evolutions of the sector, and ways to improve milk safety. A multi-stakeholder workshop was organised on 23rd July 2024 to present and discuss the main findings of the Kenya case study.

3 Results

3.1 Microbiological and chemical risks

3.1.1. Food safety risks for fresh fruits and vegetables and fish in Côte d'Ivoire

The scientific expert committee held in Côte d'Ivoire identified the main microbiological and chemical risks associated with the consumption of fresh fruits and vegetables and processed fish (Table 1). Furthermore,

[6] There is no Codex Alimentarius standards regarding microbiological criteria on fresh fruits and vegetables. Codex food safety standards are set only when the danger for humans and animals is high, which is rare with these products. In the European regulation CE 1441/2007 (update of the 2073/2005), there is no standard specific to fresh fruits and vegetables but *Salmonella* (absence in 25 g), total coliforms and Shiga toxin-producing *Escherichia coli* (STEC) (*E. coli* O157 or non-O157) are used by default. CODINORM, the Ivorian standardisation agency, usually uses the Canadian standards as references.

[7] The collective expertise is a proven methodology which consists of bringing together a group of people belonging to the same category of actors – scientists, policy makers, industry – to quickly collect relevant information on food safety issues (Montet *et al*., 2019).

scientific experts stressed the lack of statistics and available data on exposure in local markets as well as the lack of knowledge on consumer exposure to pesticides, which makes difficult to assess health risks. The existing literature is indeed limited, especially with regards to fruits and vegetables. Most of these studies focus on hazards and not on risk analysis, and either on microbiological or chemical hazards; hence the wish in this study, to conduct a risk analysis and to consider both types of hazards on the same food matrices.

Table 1. Main microbiological and chemical risks for fresh fruits and vegetables and processed fish in Côte d'Ivoire identified on the basis of the collective expertise of scientific experts

	Microbiological risks	Chemical risks
Fresh fruits and vegetables	- Pathogenic bacteria (*Salmonella, Escherichia, Shigella*) and Hepatitis virus (mainly due to lack of hygiene and water quality). Related diseases are various digestive disorders. - Mycotoxins produced by moulds at planting level, storage, transport, distribution and preservation of fruits and vegetables. Related diseases are food poisoning, which manifests through vomiting, cramps, diarrhoea, cold, pulmonary, respiratory, allergies, skin infections, and can also lead to cancer over time.	Pesticides, ripening products, mycotoxins, metallic trace elements (MTEs).
Processed fish	- Pathogenic bacteria (*Escherichia*, *Clostridium*, *Staphylococcus*, *Bacillus*), in relation to the hygiene conditions of users (viscera removed from fish, hand washing, contaminated utensils, cross contamination, etc.) and processing facilities. - Mould spores on dry products and neurotoxins. Related diseases are digestive disorders, poisoning, death.	- Polycyclic aromatic hydrocarbons (PAHs) (Benzo(a)pyrene (BaP), benzo(a)anthracene (BaA), Chrysene, Benzo(k)Fluoranthene (BkF)), MTEs (metallic trace elements) and residues of veterinary drugs. These hazards are usually found at levels below the regulatory value, there is no real risk for consumers. - Abusive use of wood species (such as *Hevea brasiliensis*) unsuitable for drying and smoking (the combustion of the latex present even in dry wood is responsible for several intoxications). Processors exposed to smoke are affected (benign runny nose with coughing or headaches, vomiting, asphyxia, loss of consciousness) as well as consumers who ingest carcinogenic particles deposited on smoked products.

Source: Scientific expert committee organised by CSRS, April 2023.

Microbiological analyses

The microbiological analyses focused on spoilage germs (mesophilic aerobic germs (MAG), total coliforms (TC), thermotolerant coliforms (THC), sulphite-reducing anaerobes (SRA), yeasts and moulds (YM)) and detection of pathogenic micro-organisms (*E. coli*, *S. aureus*, C. perfringens, *Salmonella*) - 9 germs in total[8]. The results show that **all samples of fruits were contaminated with most of the germs counted**, i.e. MAG, TC, THC and YM with high loads. These loads do not comply with the Canadian standard. MAG loads ranged from $2.2x10^7$ UFC/g for orange to $6.9x10^7$ UFC/g for mango. **Mango samples were the most contaminated with total Coliforms** ($3.6x10^6$ UFC/g). The **highest load of thermotolerant Coliforms was observed in the avocado samples** ($1x10^6$ UFC/g) and the average levels of MAG and total coliforms were higher on samples from Adjamé ($2.7x10^7$ UFC/g and $1.6x10^6$

[8] A high load of MAG in food products indicates a lack of good hygiene practices. Total and thermotolerant coliforms are an indication of faecal contamination. Their presence in food products could lead to the presence of pathogenic germs that are dangerous for consumers. A very high yeast content contributes to food spoilage. Moulds are active biodegradation agents and producers of dangerous heat-resistant toxins, causing organoleptic alteration and chemical changes to the product.

UFC/g respectively) than from the two other communes. Although *E. coli*, coagulase-positive *S. aureus* and SRA were not found in avocado, banana or orange samples, they were found in all mango samples from Abobo and in 33.3% of mango samples from Yopougon. The **absence of *Salmonella*** was also noted. In general, **the microbiological quality of fruit samples was judged unsatisfactory**.

Regarding vegetables, MAG, total coliforms, thermotolerant coliforms and yeasts and moulds were found in all the eggplant, okra and tomato samples. In the onion samples, 71.1% were contaminated with total coliforms, while 48.9% were contaminated with thermotolerant coliforms. The **okra samples had the highest contamination** of MAG ($9.3x10^8$ UFC/g), total Coliforms ($1.9x10^8$ UFC/g), thermotolerant Coliforms ($2.8x10^6$ UFC/g) and yeasts and moulds ($3.7x10^7$ UFC/g). In addition, *E. coli* was found in 13.3% of okra samples, with an average load varying between $1.4x10^5$ UFC/g and $1.2x10^5$ UFC/g. Coagulase-positive *Staphylococcus aureus* was identified in 11.1%, 26.7% and 28.9% of eggplant, tomato and onion samples respectively (mean load of $2.4x10^4$ UFC/g, $3.2x10^4$ UFC/g and $2.5x10^2$ UFC/g). In addition, no SRA nor *Salmonella* were found in any of the vegetable samples. **The microbiological quality of fresh vegetable samples was unsatisfactory** in the three communes.

In the case of fish, all **smoked sardine samples** contained MAG (mean load of $2.1x\ 10^6$ UFC/g), while 95.6% of the carp samples, 93.3% of the smoked mackerel samples and 62.2% of the fried tuna samples contained them, with average loads of $1.8x10^6$ UFC/g, $2x10^6$ UFC/g and $2.7x10^5$ UFC/g respectively. The fish samples were also contaminated with total coliforms, thermotolerant coliforms and yeasts and moulds. These contaminants were very present in the smoked sardine samples (mean loads of $3.3x10^5$ UFC/g, $7.5x10^4$ UFC/g and $3.8x10^4$ UFC/g respectively) and in the smoked mackerel samples (mean loads of $3.5x10^5$ UFC/g, $2.1x10^4$ UFC/g and $1.2x10^5$ UFC/g). These loads **did not comply with the microbiological criteria** set out in the MSP Order 250/1988 and the MIRAH/CAB Order 0882/2023 in Côte d'Ivoire. In addition, *E. coli* and coagulase-positive *S. aureus* were more identified in samples of smoked sardines (in 73.3% and 73.3% of samples respectively) and smoked mackerel (in 44.4% and 75.6% of samples respectively). Their loads also failed to comply with the microbiological criteria of MSP Order 250/1988. Although the absence of *Salmonella* was noted in all the fish samples analysed, given the non-compliance for the other germs with the MSP Order 250/1988, **the microbiological quality of the fish samples analysed was judged to be unsatisfactory**.

Chemical analyses

The results of chemical analyses for fruits and vegetables show that 33.3%, 22.2% and 66.7% of the **avocado, eggplant and okra samples contained mercury**, with mean levels of 0.53 ± 0.03 µg/kg, 0.7 ± 0.1 µg/kg and 0.67 µg/kg respectively. Nonetheless, these levels are **below the limit** permitted in the European Commission Regulation (EU) 2023/915 on maximum residue limits (MRLs). For fish, all samples contained mercury. **Fried tuna had the highest average concentration in mercury** at 0.17 mg/kg but still below the limit permitted in the Regulation (EU) 2023/915. **Arsenic was detected in 11.1% of the smoked sardine samples at a very high concentration** (2.69 mg/kg), exceeding the limit set in Codex 193-1995.

Thirteen pesticide residues were detected in samples of fresh fruits and vegetables: deltamethrin, hexazinone, fonofos, chlorpyrifos methyl, isazofos, parathion, propargite, fluquinconazole, bifenthrin, fipronil, lambda-cyhalothrin, cypermethrin and piperonyl butoxide. Traces of **chlorpyrifos methyl were detected in all onion samples** and in 33.3% of mango samples. **Deltamethrin was detected in all onion samples** and in 44.4% and 55.6% of avocado and okra samples at levels (0.007 ±0.002 mg/kg) lower than the European Union pesticides database criteria. Bifenthrin, fipronil and lambda-cyhalothrin were identified only in vegetables, namely eggplant, okra and tomato. The **highest concentrations were found in okra** (0.046 mg/kg for bifenthrin, 0.014 mg/kg for fipronil and 0.049 mg/kg for lambda-cyhalothrin). Hexazinone and fonofos were identified in 55.5% and 11.1% of avocado samples at very low concentrations. The presence of propargite, fluquinconazole, isazofos and parathion was detected in orange samples only at very low concentrations (0.005 mg/kg). **All the pesticides**

tested on fruits and vegetables had levels measured below the maximum limits in the European Union database, **except for the fipronil content in okra**, which far exceeded the maximum limit authorised.

Two types of pesticide residue were detected in fish. Deltamethrin was found in 77.8% of smoked sardine samples (with concentrations ranging from 0.021 mg/kg to 0.18 mg/kg) and 33.3% of smoked mackerel samples (with the highest concentration being 0.071 mg/kg). Ethofenprox was detected in 66.7% of the smoked sardine samples at low concentrations (on average 0.007 mg/kg). The **average deltamethrin content of smoked sardine and mackerel exceeded the maximum limits** authorised by the Codex Alimentarius CXM 2-2023. In addition, **PAHs were detected in most fish samples**. The highest concentrations were found in samples of **smoked sardine and fried tuna** (461.4 µg/kg and 181.75 µg/kg respectively). These concentrations far exceed the maximum limits authorised (12 µg/kg) in Order 0882/2023 MIRAH/CAB/ and Regulation (EU) No. 835/2011.

Risk assessment and literature review

The results of the risk assessment revealed that microbial and chemical hazards exist. However, **the health risk associated with the consumption of foods highly contaminated by microbial is also low because the rate of samples contaminated with pathogenic *E. coli* and *S. aureus* is low. Based on estimations of the frequency and quantities consumed by the Ivorian population in Abidjan, the probability to consume the most contaminated foods by chemical hazards from the targeted markets is also generally low** (hazard quotient <1) (see data and calculation in Annex 3).

The results of the lab analyses are **consistent with those of previous studies** in Côte d'Ivoire. For example, Toe (2018) collected 552 samples of vegetables salads and ready-to-eat raw mixed vegetables salads served in mass catering and found that the microbiological quality was unsatisfactory for 42.7% of vegetables salads and 61.7% of ready-to-eat raw mixed vegetable salads. *E. coli* pathovars were detected in 17.1% of vegetables and 35.3% of salad of vegetables and *Salmonella* was detected in 8.5% of vegetables and 2.6% salad of vegetables. Wognin *et al*. (2022) found bacteriological contamination of lettuce sold in Abidjan well above the limit values set by the Association Française de Normalisation (AFNOR), which were taken as references. Traore (2021) detected MTEs in vegetables (cabbage, lettuce, tomatoes, onions and onion leaves) collected in the town of Daloa, and the presence of arsenic, mercury and zinc in these foods at higher levels than the tolerated levels. Yapo *et al* (2021) detected eight pesticides associated with the consumption of market garden produce in the Korhogo department (chlorpyriphos ethyl, cyhalotrin, cypermethrin, ortho-phenylphenol, parathion, spirodiclofen, thiamethoxam and zoxamid) but they were at low concentrations.

Regarding fish, Koua *et al.* (2022) conducted a semi-structured survey with smokers, sellers and consumers of smoked fish which revealed ignorance and non-compliance with good hygiene practices, and half of the smokers ignored the risks associated with Hevea wood use for smoking. A microbiological analysis of 75 samples showed that 56% of the samples were contaminated with *Pseudomonas aeruginosa*, 68% with *E. coli*, and 84% with *S. aureus* while no *Salmonella* strain was detected. Monney *et al.* (2020) found cadmium, lead and mercury in tuna, sardine and mackerel, both in fresh state and smoked in the Abidjan area. The mercury content inside mackerel and sardines significantly decreased after their exposure to the smoke but mackerel was more intoxicated in cadmium and lead. In Montet *et al.* (2017), samples of fish had high microbial contamination, especially in *E. coli*, *staphylococci*, *Clostridium* perfringens and *Salmonella*. Fresh fish had the highest non-compliance rates with WHO quality standards, but heat treatment (e.g. braised fish) did not prevent from non-compliance. Dagnogo *et al.* (2022) evaluated the exposure of consumers to PAHs and the health risk related to the consumption of four braised fish species. All the eight PAH molecules tested were found at different concentrations with mackerel the most contaminated both in number and in concentration. However, all the hazard quotients were lower than 1 indicating low health risk for consumers. Aké-Assi *et al.* (2010) reported that PAH levels found in smoked oily fish are higher than in fresh fish. They also reported that 95% of the samples analysed of fresh and

smoked sardines had benzo-a-pyrene concentrations above the maximum value set by Ivorian regulations. The hazard quotient remains low (Aké-Assi *et al.*, 2018), but the molecule is carcinogenic (Miessan, 2024).

Characteristics of production, transportation, processing and distribution

The results on microbiological and chemical contaminations reflect the conditions under which fresh fruits and vegetables and fish are produced, stored, transported, processed and distributed. A high load of MAG, TC, THC and YM in fruit and vegetable samples could be explained by the fact that these foods are **exposed to the open air, to dust, in an unsanitary environment that probably contains animal excrement**. Given that heat treatment destroys germs, their presence in fried tuna indicates **recontamination** after cooking, or cross-contamination, highlighting conservation problems. The contamination of smoked fish indicates a **lack of good hygiene practices**. It may also be due to the presence of excrement and insects in the environment where these products are sold. While products intended for export are subject to strict safety procedures, those sold on the domestic market usually face many challenges to control sources of contamination along the food chain. However, the situation varies depending on the supply chains.

Dessert bananas are mostly grown for exports in **industrial plantations of multinationals** with strict sanitary and phytosanitary control. Those that cannot be exported (e.g. due to alterations) are sold on the domestic market but follow the same production methods. In the **mango chain**, not all the **individual small-scale farmers** and cooperatives who make up 95% of the chain follow good agricultural practices. Like dessert bananas, mangoes initially intended for exports sold on the domestic market are grown with safety procedures, but it happened in recent years that mangos coming from industrial plantations were rejected for non-compliance with the requirements of importing countries (Kaoumé et Agnini, 2022)[9]. In the post-production stages, fruits sold in the domestic market are managed (packed, transported, stored, sold) in poor hygiene conditions. They are not or barely washed and might be contaminated by packaging (including cement residues or unknown substances). No official control is done, neither before entering the market nor during commercialisation since there is no quality standards to apply for the national market.

Most vegetables are produced in conventional cropping systems with the use of chemical inputs. The literature on vegetables safety in Côte d'Ivoire highlights the excessive or misuse of pesticides in vegetable production, a problem observed in many developing countries where farmers are highly dependent on chemical pesticides to address pests (De Bon *et al.*, 2014). Mambe-Ani *et al.* (2019) surveyed 243 market gardeners in peri urban areas of Abidjan and showed that 100% farmers in these areas regularly used 43 chemical pesticides. The results indicated that the most chemical groups represented were pyrethroid, dithiocarbamate, organo-phosphorus and amino phosphonate, and the most active ingredients were glyphosate, cypermethrin and mancozeb. Unsafe or fraudulent practices such as use of unregistered substances (according to Ivorian phytosanitary guidebook) or non-compliance with recommended application frequency and doses rates were reported (92% of surveyed farmers). For active ingredient chlorpyriphos-ethyl with 45-day pre-harvest intervals, none of farmers observed this time limit. In some cases, the use of molecules originally intended for cotton crops was observed. Kpan Kpan *et al.* (2019) also exposed the excessive doses, non-respect of pre-harvest interval and non-respect of treatment frequencies. Finally, the use of contaminated water and the disposal of pesticides containers, often released in the environment, remain critical issues. After harvest, it appears that some buyers expect to see traces of pesticide on vegetables as, in their view, it extends shelf life and proves that product has been cultivated well. Due to recent programmes and projects in specific areas, some farmers are transitioning to more sustainable cultural practices, mostly in peri urban areas. When harvested, vegetables are sometimes washed or cleaned with fabric, packed in recycled bags or cardboard or wooden crates, and transported to markets. Transportation

[9] In 2021 for instance, mango from Côte d'Ivoire consignments suffered 22 interceptions at Europe gates due to Fruit flies; it was more than 60 interceptions in 2014 and more than 30 interceptions in 2012 and 2017 (Kouamé et Agnini, 2022).

can include several successive steps including motorcycle, taxi, buses, tricycle, pick-ups or trucks. None of these transportation methods are refrigerated and vegetables might be mixed with other food or non-food products.

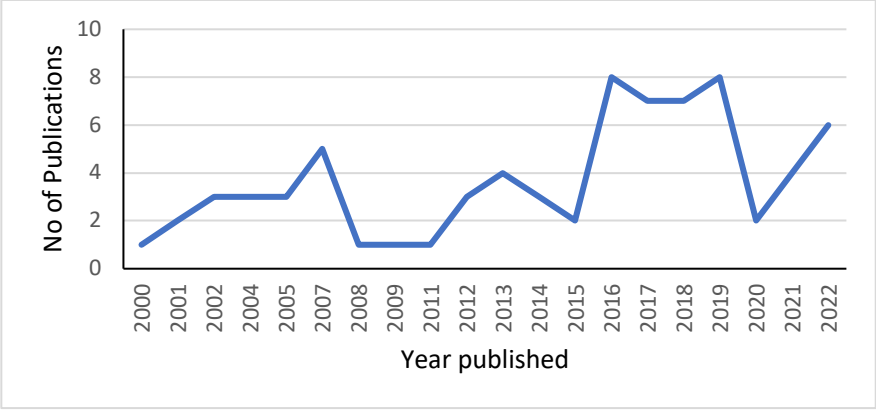
Regarding **fish**, processing and marketing processes are mostly artisanal and often affect its microbiological quality. Health hazards might result from water contaminations with heavy metals or poisonous substances, poor hygiene measures in storage, processing and sales conduction to pathogen microbial infestations, or bad practices in processing promoting accumulation of toxic compounds such as PAHs. While tuna, sardine and mackerel come from the artisanal and industrial fishing in national sea, carpe fish is imported from China and locally processed. Sardine is caught in the Lagune of Abidjan and this closed ecosystem might increase risks of contamination between fishes and from diverse pollutions.

Finally, although fruits, vegetables and fish are usually cooked in traditional meals as a safety risk management practice by consumers, the strong increase of out of home consumption (most of the daily food consumption in low-income neighbourhoods of Abidjan is with street vendors[10]) makes it more difficult for consumers to control meal preparation. Street vendors are also difficult to control due to their mobility.

3.1.2. Contamination risks for milk in Kenya

Milk in Kenya has been quite extensively studied over the past decades. A systematic literature review (SLR) of foodborne disease hazards and hazard indicators in milk consumed in Kenya was carried out and reported using the PRISMA reporting guidelines (see Annex 1). A total of 75 publications, published between the years 2000 and June 2023, were reviewed. The number of publications in recent years in the field of milk safety in the country has been rising (see Figure 2). Quality was assessed by Reviewer 1 and 2 who extracted the data and checked by Reviewer 3 and 4 following the SLR protocol. Most eligible studies were of medium rather than good quality; however, quality was improving with time which indicates the recent increase in interest in and funding of food safety research is paying dividends. Most studies have been conducted in Nairobi, Central and Rift Valley within Kenya. The geographical location of studies is appropriate considering the geographical location of risk. These two provinces have the highest concentration and numbers of dairy cattle per head of population and are the only areas fully capable of meeting local demand and providing surplus produce for other parts of the country.

Figure 2. Number of publications on milk safety from 2000 to 2023



Source: ILRI.

[10] For example, Koffi et al. (2019) show that the consumption of "Garba" (fried tuna with cassava semolina – "attiéké") is consumed from street vendors between 3-4 times in a week to 5 or more times in a week by 80% of the 547 surveyed consumers in Abobo and Yopougon.

Reviewed publications yielded 442 records covering 199 biological hazards, 147 indicators of biological hazards[11], and 96 chemical hazards. Biological hazards and hazard indicators comprised bacteria or protozoa (96.8%; n=344) and fungi (3.2%). *Staphylococcus* spp. was the most frequently reported hazard (20% of papers reported this). Combining the SLR with other information suggests the most important hazards are *Salmonella* spp., toxigenic *E. coli*, *S. aureus*, *Shigella*, *Listeria* spp., *Campylobacter* spp. and lead.

Hazards reported

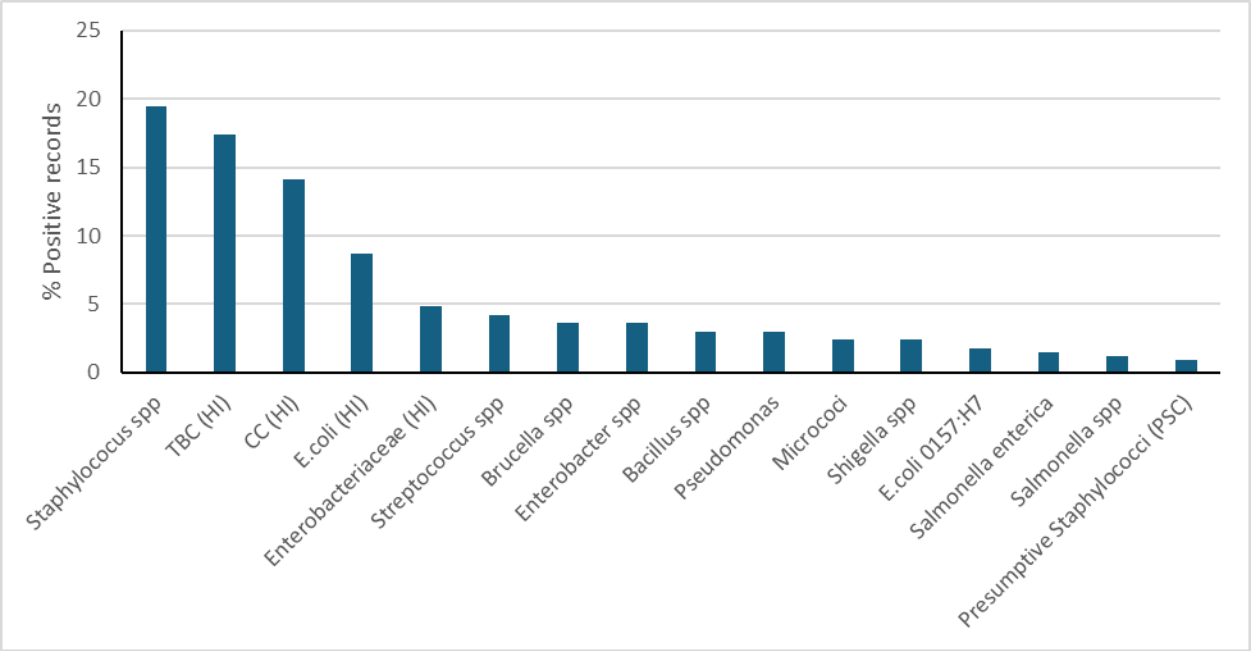
Regarding **biological hazards** specifically, the five most reported were in descending order: *S. aureus*, *Pseudomonas*, *Shigella* spp., toxigenic *E. coli*, *Salmonella enterica* (see Figure 3 and Table 2). The last three are major causes of foodborne diseases and reported by FERG globally. *S. aureus* and *B. cereus* are also very important cause of foodborne diseases although not included in the FERG. The former was well studied and there were a small number of reports on *B. cereus*. Overall, only 39% of the reports were on foodborne diseases known to have a significant health burden and the remaining were on minor or opportunistic pathogens that are easy and inexpensive to detect. Viruses are important causes of foodborne disease and frequently detected in milk but there were no studies on viral contamination. Based on our analysis, some of the most important neglected biological hazards are Norovirus, *Salmonella typhi*, hepatitis A virus and *Cryptosporidium*. All these are commonly present in milk in other countries and responsible for a huge burden of foodborne disease but there is no evidence on their absence or presence in milk in Kenya.

Only four types of **chemical hazards** were found in the SLR: aflatoxins[12], antimicrobial residues, hydrogen peroxide and formaldehyde. Among chemical hazard reports, 54 were on aflatoxins. In a review by Kiarie *et al.* (2016) all the milk sampled had detectable levels of contamination with aflatoxins, and 63% of the sampled milk had aflatoxin levels of more than the level of 0.05 ppb recommended by the EU. The second most common chemical hazard was antibiotic residues (38 studies). Adulteration of raw and pasteurised milk with hydrogen peroxide was reported in five studies. Hydrogen peroxide, a prohibited but mostly harmless preservative, was also found in several studies. Only one study reported the presence of formaldehyde, a dangerous chemical used illegally as a preservative.

[11] An indicator of hazard is the detection or measurement of a quantity that indicates the presence of pathogenic agents. An example is the *total bacterial count* in a sample.

[12] Aflatoxin in milk is Aflatoxin M1, a chemical compound of the aflatoxin class which is different from the Aflatoxin found in cereals (with B1 being the most toxic). Aflatoxins are a chemical substance synthesised by fungi. In food safety, they are considered as chemical hazards and classified as such by EFSA for instance, although their origin is biological as fungi are biological. In HACCP Aflatoxin is often considered a biological hazard (although a chemical in structure) because HACCP is interested in managing fungi.

Figure 3. Bacterial hazards and hazard indicators reported in milk (n=344) positive records



Note: TBC (Total bacterial count), CC (coliform count), PSEC (Presumptive streptococci/ enterococci (PSEC), PSC (Presumptive staphylococci)

Table 2. Summary of bacterial hazards reported in milk

Biological Hazard	% of Positive records
***Staphylococcus* spp**	19.5
Pseudomonas	3.0
***Shigella* spp**	2.4
***E. coli* 0157:H7**	1.8
***Salmonella* enterica**	1.5

Contamination along the value chain

Raw milk was the most often studied and the most likely to be contaminated (70% of raw milk samples), indicating the challenges in maintaining safety in informal markets. Raw milk had the highest proportion of bacterial hazards or hazard indicators (66% of samples). Bacteria can contaminate raw milk either during milking process, handling by retailers, storage under poor conditions, and preparation of consumption. According to Kenyan standards it is acceptable to have higher levels of hazards in raw milk as it has not undergone processes to remove hazards. Kenyans typically boil raw milk before consumption, which can reduce the risk of contamination. However, milk often contains spore-forming bacteria (e.g., *B. cereus and Clostridium perfringens)* and also bacteria which produce toxins (e.g., *B. cereus* and *S. aureus*). Spores are not killed by heating to boiling and can re-grow after milk has been heated. Bacterial toxins vary in their susceptibility to degradation by boiling. *S. aureus* and some *B. cereus* toxins are remarkably heat stable, resisting boiling for hours. Moreover, bacterial *Staphylococcus aureus* is common in milk in Kenya; it is an indicator of poor, unhygienic handling of milk and dairy products, indicating systemic problems in dairy hygiene.

Boiling of milk is not always effective at killing pathogens likely because of inadequate boiling or re-contamination; in our study, 1.5% of boiled milk contained bacteria. Although this percentage is low, if

households consume boiled milk daily (as many in Kenya do) they will be potentially exposed to disease-causing bacteria five times a year[13] which could result in a significant disease burden.

However, 22% of **formal sector** pasteurised milk was also contaminated. It indicates a more serious breakdown of quality control and regulation as, unlike informal actors, formal firms are expected to employ professional quality assurance and to be inspected regularly. Formal sector milk is not always safe, nor informal sector milk is always unsafe (Roesel and Grace, 2015). These products undergo heat processes that should render them safe, and while most consumers boil raw milk, they are much less likely to boil treated milk. So, although the level of contamination may be lower, the risk to human health may be higher as these products are considered to be safe. The presence of hazards in formal heat-treated milk may be due to the poor handling techniques of the milk during pasteurisation or poor-quality control measures.

Overall, levels of contamination of fermented milk, boiled milk and yoghurt were low. One study (Bebe, 2018) looking at ATM milk found that prevalence of both hydrogen peroxide and antibiotics was higher (8% of samples) compared to milk from plastic containers (4.5% of samples) but comparable to contamination in packaged milk (6% of samples).

Fermented milk was the next most contaminated product (16.6% of fermented milk samples). Fermentation reduces biological hazards by increasing acidity; however, in Kenya most milk is fermented using traditional methods which do not involve a culture, and this takes place under poorly controlled conditions such as temperature and time. Under these conditions, fermentation is less effective (Kwarteng *et al*., 2020).

Only 0.6% of **yoghurt** was contaminated likely because most is produced by formal industries, and sold at a relatively high price to affluent consumers. In Kenya, as with most LMICs, formal sector, packaged food, sold in supermarkets and modern retail outlets is more expensive than equivalent foods sold in traditional markets.

Overall, 42% of the reports on contamination were of hazard indicators and not hazards. Eight of the twelve most reported biological contaminants were hazard indicators. Total bacterial counts were the most common and coliforms the second. The finding of coliforms present points to poor **hygiene** practices in the **handling** of food products. The use of unhygienic water during sanitation can indirectly contaminate milk (Robinson, 2005). In Kiambu and Nairobi counties, piped water has been associated with high total bacteria counts and coliform counts possibly due to infrequent water supply (Mwangi *et al*., 2000). Although hazard indicators provide useful information on standard compliance, they are less informative than information on hazards.

Risk to human health

Aflatoxins in milk present negligible risk to health according to the most recent studies (Turna and Wu, 2021; Turna *et al.*, 2022). Concerns about aflatoxins in milk in Kenya are probably because of a highly publicised and lethal outbreak of aflatoxicosis due to contaminated maize products that killed 125 people in 2004 (Lewis *et al*., 2005). However, the study conducted by Turna and Wu (2021) in multiple countries worldwide estimated exposure to Aflatoxin M1 (AFM1), a chemical compound of the aflatoxin class, through milk consumption and a subsequent cancer risk assessment (Turna *et al.*, 2022) concluded that there is very low cancer risk associated with AFM1 exposure. Quantitative risk assessments on the health impact of aflatoxins in milk in Kenya likewise found the risk to be negligible compared to other hazards (Ahlberg *et al*., 2018; Sirma *et al.*, 2019).

Antimicrobial residues in milk are not a foodborne disease problem. They indicate a serious public health threat, by increasing the risk of emergence and dissemination of antimicrobial resistance, but not directly represent a

[13] People drink boiled milk every day or 365 times a year if they drink it every day and 1.5% is contaminated then they will drink 365*0.015 or 5.5 contaminated milk meals a year.

food safety issue. There is little evidence that the levels typically found in food cause direct harm to human health (Grace, 2015).

The presence of **hydrogen peroxide** is prohibited in traded milk in Kenya, by Kenya Bureau of Standards (KEBS) standards. However, hydrogen peroxide is a relatively safe and effective milk preservative and is even recommended as a way of improving the safety of informal milk.

The most dangerous and frequent chemical hazards in milk globally, **dioxins and heavy metals**, were absent from the papers reviewed. Dioxins from dairy products might be responsible for hundreds to tens of thousands of human cases each year globally (Grace *et al.*, 2016). There were no reports on dioxins in our review. Four of the most important heavy metals (lead, cadmium, mercury, arsenic) impose a global health burden of more than million illnesses, over 56,000 deaths, and more than 9 million disability-adjusted life years (DALYs) (Gibb *et al*., 2019). Again, there were no reports on heavy metals from the publications reviewed.

Discussion

The priority hazards that were tested are biological. Many studies have been undertaken on hazards that are easy and inexpensive to detect but not necessarily most important for foodborne diseases while other hazards that have a significant health burden (e.g. viruses) but are difficult to study remained neglected. Indeed, several of the most frequent hazards found in milk and milk products, such as aflatoxins and antimicrobial residues, do not represent a high risk for human health: aflatoxins in milk present negligible risk to health; antimicrobial residues in milk are not a foodborne disease problem but do indicate a public health problem. Conversely, several important hazards known in milk value chains globally such as viruses, protozoa, and heavy metals were not tested in Kenya and remained neglected. Most milk does not meet standards implying a risk to health and a failure of regulation.

Methodologically, most studies reported hazard indicators rather than hazards. Studies are needed that go beyond hazards to evaluate human health risk caused by hazards taking into-account processes before consumption (e.g. boiling) and vulnerability of different milk consumers. The gold standard of understanding the actual risk to human health caused by a hazard is to conduct a quantitative risk assessment. Milk hazards should be prioritised, according to risk to human health, and future studies should focus on high priority hazards. Criteria for prioritisation should include health burden, diseases that are emerging, and hazards that have been neglected.

In terms of value chain points and **technologies**, milk dispensers ('ATMS') are a recent innovation in Kenya and need to be better studied as it appears they may present unanticipated health risks. Informal milk dominates the domestic market but has safety problems. Technological solutions to improve milk safety and quality should be considered including lactoperoxidase, hydrogen peroxidase, mazzicans (an innovative container for storing milk) and boiling.

Awareness creation is needed about: the risks from formal sector milk (which is often assumed to be safe yet often found to be contaminated); current boiling processes that do not remove all hazards; household milk handling and safety; and how to decontaminate milk by adequate boiling. There is a need for **training, technology and incentives** to improve milk safety from farm to transport, vendors and to households.

3.2 Regulatory frameworks

Laws and regulations are one policy instrument, among others, that governments generally use in the field of food safety. In many LMICs, such as Kenya and Côte d'Ivoire, the regulatory framework is an inheritance from the colonial authorities. It has evolved according to dynamics specific to each national context, but has also been influenced by international and regional factors. Both countries are members of the Codex Alimentarius and

transcribe the Codex standards into their own standards. Both are also members of the WTO and must comply with the SPS agreement. Côte d'Ivoire is member of two regional integration areas, West African Economic and Monetary Union (WAEMU) and Economic Community of West African States (ECOWAS), and must comply with the laws and regulations set at this regional level[14]. At the continental level, the African Union initiatives within the African Continental Free Trade Area (AfCFTA) are also drivers of change of national regulatory frameworks.

3.2.1. Laws and regulations for fresh fruits and vegetables and fish in Côte d'Ivoire

The regulatory framework for food safety in Côte d'Ivoire includes acts related to the institutional landscape, setting the mandates of all competent authorities, and to mandatory standards (maximum limits). There is **no one single food safety strategy** or food regulation[15] yet, that would cover all national standards and regulations in relation to food safety, but a National Food Safety Policy is under preparation.[16] This policy aims to contribute to strengthening the national food safety and quality control system with a strong export focus: the policy should enable the country to fully release its export potential in products based on fruits and vegetables and to access regional and international markets.

To identify laws and regulations relevant for the targeted food products, interviewees were asked to mention all the texts they refer to in their activities. This led to a list of about 70 texts, including policy documents and standards at regional and international levels. Half of these texts are general and apply to all food products, 25 of them are specific to animals and animal products, and 15 are specific to plant products. They cover many issues related to food safety: biosafety, labelling and consumer information, fraud control, food additives, quality promotion, etc. The texts describe the different controls and sanctions, good hygiene practices, sanitary rules to be respected, etc., while a few others set maximum limits for microbiological and chemical contaminants.

The **state of laws and regulations differs depending on the food products**. For fish products, a recent law on veterinary services (Law No. 2020-995 of December 30, 2020, on the Veterinary Public Health Code) includes food safety provisions for animal products and animal-source products that set responsibilities of business operators and the administration, and the mandates of state agents for control and inspection in sanitary veterinary services. Orders related to microbiological and chemical standards for fish products have also been recently updated (Order No. 025/MIRAH/CAB on 30 September 2020). There are no similar acts setting mandatory standards for microbiological and chemical contaminants for fresh fruits and vegetables. The most recent decree that presents mandatory standards – most of them referring to specific Codex Alimentarius standards - for a list of food items (Decree N°2016-1152 on 28 December 2016 updated by the Decree N°2020-389 on 15 April 2020) does not include fresh fruits and vegetables. Only fish and preparations with fruits and vegetables are included in the list.

The **absence of decree setting mandatory safety standards for fresh fruits and vegetables** does not mean there is no standard. As a member of the WTO, Côte d'Ivoire complies with the SPS agreement which recommends that member states use international standards such as those of the Codex Alimentarius as a reference in the absence of specific national standards. However, this is a general recommendation whereas the Decree N°2016-1152 indicates the specific Codex standards to be used for the food items it covers. The national standardisation

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[14] Regulation N°07/2007/CM/UEMOA of 6 April 2007 on food safety of plants, animals and food products and regulation N°03/2010/CM/UEMOA of 21 June 2010 establishing the harmonisation scheme of accreditation, certification, standardisation, metrology activities in WAEMU. These regulations are part of the 2005 Quality Programme set in WAEMU and then extended to ECOWAS (Regulation N°C/REG.21/11/10 of 26 November 2010 harmonising the structural framework and operational rules on plant, animal and food safety within the ECOWAS region).

[15] In Europe for instance, the food law (CE 178/2002) implemented since January 1, 2005, specifies that all food consumed in Europe, imported or exported, must be safe for consumers.

[16] The development of this policy is part of the Development Project on food value chains (PDC2V). https://pdc2v.ci/wp-content/uploads/2024/08/AMI-POLITIQUE-SANITAIRE-DES-ALIMENTS.pdf

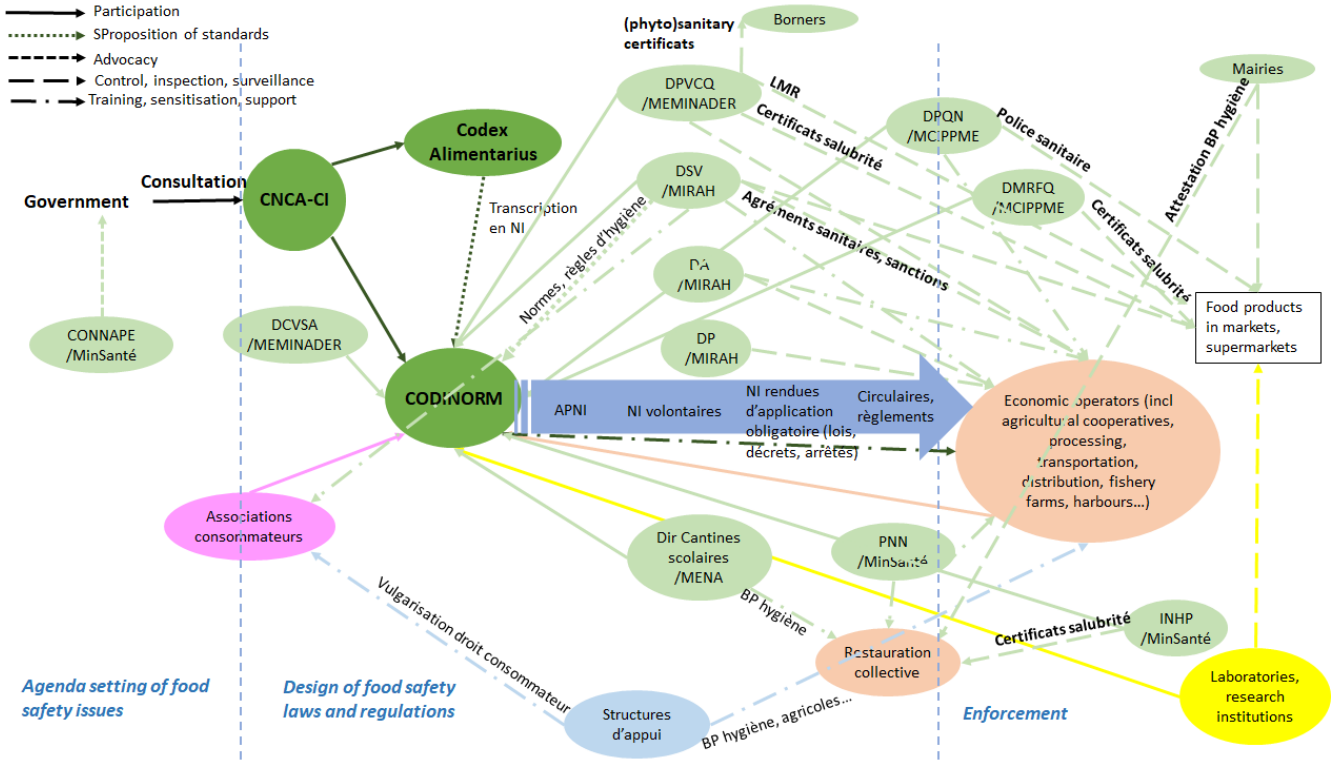
organisation, Côte d'Ivoire standardisation (CODINORM), has set Ivorian standards in addition to those of Codex Alimentarius for fresh fruits and vegetables but they are only voluntary and not been made mandatory by laws and regulations[17]. In brief, existing mandatory standards do not cover fresh fruits and vegetables, and existing standards on these products are not mandatory. As see in the previous section, international standards or regulations from other countries were used to assess microbiological and chemical contaminations of fresh fruits and vegetables. According to interviewees from the Ministry of Agriculture, studies are undertaken to set standards for fresh fruits and vegetables sold in the domestic market.

The situation today is an **asymmetry in quality control** between fresh fruits and vegetables domestically consumed and those intended for export. While exported fresh fruits and vegetables must comply with the regulations of importing countries (mostly the EU regulation), there is no control for fresh fruits and vegetables before they are placed in the domestic market. Phytosanitary controls are limited to borders and to visual controls. Only in the event of food poisoning are samples collected from local markets and analysed to identify the cause. On the opposite, export companies of fresh fruits and vegetables are responsible for controlling the quality of their products. They usually have internal quality systems and pay for lab analyses on samples of their cargo to avoid any refusal in the event of positive analyses carried out by EU customs.

As suggested by the institutional mapping below, the food safety **regulatory framework involves a wide range of actors**, from food safety agenda setting to the formulation of laws and regulation and their enforcement. Actors can be clustered into **six categories** according to their activities: 1) the competent authorities (i.e. governmental authorities responsible for implementing consumer protection measures) (in light green), 2) the monitoring and standardisation structures (in dark green), 3) the laboratories and research centres (in yellow), 4) the consumer associations (in purple), 5) the food business operators (producers, processors, distributors) (in orange) and 6) the organisations supporting the agri-food system, including development partners and donors (in blue).

[17] Out of the 535 standards listed in the 2022 CODINORM catalogue (on very various areas) 62 were indicated as mandatory. None of them cover the targeted food items. The same observation can be made for the 2024 CODINORM catalogue.

Figure 4. Institutional mapping for agenda setting, design of laws and regulations and compliance



Source: authors.

Competent authorities are ministries responsible for different food safety-related issues and controls:

- The Ministry of Agriculture and Rural Development (*Ministère d'Etat, ministère de l'Agriculture et du Développement Rural, MEMINADER*) deals with the safety of plant-based products. Within this Ministry, the directorate in charge of plant protection and quality control (*Direction de la Protection des Végétaux et du Contrôle Qualité, DPVCQ*) is responsible for **controlling the compliance of agricultural businesses** with safety standards (e.g. standards applicable to fruit export companies), including informal vendors on markets. DPVCQ also manages **hygiene controls** in warehouses and on markets, and visual phytosanitary controls at borders.
- The Ministry of Animal and Fishery Resources (*Ministère des ressources animales et halieutiques, MIRAH*) deals with animal products food safety. The Veterinary Services Directorate (*Direction des Services Vétérinaires, DSV*) is responsible for the **control and sanitary inspection** of animal products in all treatment and processing facilities, storage warehouses, distribution and mass catering. It delivers **sanitary approvals** to formal actors who handle animals, suspends or retires these approvals in case of non-compliance with standards, and products can be seized or destroyed. Two other Directorates, related to Aquaculture (*Direction de l'Aquaculture, DA*) and Fisheries (*Direction de la Pêche, DP*), do not have food control mandate but are responsible for actors' **capacity building** and improvement of fishery practices to develop the quantity and quality of the production.
- The Ministry of Commerce, Industry and Small-scale Enterprises (*Ministère du Commerce, de l'Industrie et de la Promotion des PME, MCIPPME*) is responsible for the **sanitary police** with formal food industries through its Directorate in charge of Quality Promotion and Certification (*Direction de la Promotion de la Qualité et de la Certification, DPQN*). Another Directorate in charge of Metrology, Fraud Control and Quality Control (*Direction de la Métrologie, de la Répression des Fraudes et du Contrôle de la Qualité*, DMRFCQ) oversees **controls in supermarkets and wet markets**.

- The Ministry of Health and Public Hygiene (*Ministère de la Santé, de l'Hygiène Publique et de la Couverture Maladie Universelle*) is responsible for **inspection of sites** in case of food poisoning. It also inspects private structures and issues **health certificates** to all structures open to the public (restaurants, supermarkets, hotels, etc.).
- The Ministry of National Education and Literacy (*Ministère de l'Education Nationale et de l'Alphabétisation, MENA*), especially through its Directorate on School Canteens, is part of the food safety system through **training** of school canteens staff to good hygiene practices.

Hygiene services in local authorities also play a role in controlling food safety. Municipality agents are responsible for **visual hygiene controls** in all public places and businesses (e.g. restaurants, open markets, etc.) under their jurisdiction. Representatives from the Yopougon municipality specified that they control and issue **certificates of good hygienic practice** and certificates of location to mass catering establishments.

Regarding standardisation organisations, **CODINORM**, under the Ministry of Commerce, Industry and Small-scale Enterprises, is the national leading organisation to develop new (or update) Ivorian standards, which can be made mandatory by legal acts. CODINORM has also the mandate to support economic operators and laboratories to comply with standards and to be certified. Training on standards can be organised to both formal and informal economic operators. The **National Committee of Codex Alimentarius** (*Comité National du Codex Alimentarius de Côte d'Ivoire, CNCA-CI*) has an advisory role to the government by providing advice on projects of Codex Alimentarius standards. The President of the CNCA-CI is an advisor to the African Codex Committee and participates into the Codex Alimentarius Commission activities.

Research centres and laboratories, in addition to participating in CODINORM technical discussions, have a critical role in drawing political attention on food safety by documenting food safety issues and assessing the quality of food products. Some laboratories are affiliated to ministries and support the mandate of competent authorities[18]. It was reported in the interviews that all research centres and laboratories carry out classic and advanced lab analyses, except some of them such as the Ocean Research Centre (*Centre de Recherches Océanologiques, CRO*) and the National Agronomy Research Centre (*Centre National de Recherche Agronomique, CNRA*) which lack the necessary infrastructures for advanced lab analyses.

Consumer associations members of CODINORM have a statutory seat to bring the voice of consumers. The two networks of consumer associations that were interviewed - the Fédération Nationale des Associations de Consommateurs de Côte d'Ivoire (FAC-CI) and the Fédération des Association de Consommateurs Actifs de Côte d'Ivoire (FACACI) - both claim to defend the consumer rights and protect their interests. They also have a role in disseminating rights and duties of consumers in all domains including food safety.

Food business operators, from production to processing, transportation, storage, and distribution, are supposed to know the laws and regulations and apply them. Laws and regulations are effective only if these operators comply with them. Some are members of CODINORM and can potentially influence the development of standards subsequently made mandatory. Among the four business operators interviewed, three were large companies and members of CODINORM: Société de Culture Bananière (SCB), Société Ivoirienne de Promotion de Supermarchés (PROSUMA) and Nestlé. The fourth one was a small economic operator, not member of CODINORM: Union Nationale des Sociétés Coopératives des Mareyeuses et Actrices de la Filière Halieutique de Côte d'Ivoire (UNSCOMAFHA).

[18] The *Laboratoire National d'Appui au Développement Agricole (LANADA)* is affiliated to the Ministry of Agriculture and Rural Development. The *Laboratoire National d'Essais de Qualité, de Métrologie et d'Analyses (LANEMA)* is affiliated to the Ministry of Commerce, Industry and Small-scale Enterprises. The *Laboratoire National de Santé Publique (LNSP)* is affiliated to the Ministry of Health and Public Hygiene.

Public structures that support food business operators are members of CODINORM. The National Agency of Support to Rural Development (*Agence Nationale d'Appui au Développement Rural, ANADER*), a state agency providing extension services, participates to the standardisation activities. ANADER also trains farmers to good agricultural practices, including the adequate use of pesticides. Nation-wide programmes supported by **development partners**, such as the *Programme d'Appui au Développement des Filières Agricoles (PADFA),* also play a critical role to capacity build farmers in applying good phytosanitary practices. NGOS are key in supporting business operators from the informal sector.

CODINORM is the main **forum where standards are developed**. This standardisation process is **inclusive** as research organisations, laboratories, consumer associations and enterprises members of CODINORM[19] can participate in this process. The creation of CODINORM in 1992 as a non-profit association recognised of public interest was indeed to overcome the drawbacks of a previous system centrally managed by a service in the Ministry of Commerce, which was disconnected from the realities of economic operators (CODINORM, 2024). All stakeholders are invited to participate with experts to the CODINORM technical sub-committees on projects of Ivorian standards (*Avant-Projets de Norme Ivoirienne, APNI*) before public enquiry.

The **National Council on Nutrition, Food and Early Childhood** (*Conseil National pour la Nutrition, l'Alimentation et le Développement de la Petite Enfance, CONNAPE*) is another intersectoral and multi-stakeholder forum focused on nutrition also dealing with food safety. The 2016-2020 National Multisectorial Plan of Nutrition (*Plan National Multisectoriel de Nutrition*) (République de Côte d'Ivoire, 2016) discussed within the CONNAPE Technical Committee includes food safety as one of its seven strategic outcomes. The policy document recalls that nutrition and food safety are strongly linked. It also aims to have three effects: an integrated system of risk assessment and management, including the traceability of food products; a better risk management by strengthening the epidemiological surveillance system to include foodborne disease; the training and sensitisation of all actors (producers, processors, distributors, consumers) on good hygiene practices. The document mentions the need to strengthen the food safety regulatory framework and CONNAPE advocates for an effective implementation of existing texts.

3.2.2. Laws and regulations for milk safety in Kenya

Kenyan has a comprehensive set of policies, laws, regulations and institutions for milk safety, refined over decades and regularly updated (Kang'ethe, 2020). The relevant policies comprise the ones dedicated to food safety and to international trade, but also sectoral policies in milk that include provisions on milk quality and safety. The most salient issues currently discussed are related to the *Dairy Industry Regulations* passed in 2021, as well as the proposed *Dairy Industry Bill, 2024*, and the *Food and feed safety Bill*, 2023.

Policies

Three national policies reflect the government efforts to improve food safety. The *National Food and Nutrition Security Policy (2011)* aims to increase quantity and quality of the food produced in the country to ensure food security, including food safety. The *National Food Safety Policy (2013)* aims at updating the food legislation and food safety requirements, improving the surveillance of food safety issues, traceability of products from farm to fork, lab capacities, risk analysis, enforcement, and public-private partnerships. The aim of the *National Dairy Development Policy (2013)* is to improve the livelihoods of actors in the sector, improve the fight against animal diseases as well as the feed quality and safety, and formalise and provide basic infrastructure for the sector. It lays out the strategic goal to transform the country into an exporter of dairy animals and products, which entails an alignment on international standards for milk safety. The *Kenya national dairy master plan* has similar goals,

[19] CODINORM had 306 members companies as of 8 November 2024: CODINORM: Accueil.

developing the dairy economy into an export-oriented industry. To do so, it proposes to restructure the production, and to improve the compliance of the industry with the country's laws.

Acts

The main Acts organising food safety in Kenya, in relation to milk production and products, are the followings:

- Ministry of Health

The *Public Health Act, Cap 242, (enacted in 1921, latest revision in 2017)* empowers the Ministry of Health to handle matters related to food (anything other than water and drugs intended for food preparation), in particular to inspect animals intended for human consumption, animal-source food production premises; and to prohibit the sale, import, and export of food unfit for human consumption. It is complemented by the *Food, Drugs and Chemical Substances Act, Cap 254 (enacted in 1965, latest revision in 2002)*, which established a Public Health Board whose mandate is to set standards for preparation, storage, and sale of food, and which is granted powers to prohibit unsafe food and enforce the compliance with the prescribed standards. The *Kenya Food and Drugs Authority Bill, 2019 (pending)* proposes the establishment of a Kenya Food and Drug authority to improve and integrate the surveillance, regulation, monitoring, enforcement, and awareness of the compliance with food safety standards.

- Ministry of Agriculture, Livestock and Fisheries

Regarding crops, the *Plant Protection Act, Cap 324 (enacted in 1937, latest revision in 1971)* grants the Ministry of Agriculture powers to make rules to prevent and control plant pest and diseases; inspect, disinfect, destroy, and detain infected plants; and prosecute non-compliance. It is strengthened by the *Kenya Plant Health Inspectorate Service Act, 2011 (enacted in 2012, latest revision in 2016)*, the *Crops Act, 2013 (enacted in 2013, latest revision in 2016),* and the *Agricultural and Food Authority Act, 2013 (enacted in 2013, latest revision in 2016)*. The *National Cereals and Produce Board Act, Cap 338 (enacted in 1985, latest revision in 2006)* creates the National Cereals and Produce Board, whose mandate is to establish and enforce best practices on the processing and trade of maize and wheat, which is important for the quality of animal feed and hence the safety of animal products. The *Fertilisers and Animal Foodstuffs Act, Cap 345 (enacted 23of 1962, latest revision 20 of 2015)* regulates the import and production of fertilisers and animal feed.

Regarding animal products, the *Dairy Industry Act, Cap 336 (enacted in 1958, latest revision in 2006)* aims to improve the quality and efficiency of the industry, by regulations through setting standards of quality of the products and controlling their compliance, and prescription of handling, transport, and storage practices. The *Kenya Meat Commission Act, Cap 363 (enacted in 1967, latest revision in 2006)* and the *Meat Control Act, Cap 356 (enacted in 1972, latest revision in 2007)* regulates slaughterhouses and meat. The *Animal Diseases Act, Cap 364 (enacted in 1965, latest revision in 2012)* regulates the import of infected animals. The *Agricultural Produce (Exports) Act, Cap 319 (enacted in 1921, latest revision in 1964)* regulates the export of non-conform animal products, with possibilities to restrict or ban export and seize and destroy products; and mandatory registration and possible inspection of abattoirs and dairies. The *Livestock and Livestock Products Marketing Board Bill 2019 (pending)* aims to push the adoption of standards and best practices in livestock production and processing.

- Ministry of Commerce

The *Standards Act Cap 496 (enacted in 1973, latest revision in 2004)* established the Kenya Bureau of Standards, promotes standardisation, provides for testing of products, and gives power to examine, test and sample commodities, and inspect processes and manufacturing premises. The *Trade Description Act, Cap 505 (last reviewed 2003)* prohibits false trade descriptions and false indications of price, appoints inspectors and gives them power to inspect premises and seize goods and documents.

Recent reforms and debates

The *2021 Dairy Industry Regulations*, made under the *Dairy Industry Act, 2006*, are an important set of regulations aiming at structuring the milk and dairy value chains. They require the **formalisation** of all economic operators of the value chains, from farmers to processors, traders and sellers, through registration (for farmers), licences, permits and the payment of fees (for traders, sellers, processors, cooling plants), and traceability instruments. Milk must be **pasteurised and refrigerated** along the value chains. Farmers must be paid a guaranteed minimum price for their milk. The delivery of the permits and the enforcement of the regulations is mainly granted to the Kenya Dairy Board (KDB), a parastatal entity.

The *Dairy Industry Bill, 2024* is under discussion. Its approach is similar to the 2021 *Dairy Industry Regulations*, which pushes for increased formalisation of the milk value chain. Its main propositions are to guarantee farmers a minimum price, maximum payment delays by milk processors, introduce mandatory **quality-based pricing systems**, the transformation of the KDB into a Kenya Dairy Authority that would set these minimum prices, and the decentralisation of the licensing (but not the registration of dairy businesses, still centralised).

3.3 Actors of the targeted food chains

3.3.1. Fresh fruits and vegetables and fish chains in Côte d'Ivoire

The characteristics of actors are contrasted across food chains. The **fruit chain** has been historically promoted for export since the 1950s. **Dessert banana** is the first exported fruit by Côte d'Ivoire, the country being the first African producer and exporter of dessert banana, with 80% of exportations destined to European markets (CNE, 2015-2019; Kouamé et Agnini, 2022). Banana exploitations can be small sized (5 to 20 ha), middle sized (100ha, more or less modern) and large sized (average 500ha) but 83% of national production is produced by the **larger highly intensive exploitations** (Kouamé et Agnini, 2022). The obligation to comply with European food safety regulation leads producers to respect strict procedures in harvest, transportation, grading, packaging and storage before shipping and export. Preharvest treatment for dessert bananas mainly consists in preventing fungal diseases (black leaf spot caused by Mycosphaerella musicola or M. fujiensis and fusarium wilt due to Fusarium oxysporum). After harvest, prevention consists in washing fruits with fungicides or chlorine prior packaging. Dessert banana postharvest treatments also include ethylene and gibberellic acid to slow maturation. These substances might leave residue in the fruits if improperly used. However, the majority of dessert banana producers are **certified with sustainable or organic standards**, most common certifications including Globalgap, Rain Forest, Tesco Nature's Choice and "Organic" (Kouamé et Agnini, 2022).

Mango has been introduced in the Northern parts of Côte d'Ivoire more recently but is now the 3rd exported fruit after banana and pineapple (Kouamé et Agnini, 2022). Mango production (Kent variety) is also mostly exported to the European market (95% of exported mango), Côte d'Ivoire being the first African exporter to Europe. The production is based on **smallholder farms** under 5ha, with only a few industrial exploitations. In mango orchards, fertiliser and pesticides use is rare and phytosanitary intervention often limited to fight against fruit flies Bactocera Dorsalis and Bactocera invadens. Mangoes destined for export will undergo several more steps including sorting, cleaning and washing, grading, packing, cold storage, etc. Fungicides can be used in the washing process. Some orchards were able to get private certifications such as Globalgap or Rain Forest Alliance. The propagation of fruit flies is a major scourge, with fruits improper for sale reaching up to 80% of the production (Kouamé et Agnini, 2022). Rejected fruits from the export sector because they are immature, injured, or bitten by insects' fruits, might be sold with those fallen on the floor on national or regional markets. Bancal *et al.*, (2024) estimated that 35% of **mangoes originally intended for export are sold on domestic market** (fresh or processed). Safety conditions for relocated mangos are very different from those exported. They are usually packed in recycled cardboard boxes or wooden crates and collected by wholesalers to be dispatched on local

markets without proper conservation techniques: no traceability, no temperature or pest control, low hygiene transportation and storage and rough handling (Kouamé et Agnini, 2022; Bancal *et al.*, 2024).

Vegetables are mostly grown by **small-scale farmers**, individually or in farmer groups (cooperative, NGOs) for the domestic market. Cropping systems are **conventional**, including the use of chemical inputs (fertiliser and pesticides).

Fish is an important export product to Europe (e.g. canned tuna), but the processed fishes targeted in this study are mostly produced for the domestic market by **small-scale business operators from the informal sector** (in majority **women**), using **artisanal methods**. Food safety hazards might result from water contaminations with heavy metals or poisonous substances, poor hygiene measures in storage, processing and sales conducting to pathogen microbial infestations, or bad practices in processing promoting accumulation of toxic compounds such as PAHs. A portion of smoked fish is for export, and consignments have already been rejected due to PAHs.

Except some export fruits, the targeted food chains in Côte d'Ivoire mostly include small-scale and informal economic operators who have difficulty using practices that guarantee safe foods for consumers. These actors could potentially be interested in food safety laws and regulations,but are usually on the side-lines of standardisation activities. The standardisation process within CODINORM is **inclusive**, which means that a wide diversity of non-state stakeholders (private sector, producer organisations, consumer associations, etc.) are invited to take part of discussion in technical committees**.** However, not all actors from the private sector are able to participate and standards mainly reflect the interests of those involved. Interviewees converge to underline that the private sector is mostly represented by the interests of formal enterprises while **informal operators are poorly considered**. Formal large companies (e.g. Nestlé, Cargill cocoa SARL, OLAM, Coca-cola corporation, Société de Culture Bananière - SCB, Ivorian distributor Prosuma, etc.) have the capacities to actively take part of CODINORM activities. They usually participate into all steps of standard development (projects of standards, working sessions in technical sub-committees, public enquiry, adoption of standards in technical sub-committees and committees) before approval and publication in Official Journal. They can potentially influence standards made subsequently mandatory and sometimes request CODINORM to develop new standards. Conversely, informal operators are, by definition, not registered and not invited to take part to CODINORM activities. However, they must comply with laws and regulations and face controls in places where they operate.

3.3.2. Milk and milk products in Kenya

In Kenya, the milk sector is characterised by many stakeholders who are not well organised or co-ordinated. This means there is no one overarching representative organisation that would potentially play a major role in influencing food safety laws and regulations by advocating for safety issues to be put on the political agenda, or for more or less regulations, and by strongly contributing to the design of regulations. There is in fact a diversity of actor categories with unbalanced power in influencing laws and regulations.

The milk sector in Kenya

The dairy sector is continuing to grow led by increase in consumer demand. Dairy farmers are challenged by an aging workforce, shrinking land, difficulty in obtaining reliable farm labour, and lack of technology and expertise. Consumers are increasingly concerned over milk and food safety. It is difficult to get accurate data for Kenya with estimates for important parameters (e.g. milk consumption, utilisation of inputs) varying greatly.

Most milk in Kenya is produced by **smallholder farmers**. Farmers often prefer to sell via multiple channels (cooperative, private firm, informal trader) in order to maximise advantages of each. They are mainly independent entrepreneurs who are not part of associations or not linked through formal contracts to suppliers or buyers. They have low awareness of and compliance with laws and regulations.

Most milk in Kenya is handled through the **informal markets** (70–80%), which by definition do not fully comply with laws and regulations. Informal stakeholders have a more attractive business model which include a) higher price to farmer; b) lower price to consumer; c) prompt payment to farmer; and d) extend credit to farmer. Milk brokers often supply cooperatives and processors. There is a **semi-formal sector of traders** that does not comply with all regulations but may comply with some. Actors may be members of the Dairy Traders Association.

A few large processors dominate the market creating an oligopoly. They are therefore easier to monitor and regulate. This industry has a traceability system (to some level). It however operates at around 50% capacity indicating lack of competitiveness. **Feed manufacturers** also operate under capacity.

There is often **no clear transition between formal and informal**. Therefore, the description of the compliance with laws and regulations requires three terms: formal, semi-formal, and informal (AGRA, 2019).

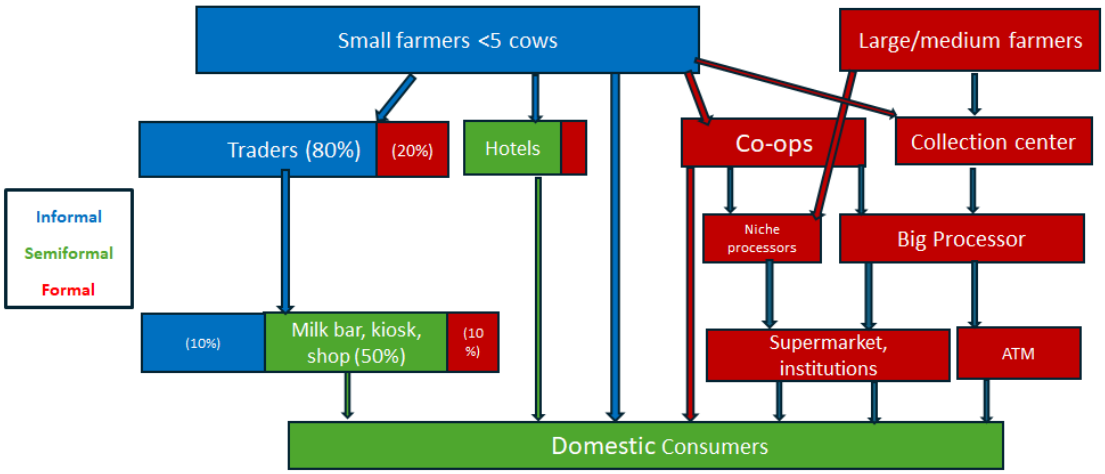
Table 3. Characteristics of formal, semi-formal and informal stakeholders in the milk sector in Kenya

Food Sector	Characteristics	Stakeholders (examples)
Formal	Pay tax, larger, follow employment law, registered or licensed, modern business management, more frequently inspected, able to access financial and other services, high lobbying power.	Large and medium farmers; processors; cooperatives; registered farmers groups; ATMs; registered dairy traders; licensed milk bars. 20% of dairy traders, <5% of milk bars, <10% hotels who are fully compliant with all regulations.
Semi-formal	May pay local authorities, do not pay tax, do not follow employment law, use some modern management, generally considered as legal operators. Sell to and buy from informal and formal sectors.	Consumers; many milk bars; many small shops; many small farmers; many restaurants and canteens. Most small permanent, established businesses as they cannot evade authorities.
Informal	Traditional, almost never inspected, 'fly beneath radar', may pay some fees. Adversarial relation with authorities.	Most small farmers; unregistered traders; roadside sellers; temporary kiosks. Actors who are mobile, transient and can avoid authorities or so marginal and numerous as to be difficult to monitor.

Source: AGRA, 2019 and ILRI.

Most of the milk is produced by small farmers in the highlands of Kenya and urban and peri-urban areas. While many small farmers are members of cooperatives, most of their milk is sold to traders who offer a better price than the cooperatives. The proportion of milk handled by the formal sector is not precisely known and there are incentives in place which militate against accurate reporting. Official support of the formal sector leads to an optimistic narrative where much of the attitudes towards the formal sector is extremely positive, while the reverse is true of the informal sector. This is markedly reflected in media articles, which are overwhelmingly positive. Best estimates suggest around 10% of all milk produced in Kenya and from 20-30% of marketed milk is handled by the formal sector which is also better equipped to largely escapes compliance with laws and regulations (Vernooij *et al.*, 2023).

Figure 5. Informal (green), semi-formal (blue) and formal (red) milk channels in Kenya



Source: ILRI.

Important stakeholder groups

An identification of the stakeholders and their relative interest and influence on milk safety, including its laws and regulations, was carried out. The stakeholder groups were, as in the previous graph, identified according to their level of informality, and whether they are directly involved in the production, transformation, and selling of the products (primary stakeholders), or whether they support or regulate it (secondary stakeholders). The results can be summarised as following.

Stakeholders with highest power and interest in milk safety:

- Large processors: just four or five large processors handle more than 80% of formal sector milk. If milk is perceived to be unsafe their business is at risk. Large processors are well-connected with the government and able to lobby.
- Central regulators: ultimately responsible for milk safety. Major role in setting standards and interacting with international organisations with role in standards and safety (East African Community, African Union, World Organisation for Animal Health, WTO).

Stakeholders with high power and high interest in milk safety:

- Public health stakeholders: milk-borne disease a major public health issue.
- Cooperatives: interest high because poor milk quality impacts business but, because of structure, are less influenced by bottom line than large processors. Some power to influence, although less than large private processors; supported by government.

Stakeholders with high interest but lower power:

- Small farmers: produce 80% of the milk but have low power.
- ATM: high interest but less power as fewer in number and not organised.
- Informal traders: high interest but less power due informality

This description shows **an important disconnect between actors with high aggregate or collective volumes but low influence on milk safety and those with less volume (on aggregate), big ambitions and high influence**. The

informal sector, especially small farmers and informal market traders, have little influence power but high interest in milk safety given that their livelihoods are highly dependent on milk sales and if customers stop buying or government cracks down on their practices they will be strongly affected. They represent 80% of the milk produced and are therefore key to milk safety. The formal sector is powerful and well connected politically, has a high interest in milk safety, and pushes for formalisation and pasteurisation. Some stakeholders with much power have less interest because milk safety is only one of many concerns or because of lack of accountability (county regulators).

Table 4. Interest and influence on milk safety of primary stakeholders according to their formal, semi-formal and informal characteristics

	Interest	Influence	Milk handled	Number of stakeholders
Small farmers (1-5 cows)	High	low	80%	*2 million*
Medium-large farmers)	High	low	20%	*hundreds*
Dairy cooperatives	high	high	10%	*hundreds*
Milk collection centres	high	low	10%	*hundreds*
Traders	high	low	70%	See below
Direct to hotel, consumer	low	low	10%	See below
Large milk processors	High	high	15%	*4 major*
Small processors and added value products	High	low	5%	*Dozens*
Traders affiliated with the Dairy Traders Association (DTA)	High	medium	20%	6,000
Traders un-affiliated DTA	High	low	80%	24,000
Supermarkets, hotels, institutions	Low	medium	15%	*thousands*
ATMs (automatic milk dispensers)	High	low	5%	*hundreds*
Milk bar, kiosk, small shop (duka)	medium	low	80%	*100 thousands*
Consumers (Kenyan)	medium	low	99%	50 million
Exporters	medium	medium	1%	

Source: ILRI. Note: primary stakeholders are actors directly involved production, processing and distribution of milk.
Note: the colour code is green for informal stakeholders, red for formal and blue for semi-formal stakeholders.

Table 5. Interest and influence on milk safety of secondary stakeholders according to their formal, semi-formal and informal characteristics

	Regulation	Interest	Influence
Genetics (Artificial insemination)	Yes	medium	medium
Genetics (local bulls)	No	medium	medium
Feed manufacturers (40% informal – unregistered)	Formal are regulated	medium	low
Animal health service providers (vets, extension)	Yes	medium	medium
Animal health service providers (agrovets – only 50% are licensed)	Weak	Medium/high	Medium/high
Service providers (informal sector drug sellers)	No	medium	low
Government Agencies (e.g. Kenya Dairy Board, Kenya Veterinary Service)	Yes	low	high
NGOs (e.g. Technoserve, Heifer, Farm Input Promotions-Africa)	Yes	medium	medium
Research and academia	Yes	low	medium
Media	Yes	low	low

Source: ILRI.
Note: the colour code is green for informal stakeholders, red for formal and blue for semi-formal stakeholders.

3.4 Barriers to effectiveness of laws and regulations through the lens of actors' strategies

3.4.1. In Côte d'Ivoire, a focus on state capacities and institutional issues

The results of the food safety assessment of collected samples showed that current laws and regulations are not effective in protecting consumers from contaminated food. Based on expert committees and KIIs the following barriers to the effectiveness of laws and regulations were identified.

A lack of enforcement of existing laws and regulations

The most frequently reported barrier was the lack of enforcement of competent authorities who are responsible for carrying out controls and inspections, due to **limited human, financial and logistical capacities** (e.g. inspectors, equipment, capacities of laboratories, etc.). Human constraints are of three types: the insufficient number of state agents, the lack of training or capacity building, and agent mobility. Although the DPVCQ is responsible for phytosanitary controls at the borders, controls of informal vendors on markets and hygiene controls on markets[20], the number of state agents from this directorate (300) is recognised to be far too low. The same situation pertains for the number of inspectors from the DSV responsible for inspections and controls at any time of the food safety of animal products[21] and of fishermen at the port of shipment in particular; and from the DPQN to control industries and small-scale enterprises (6 for the whole municipality of Abidjan). Health certificates for agricultural plant products are therefore not issued in practice by the DPVCQ, food products sold on the domestic market virtually not controlled and samples not collected as part of sanitary controls. The national institute for public hygiene *(Institut National d'Hygiène Publique*, INHP) under the Ministry of Health and the Ministry of Economy and Finances performs inspections in case of food poisoning and at the request of structures open to the public, instead of unannounced inspections to deliver sanitary certificates, because it lacks inspectors (5 in Abidjan) and reagents.

Public laboratories have limited financial and human capacities which explains the slowness of analyses. They lack modern equipment to carry out advanced analyses such as the dosage of heavy metals, organic pollutants, pesticide residues, veterinary medicines, mycotoxins and other chemical substances; or lack trained staff to handle modern equipment. They also lack reagents or chemical products and equipment for field missions (vehicles, thermometers, gloves, coolers, etc.).

The **lack of communication and dissemination of laws and regulations** by the public authorities to the business operators, as part of public action to develop a food quality culture and quality control systems within business operators, was also reported. If not aware, business operators cannot comply with of laws and regulations. This was illustrated by the expert committee with the private sector: participants from formal enterprises underlined the obsolescence of laws and regulations while public authorities' representatives answered that updated versions exist but are not known because information is not enough or not correctly transmitted.

It is worth noting that **implementation constraints are not specific to laws and regulations**. It is quite common in LMICs that policy documents remain not or partly implemented due to a lack of budget. The implementation phase often relies on the willingness and capacity of development partners to fill the gap. This external dependency is illustrated by one interviewee: "*most of the public budget was used for salaries and was insufficient for the analyses, even with the additional resources coming from services delivery. The equipment was often financed with projects, and this created problems for maintenance once projects came to an end*".

Sometimes laws and regulations are not effective because they **lack enactment acts or are incomplete**. The slowness of enactment was underlined as a barrier that affects the functioning of organisations involved in food

[20] Decree No. 2021-799 on the organisation of the Ministry of State, Ministry of Agriculture and Rural Development, December 8, 2021.
[21] Law No. 2020-995 on the Veterinary Public Health Code, December 30, 2020.

safety. For example, the DPQV is expected to oversee the control of MRLs at the borders but has not yet received the Decree to effectively ensure his mandate.

The absence of laws and regulation setting mandatory standards for fresh fruits and vegetables

The current regulatory framework that sets mandatory standards (mostly from the Codex Alimentarius) does not include fresh fruit and vegetables with specific microbiological and chemical criteria. The Canadian norms, the EU regulation and the Codex Alimentarius were used to assess the quality of the collected samples. This absence of reference to specific criteria for fresh fruits and vegetables can be analysed as a **political agenda issue.** Driving forces for agenda setting, such as consumer associations, research or the media, have limited resources and power in the context of Côte d'Ivoire. Consumer associations have limited means in Côte d'Ivoire. They lack capacities to effectively participate in all sessions organised by CODINORM and to bring the consumer interests into the discussions. They can hardly be influential to advocate for the issue of mandatory standards for fresh fruits and vegetables to be put on the political agenda[22]. The contribution of media in raising awareness is also limited (Montet *et al.*, 2017). The media coverage of food safety risks is only occasional, when food poisonings occur, and we found much more articles on fish (smoked fish) than on fresh fruits and vegetables.

Data and research on the safety of fresh fruits and vegetables are relatively limited. Participants from the Ministry of Agriculture in the public actors "expert committee" recognised that they lack agricultural statistics on fruits and vegetables in general, the priority being given to staple and export crops. State agents from the *Office Public des Cultures Vivrières* (OPCV) lack of means to collect data on agricultural production, food flows and to communicate statistical reports. The lack of research data on emerging food safety risks, such as those linked to pesticides or ripening products, could also contribute to the lack of a political agenda for pesticide residues. Lab analyses on chemical residues require advanced skills, is costly and requires specialised equipment.

Formal large companies are mostly export-oriented and seem not to be influential regarding mandatory standards for the domestic market. They invest time in CODINORM activities and have already requested new standards, as it was reported for the organisation on dessert banana, but these are voluntary standards. The demand for mandatory safety standards usually comes from the competent authorities. The absence of laws and regulations setting mandatory standards for fresh fruits and vegetables also reflects the **complexity** of setting accurate and adapted MRLs for informal sector actors. As stated by one key informant *"with too stringent standards on pesticide maximum residue limits for fresh fruits and vegetables the Ivorian population would simply stop eating tomatoes"*.

The inadequacy of laws and regulations with capacities of informal operators

Large formal companies usually have their own quality systems, including international certification schemes (Food Safety System Certification, GlobalGap, Rainforest Alliance, etc.) and lab analyses (e.g. the case of Nestlé), to comply with Ivorian and international standards. Furthermore, regulatory texts and institutions related to the support of the private sector only target formal business operators. According to the Law N°2°13-866 of 23 December 2013 about standardisation and quality promotion, the role of the State is to accompany enterprises to understand and comply with standards. The Ministry of Commerce, Industry and promotion of SMEs supports enterprises from the formal sector. CODINORM disseminates standards and provides training to economic operators mostly from the formal sector.

In the case of fish, updated laws and regulations have been set and barriers to their effectiveness relate more to the **difficulty for informal actors to comply** with standards and good hygiene practices. This again raises the

[22] It was noted by key informants that, in France, consumer associations have a legal delegation to request expert collectives to work on specific issues within the national agency on food safety, environment and labour (*Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail*, ANSES).

question of the level of standards and their adequacy for the informal sector. Capacity building of informal sector operators, training and low-cost technologies are critical in this regard, but usually requires they are organised. The FAO Thiaroye Technique (FTT)[23] was mentioned as a low-cost technology for smoking fish. The case of UNSCOMAFHA was also mentioned as they received trainings on good hygiene practices and smoking practices from the Ivorian State, FAO and INADES Formation. The high illiteracy rate among informal operators was raised as an issue for compliance with standards as it makes sensitisation on good hygiene practices more difficult. Representatives from local authorities also stress the difficulty to organise sensitisation and controls with informal vendors due to their mobility. At the same time, it was underlined that too stringent sanitary rules for informal vendors have pervasive effects and might encourage fraudulent practices.

The challenges of a coordinating organisation

The **lack of coordination** between all organisations involved in food safety controls has been frequently reported as a barrier to the effectiveness of laws and regulations. The institutional landscape was repeatedly qualified as segmented or fragmented, leading to overlaps. This is illustrated by one interviewee from the Ministry of Agriculture: *"each structure organises its own control. For the moment, there is no collaboration. Everyone gets up and does their own checks, which means that the business operator feels harassed, because the Ministry of Health official will come and say that I'm in charge of health. He'll ask you for a health certificate. After that, the Ministry of Trade will say I'm checking the metrology of equipment and products. They do their inspection and leave. (...) we would say no, the products you sell, the MRLs, (....) from a phyto-sanitary point of view, it's not good. (....) So, this creates overlap."*

The weakness of the **chain of decisions and responsibilities** in case of food poisoning and need to withdraw the concerned product from the market was also reported. The delegation of responsibility that would help the system of response to sanitary crises be efficient 24 hours a day does not exist. There is a lack of laws and regulations that clearly define who sees the problem within the government, who receives the alerts and who is responsible to implement a rapid response to the crisis (exemption of the hierarchy). Better coordination between existing services responsible for controlling and stopping problematic activities is seen as a way to combine efforts. An effective system would be one with clear responsibilities for each actor: decision-makers to communicate when a danger is identified and to prevent the spread of the problem; controllers to react as short as possible after the alert; experts to advise decision-makers; business operators to comply with food safety laws and regulations.

The need of a coordination framework emerged as a strong recommendation from the expert committees and the interviews. According to one representative from the Ministry of Agriculture, a **coordination agency** would help *"to clarify texts, to say you, your mandate stops here, your mandate starts here. And it is also to create a real framework of collation between structures so that the economic operator doesn't feel too much rushed by controls"*. The case of the National Food Safety Agency *(Agence Nationale de la Sécurité Sanitaire des Aliments, ANSSA)* in Mali, created in 2003, was mentioned by one public actor as a reference experience in the WAEMU[24]. More recently, in 2017, a national food safety agency (*was mentioned by one public actor*) was also implemented in Benin.

This recommendation for a coordination agency was already proposed by the 3C Ivoire project funded by the EU (EuropeAid) from 2011 to 2015. A detailed diagnosis of the food safety system concluded that there was "a multiplicity of structures intervening at the institutional level and a lack of coordination and communication

[23] The FAO Thiaroye Technique is a new fish smoking technology pioneered by FAO that helps to produce safe and quality smoked fish with low levels of Polycyclic Aromatic Hydrocarbons (PAHs).

[24] https://maliactu.net/mali-agence-nationale-de-la-securite-sanitaire-des-aliments-anssa-une-piece-maitresse-de-la-prevention-de-plus-de-70-des-maladies/

within the organisations involved" (Montet *et al.*, 2017). The number of ministerial structures involved in food inspection which tend to produce reports in isolation was identified as ineffective risk management.

The project set up an experimental **national coordinating committee for food safety** whose mandate was "to assess the effectiveness of health controls, prevent health risks and coordinate scientific actions, national actions of food safety and disseminate information" (Montet *et al.*, 2017). This committee was based on the model of a national agency which recognises the independence of scientific expertise. An experimental **national expert committee** to document food safety problems was also created, with 15 experts selected considering their expertise, the multi-disciplinary and the absence of conflict of interest (Montet *et al*., 2017). The 3CI project clearly stated that the National Coordination Committee for Food Safety would steer ministries' activities but not act as a control agency to avoid any substitution. This recommendation seemed to be taken up when a ministerial **Decree in 2016 set the creation of a public food safety agency** to coordinate food safety activities (Montet *et al.*, 2017). The official opening ceremony of this agency was organised by the interprofessional fund for agricultural research and advice (*Fonds Interprofessionel pour la Recherche et le Conseil Agricoles*, FIRCA) on January 24th, 2017, and the Minister of Research of Côte d'Ivoire publicly announced the creation of the agency (Montet *et al*., 2017)[25]. Following the 3CI project, another study financed by the European Development Fund and carried out by FIRCA had the aim to implement the National Agency for Food Safety.

Yet, no progress was made since the end of the FIRCA study in 2019. In June 7th, 2023, the Decree No 2023-559 designated LANADA to "facilitate the exchange of information, consultation and harmonisation of sectoral food safety policies" (article 5) and to include a **Sub-Directorate for Food Safety "responsible for coordinating all activities relating to food safety"** (article 18 bis). This Sub-Directorate is now commonly named as the public agency though it has not the ambition of the National Agency recommended by the 3CI project.

Some interviewees underlined that more information and communication would have been needed to better explain that the National Food Safety Agency would not substitute the ministries in conducting sanitary controls. However, the **risk of competition** inevitably occurs when a new organisation is set up, especially in contexts of limited public resources. Any new organisation requires budget, staff, equipment and reconfigures the institutional landscape in terms of prerogative, means or even prestige. This risk was perceived by the existing execution organisations and can explain their resistance to plan to create a new organisation, as reported by one interviewed public actor: *"it's like taking away their prerogatives".* Interestingly, the main argument to justify the creation of a Sub-Directorate in a pre-existing structure instead of creating a public agency was that the government did not want to complexify further the institutional landscape and preferred to strengthen existing organisations rather than diverting limited resources.

3.4.2. In Kenya, laws and regulations as a tool in a long battle for the access to the milk market

As seen in the systematic literature review, many hazards are present in milk, including in the pasteurised milk and in formal food chains. This shows a low of compliance with regulations across the food chains. To identify the reasons of non-compliance and the possible paths forward, data was produced in the form of an expert workshop, focus groups discussions, and key informant interviews.

Reasons of low compliance

Issues are related to the structure of public action, consumers' willingness to pay for quality, and a fraught history of competition between the formal and informal sectors.

[25] For example, the 2016-2020 National Multisectorial Plan of Nutrition states that "The Government has begun the process of formalisation of the Ivorian Food Safety Agency (*Agence Ivoirienne de la Sécurité Sanitaire des Aliments*)".

Many **regulations and policies** exist but **are not fully coherent**. There are ongoing efforts to address this challenge: Kenya's parliament is considering a *Food and Feed Safety Control Bill*, which, if approved, will coordinate the different government agencies involved in food safety by establishing the office of the food safety controller.

The most recent initiative to improve milk safety was the *Kenya Dairy Industry Act and Regulations, 2021*. In general, **enforcement** of laws and regulations is irregular and rare because regulators lack resources for enforcement and because the informal sector comprises a very large number of small businesses. Some specific provisions of the *Dairy Act and Regulations* are difficult to enact. The *Regulations* require farmer registration, more reporting by business operators, meeting hygiene requirements; stops selling of raw milk by vendors and farmers; setting minimum price; and increased traceability. Compliance is partial: compliance with licensing is estimated to be highest for feed manufacturers (60% licensed), followed by agro-vets (50% compliance) and by milk traders (30% compliance). From the point of view of small businesses, a pervasive problem is that **too many licenses** are required to operate a business. This leads to excessive cost, transaction cost, and non-compliance. Farmers do not require licensing.

Also, policy and regulations are made **in the absence, or contradictory to evidence** regarding milk safety for public health. The regulatory framework is largely based on that of high-income countries and not on the needs of the majority informal sector. The regulated milk chain operators are perceived to incur high costs and have not benefited from regulatory compliance. Many **customers prioritise a low price** and the current quality rather than paying the extra cost for the quality assurance provided by the respect of regulations – and, as seen in the SLR, pasteurisation does not guarantee safe milk for customers. **Milk is not rewarded for quality**, considering that in Kenya, like in many LMICs, there are safety issues and improving quality is often correlated with improved safety. Quality-based payment schemes are therefore incentives to improve quality and at the same time to improve food safety. However, these schemes have not been financially sustainable. Inadequate cooling facilities and transportation challenges (including containers) lead to milk quality degradation. Informal milk stakeholders (small farmers, processors, informal market trader) lack human and financial capacity to be fully compliant with current safety regulations, and lack of benefits from compliance while they are those the most vulnerable to regulatory overreach and punitive regulations. Therefore, small businesses often prefer **strategies of avoidance of controls** that are either individual (corruption) or collective (information sharing of controller patrols, hide-and-seek).

More broadly, stakeholder **conflicts of interest** (COI) underly some of the dairy sector challenges. These conflicts are more at the national level than at county level. Most COI deal with income and this is related to regulatory compliance. For business stakeholders, profit motivation incentivises them to a) disadvantage other businesses (disloyal competition) (e.g. formal processors took out adverts claiming informal sector milk was dangerous) and b) avoid compliance. Regulators charge for services offered but this is in conflict with informal sector vendors' desire to reduce costs and make profits, especially when vendors do not always see a direct benefit in the services charged for. Farmers and traders have long memories, and the relationship between the formal and the informal sectors have been fraught for decades. Even when the regulatory system improves (and there have been recent improvements) it takes time to regain trust lost because of previous problems.

Going forward

The demand for milk in Kenya is important and growing over the long term. Cost of living crisis may have reduced demand temporarily, but imports of milk from Uganda have increased and stabilised in the past 5 years, underlining the strength of demand. The production potential of the country is significant and much higher than the current production. The emergence of new milk brands and increasing use of milk ATMs and pasteurisation

facilities suggest innovation and growth. Goat and camel milk are emerging as niche markets with significant potential.

At the institutional level, the recent **African Union Food Safety Strategy for Africa** provides an excellent framework for improving food safety and food safety regulation but has yet to be operationalised at national level. Improving coordination and communication between key government agencies (especially Ministry of Health, Kenya Dairy Board, and County Councils) could improve compliance and milk quality and safety. This could include combining operating fees in a "one stop shop" mechanism moving towards **less punitive and more positive enforcement** of regulations, and increasing the number of trained inspectors.

Processors are best placed to improve the safety of milk from aggregators and cooperatives. However, processors operate at 50% capacity. Building cooperation and **collaboration between informal and formal sectors** would make sense economically and in terms of milk safety. A way to help the informal sector vendors to comply with regulations could be to organise them into groups and providing them loans for bulk pasteurisers and engaging NGOs to support capacity building and infrastructure development for informal traders.

Cooperatives and aggregators are best placed to improve the safety of milk from farms. Fluctuating milk prices and low profitability discourage farmers from sustaining dairy farming. High production costs and poor feed quality further exacerbate economic difficulties. Improving the stability of the price paid to farmers would help develop the production sold. Developing a **cost-neutral quality-based payment systems** would incentivise the production of high-quality milk.

Government-led **training and education campaigns** would be useful for consumer and farmer education about milk safety and quality. Utilising digital tools like mobile apps would also help improve extension services and farmer training. Promoting the use of digital weighing scales and milk analysers could enhance the accuracy and transparency in milk quality assessment. Encouraging the adoption of tamper-proof aluminium or plastic containers would help maintain milk integrity during transport.

4 Discussion

This study aimed to assess the effectiveness of laws and regulations in improving food safety and quality in two countries and several food chains, milk sector in Kenya and fresh fruits and vegetables and fish in Côte d'Ivoire. The two countries feature similar challenges that are convergent with what is found in the literature regarding food safety in LMICs. Furthermore, the proposed analytical framework and the comparative perspective across the food chains add new insights on the analysis of barriers and levers to effective laws and regulations.

A low effectiveness of laws and regulations to improving food safety and quality

There is a dense regulatory framework progressively built over decades in the two countries. Kenya has a national food safety policy and Côte d'Ivoire is developing one. Laws and regulations for animal products in Côte d'Ivoire are updated while there is no laws and regulations that apply to fresh fruits and vegetables, and especially no mandatory standards regarding pesticide residues which is often observed in LMICs (Aworh, 2021).

We showed in the two countries that current **food safety laws and regulations are not effective to guarantee safe foods** on domestic markets for all the food items targeted in this study. The microbiological and chemical analyses on fresh fruits and vegetables and fish in Côte d'Ivoire have concluded that their quality is unsatisfactory. The SLR on milk safety in Kenya brings evidence of higher contamination of raw milk sold by informal traders compared to pasteurised milk from formal traders but the latter, which should be safe, is often also contaminated. A result already underlined in Tanzania (Blackmore *et al.*, 2022a) and in Kenya by (Blackmore

et al. (2015) who reported that "food sold in the informal sector is not necessarily risky and food in the formal sector is not necessarily safe".

High contamination does not mean the risk for consumers' health is high. The risk analysis conducted in Côte d'Ivoire with estimation of the production and consumption patterns of the targeted foods shows that the risk for consumers is low. Regarding milk, the literature underlined that because milk is usually boiled or consumed quickly the risk of disease for consumer is low (Blackmore *et al.*, 2022b). However, in both countries, the lack of data was raised, especially for fruits and vegetables in Côte d'Ivoire. The SLR also shows that most studies focus on hazards and indicators of hazards rather than on risk assessments, and most studies provide data on the presence of substances with minimal risk for public health while crucial pathogens are overlooked, thereby highlighting research gaps.

This lack of accurate data means that laws and regulations are not always evidence informed. Historically, the regulatory framework has been framed on the model of that of high-income countries and not based on the local situations and practices of business operators who mostly evolve in the informal sector.

Public institution capacities

- Weak state capacities to enforce laws and regulations

The **low capacity of competent authorities in food controls to enforce existing laws and regulations** on standards, licensing and registration, is a barrier to their effectiveness. In both countries, the lack of resources for enforcement while the targeted food chains comprise many small operators in the informal sector was raised. The **lack of inspectors** to control the application of laws and regulations is a problem extensively stressed in the literature about food safety in LMICs (e.g., (Blackmore *et al.*, 2022a; Boatemaa *et al.*, 2019; Oloo *et al.*, 2018). While laws and regulations are the stepping-stones of a food safety system, they are of any worth if they cannot be enforced and implemented (Hadjigeorgiou *et al.*, 2013). Strengthening enforcement of laws and regulations requires therefore increased public resources and capacities for controls, i.e. more inspectors, collects of samples, laboratory capacities, sanctions in case of non-compliance, etc. In LMICs contexts, food safety lacks funding compared to other challenges like lack of electricity, roads or food insecurity (Oloo *et al.*, 2018). More resources could be dedicated to food safety if higher on the political agenda. However, the room for manoeuvre is limited given the general weakness of national budgets.

- Lack of coordination among food control institutions

The lack of coordination of the competent authorities in food controls is highlighted in the two countries. In Côte d'Ivoire, a **national food safety agency** was proposed ten years ago to overcome the lack of coordination and ended up in 2023 with the creation of an intersectoral coordination unit within the public laboratory LANADA. In Kenya, the 2019 *Kenya Food and Drugs Authority Bill* proposed the establishment of a Kenya **Food and Drug authority** to improve and integrate activities of risk assessment, management and communication. A Food and Feed Safety Control Bill is also reflected for better coordination of the different government agencies and for policy coherence.

This problem of coordination is frequently raised in the literature on food safety. This manifests by multiple jurisdictions, a fragmented food safety system/ governance, the complexity of the regulatory framework (Mkhwanazi *et al*., 2024; Oloo *et al*., 2018). Boatemaa *et al.* (2019) highlight problems of overlap and conflicting roles between three departments in South Africa in charge of managing food safety (Health; Agriculture; Trade and Industry), which use different risks management frameworks, inspection methods and enforcement approaches. This situation is often compared to the one of high-income countries where government agencies (e.g. Food and Drug Administration in USA, European Food Safety Authority – EFSA - in Europe) are responsible

for developing and enforcing food safety policies, conducting inspections and monitoring food recalls[26] (Hadjigeorgiou *et al.*, 2013; Mkhwanai *et al.*, 2024). Interestingly, in addition to forming expert committees that mirror those of Codex, the African Union is fronting the formation of an African Food Safety Authority (AFSA) that should set standards for food chains in Africa on the model of EFSA (Oloo *et al.*, 2018).

In this study, we shed light on the difficulty to implement such governance reforms, which inevitably reconfigure the institutional landscape and affect interests of pre-existing structures. Hadjigeorgiou *et al.* (2013) recall that specific circumstances helped to overcome this difficulty in Europe. This is the serious food crises during the 1990s, such as the epidemic of bovine spongiform encephalopathy (BSE), which forced the EU and EU Member States to review their national food safety systems. The authors promote the model of a single food safety agency, or a similar organisation at the national level, to facilitate interaction, cooperation and supervision between the different bodies involved in food control. Though this model is not unique (integrated systems where agencies are assigned jurisdiction on aspects of food safety is another model, Oloo *et al.*, 2018) nor easily replicated in LMICs, the effectiveness of laws and regulations requires the government to clearly set who is responsible for enforcing rules and standards.

Difficulties for informal actors to comply with laws and regulations

The **low compliance of informal actors with the existing laws and regulations** is underlined as a major barrier to their effectiveness. Existing standards are often not respected, as shown by the results of the food safety assessment in both countries. The **cost of compliance** for informal sector actors was indeed raised as a major reason for low compliance in the two case studies. In Kenya, it was mostly referred to the many licenses required to operate a business, or to the amount of obtaining the unified business permit in Nairobi county (around 23,900 KES, valid for one year). The cost of compliance is also in conflict with profit motivation of business actors and their desire to reduce production costs.

Though the low compliance of the informal sector questions the effectiveness of laws and regulations, **formal sector actors are mostly compliant** with laws and regulations. In Côte d'Ivoire, formal export operators of fresh fruits and vegetables and fish have the capacity to comply with laws and regulations of importing countries, though some consignments have already been rejected. In Kenya, it was reported that the formal and regulated milk chain operators are those bearing the cost of compliance while not benefiting from this compliance. However, formal pasteurised milk represents a small share of the market (about 30%) while raw milk from the informal sector remains very popular; hence the **regulation-reality gap** between regulations encouraging pasteurised milk (considered as "modern" and safe milk) and the reality of the market (Blackmore *et al.*, 2022b). In short, informal sector actors in the milk chain have little capacity to comply with laws and regulations but are the most vulnerable to punitive regulations, while the formal sector actors have the capacity to comply but also to evade full compliance.

This asymmetry between formal and informal sectors, or export and domestic products in the compliance with rules and standards is highlighted in the literature. Oloo *et al.* (2018) mention the existence of two tier-food safety operations between multinationals and local startups. In the milk and meat sector in Ethiopia, (Nyokabi *et al.*, 2023) show there is stricter enforcement of food safety standards when these products are destined for export compared to products sold in the local market. Export-oriented value chains have developed tools for **self-regulation** which enables them to comply with the quality standards required by importing countries (norms for handling and processing, traceability, internal standards, auditing techniques, etc.). Overall, the regulatory approach works for formal and export markets but not for informal and domestic markets.

[26] All responsibilities are not always combined. For instance, EFSA has maintained the duties of risk assessment and risk communication while risk management belongs to the European Commission and the Council of the European Union (Hadjigeorgiou *et al.*, 2013).

Inadequate laws and regulations foster informality rather than decrease it

- The inadequacy of laws and regulations with the capacities of informal sector actors

As stated by Blackmore *et al.* (2015) and repeated in this study for the milk sector, ***"when five per cent of milk fails to meet standards, you have a problem with milk. When 50 per cent does not meet standards, you have a problem with standards"***. Beyond the cost of compliance, one of the main reasons for the low compliance of informal sector actors with laws and regulations is the inadequacy of rules and standards with their capacities. Most of the norms set to regulate the quality of the products are indeed about maximum concentration of contaminants (MRLs) established at the international level with the purpose to support international trade. They should be acceptable to all countries including high-income countries, the most demanding ones. The WHO strategy for food safety advocates for *first* strengthening national laws and regulations based on the Codex Alimentarius standards, and their enforcement by the public administrations (WHO, 2022).

However, these international norms are stringent, making unrealistic their compliance in LMICs by food chain actors who mostly operate in the informal sector and for the domestic market. Most LMICs have not developed national fine-tuned local norms for many contaminants. Many papers in the literature about food safety systems in LMICs observe that the level of contaminants on domestic markets is high compared to international standards. They often advocate either for laws and regulations more tailored to the local situations, or for more rigorous enforcement by the public administrations. Reaching such goals would require changing the laws and regulations or strengthening the administrations in charge of controls. Such strategies have rarely been developed.

Developing ever stricter laws and regulations or strengthening the enforcement of laws and regulations by the police would likely be **unsuccessful and have pervasive effects on the informal sector**. Our findings are consistent with studies highlighting the perception of the informal sector actors being harassed. In the milk sector in Tanzania, the tensions between regulators and informal actors leads to "**adversarial relationships**" because of harassment, physical abuse, confiscation of goods and forced relocations (Blackmore *et al.*, 2022a). Blackmore *et al.* (2015) underline that criminalising informal vendors has been unsuccessful and leads informal sector actors to run their business "underground". Furthermore, in most LMICs, a robust legal framework is already in place for food safety. Limiting the public action in food safety to strengthening enforcement may also indirectly increase the economic costs of the products.

The recognition of the failure of this traditional approach of laws and regulations to improve food safety on domestic markets and the need to avoid **over-regulation** is at the heart of the **African Union Food Safety Strategy for Africa 2022-2036**: "Governments will require a paradigm shift in the way regulation is conducted. The traditional 'command and control' model is not well adapted to informal food markets where most of the population source their food in Africa" (African Union, 2021, pxi).

- The lack of inclusiveness of informal sector actors in the design of laws and regulations

The inadequacy of laws and regulations with capacities of informal sector actors raises the **issue of the way laws and regulations are designed**. The **lack of inclusiveness of informal food chain actors** in the design process of laws and regulations contributes to a disconnection between the level of rules and standards and their capacity to be compliant. Most often, food safety laws and regulations are made with and for formal enterprises while informal actors who make up most of the food systems in LMICs are left behind. This observation is consistent with other studies stressing that informal actors are not well represented in policy discussion and food safety

systems (Blackmore *et al.*, 2022a; Oloo *et al.*, 2018)[27]. Though it is recommended to organise consultations with those likely to be impacted by the national food safety systems (e.g., WHO, 2022), the particular attention to be given to the informal sector is often missing. The development of the African Union Food Safety Strategy is a step towards this attention. The participatory process adopted for its formulation contributes to stronger adequation with the realities of Africa and the informal sector.

It must also be recognised that **laws and regulations can be an instrument of power** for formal business operators to develop their position on the market while delegitimising and evicting informal sector operators. In Kenya, the domestic market for milk is the subject of a competition between formal and informal sectors actors. Previous studies in the milk sector in Kenya have highlighted the influence of vested interest of large operators on regulation, to reduce competition and gain greater market access (Blackmore *et al.*, 2015). It is also convergent with other studies in Tanzania, where the government has adopted a pragmatic and permissive approach regarding the legislation on licensing in the milk sector, but the formal sector calls for stricter enforcement (Blackmore *et al.*, 2022a). The situation is different in Côte d'Ivoire as formal business operators involved in the targeted food chains are more interested in exports than in the domestic market.

Lastly, **not all risks of contamination are explicitly addressed in the regulatory framework.** The case of Côte d'Ivoire showed that "emerging" safety risks such as pesticides residues in fresh fruits and vegetables sold on the domestic markets are not covered in the most recent regulatory texts. The absence of reference to either national or international MRLs often leads labs to use regulations from industrialised countries. Studies on pesticide residues in fruits and vegetables in Ghana and Egypt that used EC regulation found high proportions of samples exceeding MRLs, while a similar study in South Africa using the national regulations found most of the samples detected with pesticides were compliant with South African regulations (Mutengwe *et al.*, 2016). The absence of text setting specific mandatory standards for fresh fruits and vegetables on the domestic market can be analysed as a political agenda setting issue. In contexts where consumer associations and media are often weak, it is unlikely that the social demand will be the most driving force of the political agenda for food safety. However, it is observed an increase in consumer demand for higher quality and safer food products in LMICs (Oloo *et al.*, 2018). Media can also have a leading role in bringing attention to safety issues as it was the case in the listeriosis crisis in South Africa (Boatemaa *et al.*, 2019). Furthermore, the risk assessment carried out on fresh fruits and vegetables samples in Côte d'Ivoire showed that the risk for consumer health is minimum. The setting of microbiological and chemical MRLs for fresh fruits and vegetables should therefore be cautiously developed.

Variations by food chains

The salience of the above issues varies greatly according to the characteristics of the food chains (Table 6Table 6). Based on the cases studies developed in this report, and on the existing literature, we can highlight recurring patterns of relationships between the stakeholders and the laws and regulations, hence of their effectiveness.

Export-oriented food chains exhibit a high compliance with food safety standards. The cost of the quality control is supported by exporters (self-regulation) and importing countries, and the economic risk of compliance with food safety standards rests on exporters. The standards they adhere to are mandatory quality standards of the importing countries, but also more ambitious private standards on a voluntary basis to satisfy affluent consumers' demand. The exporting countries have not developed national laws and regulations for the food safety in these food chains for their own domestic market.

[27] The issue of inclusiveness and representativeness of actors who are not (or not well) organised in the governance of public problems is not specific to food safety, and to LMICs. The same observation can be made with populations affected by food insecurity and malnutrition, whose voice tends to be indirectly represented by local or international NGOs.

Domestic-oriented food chains have a low level of compliance. Most of the production is made by small-scale farmers who receive little support and training by public extension services. The products are sold unprocessed through small- or medium-sized traders onto informal markets, or processed with artisanal methods by small-scale processors. The quality of the products is assessed by the final consumers, who are sensitive to quality and price and cannot afford the costs of quality guaranteed by a formal standards-based system. There is a potential need for public action to improve public health; however, the issue has not yet gained prominence on the political agenda. Improvements require the establishment of the issue as a public problem, mobilising a set of relevant public authorities and private stakeholders, and a food systems approach, that addresses the food safety issues within the broader scope of the food chains, to foster the evolution of economic models and arrangements among stakeholders.

Value chains with both domestic and export orientations combine these features, which leads to contradictions and potentially conflictual relationships.

Table 6. The effectiveness of laws and regulations according to the characteristics of the targeted food chains

Food chain	Effectiveness of laws and regulations	Characteristics of the food chain	Barriers
Fresh fruits for export	Effective: - Ability of importing countries to enforce their laws and regulations (controls, sanctions) - Ability of export companies to comply with laws and regulations of importing countries (significant economic losses in case of rejected consignments)	Formal sector Mostly large-scale farms for dessert bananas Mostly small-scale farms for mango Self-regulation: internal quality system, private standards, internal training for farmers	No interest of export business operators in the domestic market, hence in national laws and regulations regulating this market
Fresh fruits and vegetables for the domestic market	Not effective: - no specific mandatory standards for microbiological and chemical quality - lack of enforcement of existing general laws and regulations	Mostly small-scale farms Mostly informal sector actors Often misuse of pesticides and ripening products for vegetables and fruits No certification system (except limited initiatives of PGS)	Increasing consumer demand for food safety but weak consumer associations to influence the political agenda for specific laws and regulations
Processed fish for the domestic market	Not effective: - lack of enforcement of existing laws and regulations - cost of compliance - lack of inclusiveness of informal sector actors	Mostly informal sector actors Low capacity of small-scale processors Bad hygiene practices Limited training (mostly through development aid projects)	Inadequacy of laws and regulations with capacities of informal actors
Milk	Mostly effective for pasteurised milk Mostly not effective for raw milk	Majority of informal sector actors on the domestic market (raw milk very popular) Competition between formal and informal sector actors on the domestic market	Inadequacy of laws and regulations with capacities of informal sector actors

Source: authors.

Limitations

This research study has several limitations:

- The study enables to highlight the perceptions, interests and influences that different stakeholders involved in the targeted food chains and the food safety system have on laws and regulations. However, future research could focus on better understanding the perceptions of business operators on food safety issues

and on analysing their current food safety management practices to give insights on what could be a more bottom up and inclusive approach of laws and regulations.

- The issue of lack of enforcement of laws and regulations was identified as one of the main barriers to their effectiveness but it was not possible to collect information on how the current enforcement is deployed on the national territory. For instance, the following questions remain unanswered: are there territorial disparities in the controls? Are these controls mainly focused on large urban municipalities? What is the role of local authorities in ensuring a territorial coverage of controls?
- The lack of inclusiveness of informal sector actors in the formulation processes of laws and regulations was raised as one explanation of their limited effectiveness. However, it would be interesting for future research to analyse precisely such processes. Specific case studies of laws and regulations could be analysed using a political science analytical framework in order to describe precisely how the issues were framed and formulated, who the actors were, what their visions and interests were, what the debates and power relations were, and how this resonates with the political economy of food chains.

5 Conclusion and policy recommendations

Setting rules and standards that are made mandatory by laws and regulations, controlling their application and providing sanctions in case of non-compliance has historically been the approach for governments to manage food safety. Evidence of the persistent burden of food-borne diseases in Africa despite some progress shows that laws and regulations are not effective enough to protect the consumer health. Two studies were conducted in Côte d'Ivoire on fresh fruits and vegetables and fish and in Kenya on milk to assess the effectiveness of laws and regulations to improve food safety and quality in the targeted food chains.

In both countries, the data collected on the safety of the targeted food products confirmed high levels of contamination for several contaminants but the risk for health was limited or not enough studied. The case of Côte d'Ivoire stressed the low state capacity to enforce laws and regulations, the lack of coordination between organisations which tend to compete, and the disconnection between existing standards in fish and the capacity of informal sector actors. Formal sector actors are mostly oriented towards export market and have low interest in more effective laws and regulations for the domestic market. In Kenya, the results showed that laws and regulations are not adapted to the capacities of actors involved in the informal milk sector because of the cost of compliance, and may generate perverse effects by fostering informality. The research study confirmed the interest of using an analytical framework built on policy analysis and political economy, and to set up interdisciplinary research teams to study issues related to laws and regulations.

Based on these results, the research study recommends two avenues for action to improve food safety in Côte d'Ivoire and Kenya that could be useful for other LMICs:

A new approach for designing food safety laws and regulations

Laws and regulations remain necessary to contribute to food safety, but their design process should be substantially renewed to ensure they are adapted to the realities of food chain actors, especially from the informal sector, and thus more effective. A more inclusive and gradual process with informal sector actors is critical if we want them to comply with laws and regulations.

Informal sector actors should be involved at the very beginning of the design process of laws and regulations[28]. All food chain actors (farmers, traders, and retailers) in informal markets are indeed *de facto* managers of food

[28] This is an observation relevant for policy-making processes in general. The importance of consultation with industry stakeholders to ensure compliance and effectiveness of regulatory frameworks was also stressed fir industrialised countries (see for example Garcia *et al*., 2013 about food safety co-regulation).

safety (Grace, 2015) and their risk management strategies should be taken-into account. In the milk sector, several studies in Tanzania and Kenya have shown that milk informal market actors are concerned with food safety and quality and recommend building policy interventions on the **indigenous practices** they use to mitigate risk (e.g. Blackmore *et al.*, 2022a, 2022b). It must be noted that legitimising the informal sector and recognising its importance, strengths and challenges (Blackmore *et al.*, 2015) constitutes a **complete shift** in the way food safety systems are set. The **difficulty to engage with informal sector** actors should also not be underestimated: low-skilled operators, mobility, often no representatives, fear to be exposed and sanctioned (Blackmore *et al*., 2022a). There is therefore a need to reflect on how to engage with informal sector actors and how to address the lack of voice and representation of the informal sector in policy making (Blackmore *et al.*, 2015).

Furthermore, because of high non-compliance with standards that are unachievable by the informal sector **a "staircase" approach** is recommended to gradually improve food safety. As a pragmatic approach, future laws and regulations could for instance consider the possibility to set **progressive standards** adapted to the informal sector (Alpha et Broutin, 2009) The development of **regulation for the informal sector** is therefore an area for future research (Aworh, 2021; Mkhwanazi *et al.*, 2024). This is the aim of the EU-funded Up-Rise project on managing the risks of mycotoxin contamination in fermented products, which are mainly supplied by the informal sector actors in African countries.

The use of other policy instruments to improve food safety

Even better designed laws and regulations will not suffice to ensure safe foods for consumers. Laws and regulations are not the unique tool in the hands of policy makers to improve food safety and many other policy instruments can be used: incentives, delivery of public services such as infrastructures (storage facilities, market infrastructures, education, etc.), sensitisation and communication, etc. A comprehensive public policy that addresses food safety as a public problem is critical for policy direction, mobilisation of resources and policy instruments, coordination and compliance with laws and regulations (Mkhwanazi *et al.*, 2024; Oloo *et al*., 2018).

The following policy instruments could be considered to leverage **public and private investments** (EU Global Gateway Strategy):

- **Infrastructures**: they are critical to providing food chain actors with a better and safer environment for their business. The improvement of fish processing sites was recommended in Côte d'Ivoire, where only four landing stages exist for the whole country. Market infrastructures to improve basic hygiene in wet markets is an area of investment for local authorities and other stakeholders. Wholesale markets in many places of SSA are in very poor shape, heavily congested, badly maintained and sometimes badly designed and constructed (Aworh, 2021). The absence of adequate infrastructures such as electricity for proper refrigeration, potable water, waste disposal and storage facilities, is indeed identified as a key barrier to comply with food safety regulations (Aworh, 2021; Boatemaa *et al.*, 2019; Nyokabi *et al*., 2023). Conversely, good infrastructures in packinghouses for market preparatory treatment (sorting, grading, washing, etc.), in storage, and transportation infrastructures such as cold chains using renewable energy, and in markets will contribute to food safety (Arworh, 2021; Mkhwanazi *et al.*, 2024).
- **Technological solutions**: many low-cost (and low carbon) technologies have proved to be effective in improving food safety. For example, FAO Thiaroye Technique (FTT) ovens are recommended for the safety of smoked fish. Their access could be promoted in major fish production areas through raising awareness and advertising of these low-cost technologies. In the milk sector, technological solutions exist to overcome inadequate cooling facilities and transportation challenges: e.g., lactoperoxidase, hydrogen peroxidase, mazzicans (an innovative container for storing milk) and boiling. The main issue is the access to finance by small-scale operators to invest in these technologies. It is raised in the literature that limited access to capital to invest in equipment such as aluminium containers, coolers and fridges is a main barrier to compliance

with food safety regulations (e.g., Nyokabi *et al*., 2023). Among the technologies promoted in the literature, ICTs used by cooperatives and aggregators is also seen as a lever to improve traceability and food safety (Aworth, 2021).

- **Incentives**: it was particularly raised in the case of Kenya that milk actors lack incentives to improve food safety and benefit from compliance. There is a need to move from a punitive to a more positive enforcement of regulations with for instance a cost-neutral quality-based payment system.

- **Training**: the literature stresses the need for tailored training, that reflects local social, cultural and economic context to incentivise compliance (Nyokabi *et al*., 2023) and that recognises the complexity of impact pathways to ensure effective training (Blackmore *et al*., 2022a; Boatemaa *et al.*, 2019). Training should focus on informal sector actors, as they are those in most need to be capacity built on good agricultural and good hygienic practices. Training will not only improve their practices and the safety of their products but also contribute to give them a stronger voice and be better considered in the food safety system (Boatemaa *et al.*, 2019).

  Many modalities of training are possible: development of professional training, training of trainers, guides on good hygiene practices, on response to crises to sensitise all food chain actors, etc. An example of training in the milk sector is the Training and Certification (T&C) scheme implemented by the KDB to facilitate a progressive licensing and formalisation of informal businesses (Blackmore *et al*., 2015). The European Commission supports the Better Training for Safer Food (BTSF) programme, which provides courses on various aspects related to food safety and includes a network of National Contact Points from over 80 non-EU countries. Public extension services could also play a major role in improving the quality of production throughout the country. They have been severely weakened since the wave of structural adjustment plans in the 1980s-1990s, but initiatives exist to use digital tools to overcome the lack of staff (e.g. hotline) and to revise curricula towards more agroecology and nutrition.

- **Support of the structuration of food chain actors**: better organised informal sector actors (e.g. farmer cooperatives, associations, etc.) can help them to benefit from training and loans to invest in equipment and technologies, and to influence laws and regulations. Strengthening consumer associations is also a way to make consumer concerns about food safety more audible, to raise consumer awareness and give them a stronger role in food safety systems (e.g. Oloo *et al.*, 2018).

- **Sensitisation and education**: all food chain actors involved in production, storage, transportation, processing, distribution, consumption need to be sensitised about risks of food safety hazards associated to their practices. National sensitisation campaigns on food safety are usually recommended. In Côte d'Ivoire, it was for instance recommended to launch a campaign against the use of wood rubber for the smoking of fishery products, using all media. General public education and improved curricula in tertiary education can also contribute to increase public awareness and food safety expertise.

Overall, the proposed recommendations advocate for **a new framing of food safety in LMICs focused on the informal sector and the domestic market**. Laws and regulations have been historically framed as a way to facilitate international trade, with substantial technical assistance provided to formal export business operators to help them comply with high international standards. The spillover effects of this approach on the informal sector have been limited. Though high standards are relevant for export value chains on the global market, a progressive (or "ladder") approach might be relevant for domestic markets and regional trade, starting from the existing level of food safety and progressively increase the level of standards. Specific technical assistance programmes should be geared towards the informal sector (WHO, 2022), where most of the improvement in the quality of production, handling, transport, and sale of products is needed. Intermediary actors working with

the informal sector (e.g. associations, NGOs) are critical entry points to ensure more inclusive and participatory approach for future laws and regulations.

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Annex 1. Methodology of the systematic literature review on the assessment of microbiological and chemical contamination of milk in Kenya

Below is the summary of an article currently being finalised for submission to a journal.

Dairy milk is one of the most widely consumed food products. Owing to its rich nutritional value, milk acts as a good medium for microbial growth. Contamination can occur during handling, processing or storage (Ongarora & Karwimbo, 2019). Consumption of milk has been shown to improve child nutrition and growth (Mosites et al., 2017) (Dror & Allen, 2011). However, milk can also contain hazards, that is, biological, chemical, or physical substances that can cause foodborne disease (FBD).

A hazard is any substance in food that can cause harm. Hazards present in food in Kenya and neighboring countries have also been summarised by (Mutua et al., 2021). Most common in literature reports were Campylobacter spp., E. coli, S. aureus and Salmonella spp. All of these were reported in milk.

Systematic reviews involve a thorough search of all the available data on a certain topic. It's considered a good source of evidence owing to its transparency, accuracy and replicability. A Systematic Literature Review (SLR) was undertaken to establish the current evidence on foodborne hazard occurrence in milk in Kenya between the year 2000 and June 2023, to identify potential solutions for improvements in milk safety and quality.

METHODS

A review protocol was developed to guide the activity (Appendix 1). The review followed the established "Preferred Reporting Items for Systematic Reviews and Meta-Analyses. The review identified peer reviewed papers published between the years 2000 and June 2023 from studies conducted in Kenya, published in English, and on milk. Searches were done in five databases, namely PubMed, Google Scholar, CAB Direct, Web of Science and Africa Journal Online (AJOL).

All search outputs were aggregated in Mendeley. The resultant file was exported to Rayyan QCRI software. Rayyan QCRI (https://rayyan.qcri.org/) is a web and mobile-based application that facilitates screening of articles in the SLR process (Ouzzani et al., 2016). Publication titles and abstracts were then screened against the inclusion and exclusion criteria as specified in the study protocol. The screening was done independently by reviewers 1 and 2, and any disagreements addressed by the third and fourth reviewers. Full paper review was also done in Rayyan. Data extraction and quality assessment happened concurrently.

RESULTS

Seventy-five (75) publications were available for data extraction. The included studies yielded a total of 440 results on individual hazards (80% of studies reported on multiple hazards).

The review found both biological (n=344 records) and chemical (n=96) hazards, out of the 440 records included in the review. The number of records with biological hazards (n=344) included: bacteria (96.8%) and fungi (3.2%). For bacterial contamination (n=333 positive records), Total bacterial count (TBC) (17.4%), Coliform (14%), *Staphylococcus spp.* (10.5%), *Staphylococcus aureus* (9.9%), and *E. coli* (8.7%) were the main pathogens observed. Chemicals found (n=96) included aflatoxins (55%) and antimicrobial residues (38%).

DISCUSSION

Raw milk had the highest proportion of bacterial hazards or hazard indicators (66% of samples). Bacteria can contaminate raw milk either during milking process, handling by retailers, storage under poor conditions, and

preparation of consumption. Twenty-two percent of formal sector pasteurised milk was also contaminated, indicating a more serious breakdown of quality control and regulation.

Only four types of chemical hazards were found in the SLR: aflatoxins, antimicrobial residues, hydrogen peroxide and formaldehyde. Milk is being very easily adulterated throughout the world and significantly worse in developing and underdeveloped countries due to the absence of adequate monitoring and lack of proper law enforcement. Apart from the ethical and economical issue, it also creates health hazards. Possible reasons behind it may include demand and supply gap; perishable nature of milk; low purchasing capability of customer and lack of suitable detection tests (Reddy et al., 2017) (Kamthania et al., 2014)

CONCLUSION

This review has highlighted the presence of several hazards in milk and milk products that are of importance to public health in Kenya. There is a need to improve the quality of milk. Most milk does not meet standards implying a risk to health and a failure of regulation.

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Appendix 1. Review protocol

Aspect of the protocol	Detailed description
Rationale	This is a study on occurrence of hazards in milk in Kenya. It aims to 1) identify the hazards 2) Identify any other key gaps in the evidence on milk quality and safety.
Aim	To identify biological and chemical hazards associated with milk consumption in Kenya (according to prevalence within milk and incidence and health burden in humans).

Research question	• What hazards (biological/chemical) have been identified in milk consumed in Kenya? • What is the prevalence (% of contaminated products) and concentration of hazards in milk consumed in Kenya? • What is the spatial distribution of studies reporting these hazards (i.e., where, within the country, were the studies conducted)? • What is the incidence (annual n. of clinical cases, annual n. of deaths resulting from milk- associated hazards) of milk-borne disease in Kenya? • What type of supply chain is the evidence associated with? • What is the health burden associated with milk-associated hazards in Kenya (DALYs, % of symptomatic cases; severity; mortality; hospitalisation; duration of illness; long-term sequelae)? • What is the consumption pattern for milk products? • Are there any temporal or seasonal trends in the data?
Key Words	Milk, Milk Safety, Hazard, Disease, Illness, Foodborne, Risk, Kenya
Population	All milk consumed in Kenya.
Intervention	n/a
Control	n/a
Outcome	• Prevalence (% of contaminated products) and Concentration of hazards • Incidence (annual n. of clinical cases, annual n. of deaths resulting from milk-associated hazards) • Health burden (DALYs; % of symptomatic cases; severity; mortality; hospitalisation; duration of illness; long-term sequelae) • Produce a prioritised list of milk-borne associated hazards in Kenya.
Setting	Kenya
Protocol registration	The protocol is registered with INPLASY. Registration number is INPLASY2023120076
Eligibility criteria **Eligibility criteria**	<u>Inclusion criteria</u> • Type of studies: observational studies, secondary data analysis, (literature) reviews. • Time limits: Studies published from 2000 to June 2023. • Language – English. <u>Exclusion criteria</u> • Studies that do not consider biological or chemical hazards associated with milk. • Studies conducted outside the established time frame (2000 - June 2023) • If the population is outside Kenya. • Experimental laboratory studies. • Antimicrobial resistance studies. • Studies not reporting information on milk-associated hazard presence, prevalence, incidence, or health burden (i.e., studies looking at prevalence of hazards at primary production on targets that are not food per se: i.e., faeces from animals, serology from animals, or carriage in vectors)
Information sources	Online databases: PubMed, CABI, Web of Science, African Journals Online and Google Scholar

Search	Here we will include a study summary table with search findings (see annex 1-5)
Study selection	Primary and secondary studies, (literature) reviews
Data collection process	TITLE/ABSTRACT • Download of titles/abstracts and removal of duplicates. • Independent double screening of title/abstract (inclusion/exclusion criteria) (reviewer 1 and 2). Screening will be done using the Rayyan QCRI software https://rayyan.qcri.org/welcome. The tool also allows for identification and removal of duplicates. • Discussion to reach agreement (reviewer 1 and 2) or review of articles considered relevant by only one reviewer (by reviewer 3 and 4) • Selection of articles considered relevant by at least 2 of the reviewers. • Reviewers 3 and 4 will monitor the whole review process on Rayyan. FULL PUBLICATIONS • Download of full publications (reviewer 1) • Full paper double review (inclusion/exclusion criteria) (reviewer 1 and 2) using the Rayyan QCRI software. • Any discordance in classification to be reviewed by reviewer 3 and 4. • 5% of included and excluded publications will be reviewed by reviewer 3 and 4. • Full paper single review (quality criteria) by reviewer 1 and 2. DATA EXTRACTION • Reviewers 1. • Standardised data extraction file. • Pretesting of template by both reviewers (5-10% of the publications) and comparing data extracted. • Single data extraction and combining data into one database. • Validation of the data entered by reviewer 1 by reviewer 3 (review entries for 10-15% of randomly selected papers).
Assessment of bias	Follow Cochrane "assessment of bias" http://handbook.cochrane.org/chapter_8/8_assessing_risk_of_bias_in_included_studies.htm

Appendix 2: Search Syntaxes

PubMed Key words / syntaxes	extracted	Hits
Milk AND (safety OR quality OR borne OR related OR associated OR illness OR disease OR pathogen OR poison* OR microb* OR virus* OR parasit* OR toxin OR toxicant OR metabolite OR chemical OR intoxica* OR contaminat* OR pesticide OR hazard OR bacter* OR protoz*) AND Kenya* NOT "breast milk" NOT "breastmilk"	07/9/2023	363

Google Scholar Syntax	Date Extracted	Number of hits

Kenya AND milk safety OR illness OR disease OR pathogen OR poison OR microbe OR virus OR parasite OR toxin OR toxicant OR metabolite OR chemical OR intoxication OR bacteria OR hazard -breast -human	07/9/2023	17300

CAB Direct	Date Extracted	Number of hits
Milk AND (safety OR quality OR borne OR related OR associated OR illness OR disease OR pathogen OR poison* OR microb* OR virus* OR parasit* OR Toxin OR toxicant OR metabolite OR chemical OR intoxica* OR contaminat* OR pesticide OR hazard OR bacter* OR protoz*) AND Kenya* NOT “breast milk” NOT "human milk"	07/9/2023	1417

Web of Science	Date Extracted	Number of hits
Milk AND (safety OR quality OR borne OR related OR associated OR illness OR disease OR pathogen OR poison* OR microb* OR virus* OR parasit* OR toxin OR toxicant OR metabolite OR chemical OR intoxica* OR contaminat* OR pesticide OR hazard OR bacter* OR protoz*) AND Kenya* NOT “breast milk” NOT "breast milk" NOT "breastmilk"	07/9/2023	635

Annex 2. Methodology for the assessment of microbiological and chemical contamination of the targeted food products in Côte d'Ivoire

The sampling of the targeted food products for lab analyses was organised through fieldwork from February to June 2024. A total of 540 samples of fruit, vegetables and fish were collected from the various sites identified using the EC 333/2007 method during this period. Samples of the most consumed fresh fruits (avocado, banana, mango, orange) and fresh vegetables (aubergine, okra, onion, tomato) were taken from a wholesale market in each of the communes of Yopougon, Abobo and Adjamé. An exploratory mission carried out in June 2023 indicated that it was necessary to focus on wholesale markets rather than retail markets.

The most commonly consumed varieties of the different fruits and vegetables were sampled from 3 vendors per market, with one variety per vendor. The vendors were selected at random and then interviewed using a survey form during the fieldwork period. In addition, five samples were taken from each of the three vendors selected per commune. Samples were taken from one vendor each week. As a result, 15 samples per product and per municipality were taken, giving a total of 360 fruit and vegetable samples (Tables 1 and 2).

For the most commonly processed fish (fried tuna, braised carp, smoked mackerel and smoked sardines), samples were similarly collected respectively in the same markets from 3 different vendors per commune. The samples were collected 5 times from the same vendor at one-week intervals. Consequently, 15 samples per type of fish and per commune were taken. In all, 180 fish samples were taken from the vendors (Tables 1 and 2).

The various samples were taken under the sales conditions of the vendors. Thus, 500 g of samples of fresh fruit and vegetables and fish (smoked, braised, fried) were first taken and placed in sterile Stomacher bags. The samples were labelled and placed in a sterile Stomacher plastic bag, then rapidly transported to the microbiology laboratory of the Centre Suisse de Recherches Scientifiques in Côte d'Ivoire in coolers containing carboglasses for microbiological analysis of the fruit and vegetables, and to the microbiology laboratory of the Centre de Recherche Océanologique (CRO) in Côte d'Ivoire for microbiological analysis of the fish. Around 1kg of the same samples of fresh fruit and vegetables and fish were also taken, wrapped in aluminium foil, labelled and transported to the ENVAL laboratory in Côte d'Ivoire in coolers for chemical analysis (pesticides, trace metals, polycyclic aromatic hydrocarbons). All the lab analyses were therefore made in Côte d'Ivoire, in different labs according to their field of expertise, by the CSRS team in the CSRS and CRO labs. The analyses in ENVAL were sub-contracted.

All the details of each sample, including the name of the seller, the place where the sample was taken, the provenance or origin of the product, the date on which the products were received by the seller, the time taken for the products to run out, and the mural products used, if any, were systematically recorded when the samples were collected.

Table 7. Sampling plan

Type of sample	Municipalities	Collection points	Sampling frequency	Nb of sampling / product	Total nb of Samplings
Fruits and vegetables					

8 products: - Mango - Banana - Avocado - Orange - Tomato - Okra - Eggplant - Onion	3 municipalities: - Yopougon - Abobo - Adjamé	3 sellers / product	1/ week x 5 weeks	45 samples / fruit or vegetable	360
Fish					
4 products: - Braised Carpe - Smoked Mackerel - Smoked Sardine - Fried Tuna (“*garba*”)	3 municipalities: - Yopougon - Abobo - Adjamé	3 sellers / product	1/ week x 5 weeks	45 samples / fish	180
Total	3 municipalities	36 collection points	5 dates of collection	45/ products	540

Type of product	**Vernacular name/ Variety**	**Scientific name**	**Family**	**Nb of collected samples**
Fruits and vegetables				**360**
Mango	*Mango “Kent”*	*Mangifera indica*	Anacardiaceae	23
	Fibrous mango (Assabonou)			22
Banana	*Desert banana “Giant Cavendish”*	*Musa acuminata*	Musaceae	23
	Conakry banana			22
Avocado	*Long avocado*	*Persea americana Mill.*	Lauraceae	22
	Round avocado			23
Orange	*Côte d’Ivoire orange*	*Citrus sinensis*	Rutacées	45
Tomato	*Salad tomate*	*Solanum lycopersicum*	*Solanaceae*	23
	Traditional tomato			22
Okra	*Dioula okra*	*Abelmoschus caillei type dioula*	Malvaceae	22
	Baoule okra	*Abelmoschus esculentus type baoulé*		23
Eggplant	*Krangbô eggplang*	*Solanum macrocarpon*	*Solanaceae*	22

	N'drowa eggplant			23
Onion	*White local onion*	*Allium cepa*	Liliacées	23
	Purple local onion			22
Processed fish				**180**
Braised Carpe	Carpe	*Cyprinus carpio*	Cyprinidés	45
Smoked Mackerel	Mackerel	Scomber scombrus	Scombridae	45
Smoked Sardine	Sardine	*Sardinella*	Clupéidés	45
Fried Tuna "*garba*"	Thon (faux thon)	*Thunnus thynnus*	Scombridae	45

Annex 3. Methodology for the risk assessment estimation

The Codex Alimentarius nomenclature (Codex Alimentarius Commission, 2007) describes risk assessment in terms of four analytical steps:

- hazard identification,
- hazard characterisation,
- exposure assessment,
- and risk characterisation.

Risk assessment gives the risks associated with the consumption of specific food items and must be undertaken independently of risk management, comprehensively, objectively, transparently and based on available scientific data. The results of the risk assessment may be expressed as:

- an indication of the inherent uncertainties,
- qualitative expressions of risk,
- a quantitative risk assessment.

In this study, the **risk assessment of exposure to microbial hazards** was carried out in accordance with two steps of the Codex Alimentarius: hazard identification and exposure assessment. It was not possible to carry out an exhaustive characterisation of the risk associated with the consumption of fruit, vegetables and fish due to the lack of data on dose-response effects. The hazard considered in this study is the contaminating germs that have caused food poisoning in Côte d'Ivoire and that were isolated from our samples of fresh fruit and vegetables and processed fish – namely coagulase-positive *Staphylococcus aureus* and *Escherichia coli.* Exposure assessment is the evaluation of the probable ingestion of a microbial hazard via the consumption of fresh fruit and vegetables or processed fish. It consisted in determining the probability of consuming these food foods contaminated with *E. coli* and coagulase-positive *S. aureus*. This probability was calculated by multiplying the proportion of people consuming the food as is (Pc) by the proportion of food collected at the point of sale exceeding the acceptability limits (Pv).

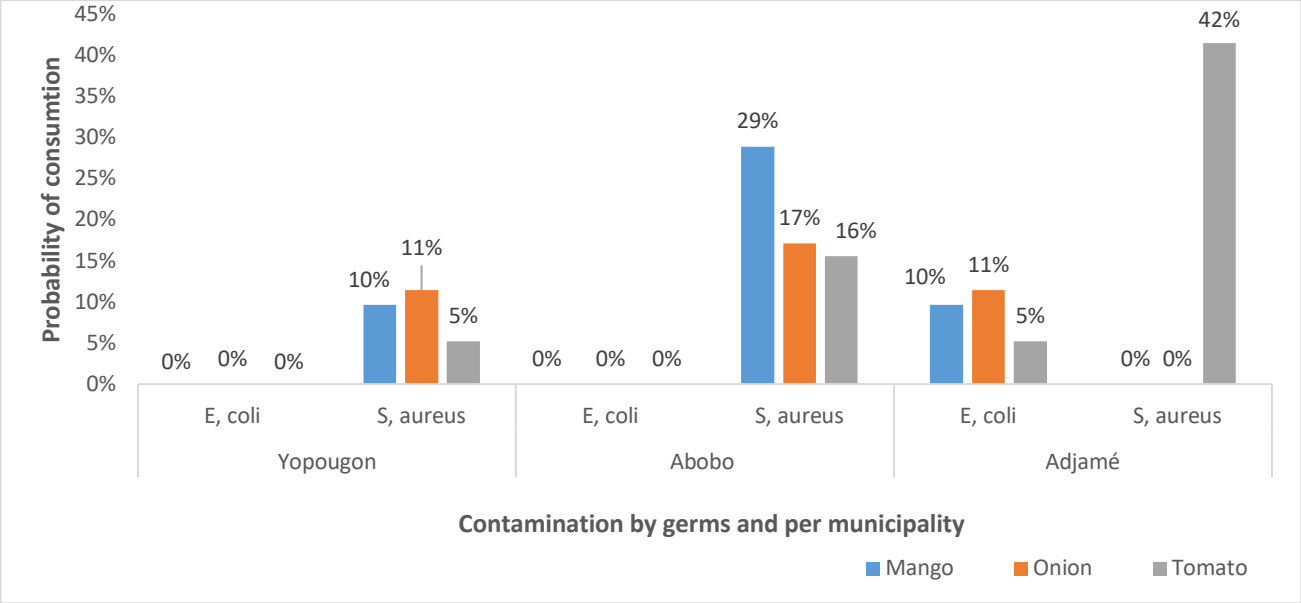
$$\mathbf{P = Pc\ X\ Pv}$$

The assessment of exposure to microbial hazards was done for the consumption of mango, onion, tomato and fish only as they are consumed with their skin by the population. Indeed, microorganisms were found on the surface (skin) of the selected food items. For fruits such as dessert bananas, oranges and avocados that are not consumed as they are it was not relevant to assess consumer exposure to microbial hazards. Similarly, because eggplants and okra are not eaten raw the risk assessment didn't apply to these products. The proportions of mango, onion, tomato and fish samples exceeding the acceptability limits for *E. coli* and coagulase-positive *S. aureus* have been expressed, while the proportions of people consuming the fruit and vegetables used come from survey data from the Institut National de la Statistique (INS, 2022)[1].

The figure below shows the probabilities of consuming tomatoes, onions and mangoes contaminated with *E. coli* and coagulase-positive *S. aureus* from the wholesale markets of Yopougon, Abobo and Adjamé. These probabilities are zero for *E. coli* from the Yopougon and Abobo markets, while they are between 5% and 11% from the Adjamé market. The probability of consuming fruit and vegetables contaminated with coagulase-positive *S. aureus* also varied depending on where the samples were taken and the food item. These probabilities

[1] Enquête Harmonisée sur le Conditions de Vie des Ménages 2018-2019. World Bank, Development Data Group. https://doi.org/10.48529/8WH3-BF40.

are zero for mangoes and onions from the Adjamé market, but 42% for tomatoes from the same market. The probability of consuming mangoes contaminated with coagulase-positive *S. aureus* from the Abobo market is also relatively high (29%).



The **risk assessment of exposure to chemical hazards** followed the steps of identifying and characterising the hazard using the results of toxicological analyses and information gathered from the literature on the chemical contaminants identified. These data also enabled to carry out the risk exposure assessment and risk characterisation. The daily exposure dose (*Dose Journalière d'exposition*, DJE) is the dose of a substance received by the body based on the weight of an adult individual (70kg) and the number of days in a lifetime. DJE for ingested substances is obtained using the following formula:

$$DJE = \frac{\mathbf{Qi} \times \mathbf{Ci}}{P}$$

DJE : Dose Journalière d'Exposition (mg/kg/day),
Ci: Concentration of the substance ingested in matrix i, expressed in mg/kg or mg/L,

Qi: Quantity of fruit ingested per day by an adult, expressed in kg/d

P: Adult body mass (70 kg)

F: Frequency of exposure = 1

By characterising the risk associated with a chemical hazard, it is possible to calculate the health risk to which consumers are exposed. Bibliographical data is used to better assess the hazard and the harmful effects on consumer health. Characterisation of the risk to human health from contaminants is highly dependent on their toxicological effects. For substances with a non-threshold effect, the risk is assessed by dividing the estimated

DJE of each contaminant by its acceptable daily intake (*dose journalière admissible*, ADI), which is the hazard ratio (ratio de danger, RD).

$$RD = \frac{\mathbf{DJE}}{\mathbf{DJA}}$$

For threshold substances, the human health risk associated with contaminants is determined by dividing the DJE of each contaminant by the toxicological reference value (*valeur toxicologique de reference*, VTR). The hazard ratio is determined as follows:

$$RD = \frac{DJE}{VTR}$$

- RD < 1 means that the exposed population is theoretically out of danger, i.e. this exposed population is not likely to develop the health effects studied.

- RD > 1 means that the toxic effect may occur without it being possible to predict the probability of this event occurring.

Two pesticide molecules were selected for the risk assessment calculation, those found at levels exceeding the MRLs in the samples: deltamethrin (pyrethroids) in fish and fipronil (triazole) in okra. Regarding trace metals, only the arsenic molecule was found in smoked sardines, with a concentration exceeding the maximum limit. In order to assess consumer exposure to these chemical hazards in the samples of fresh okra and smoked fish, daily consumption quantities of 20 g/d of fresh okra (MEMINADERPV, INS) and 56 g/d of smoked mackerel and smoked sardine (N'Doua, 2024; Aké-Assi, 2018) were used to calculate daily oral intakes of fipronil and deltamethrin. The average body weight for an adult was 70 kg. The assessment of consumer exposure took into-account the daily doses of pesticides (fipronil and deltamethrin) and trace metals (arsenic) ingested.For deltamethrin and fipronil, acceptable daily intakes (*Dose journalière admissible*, ADIs) of 10 µg/kg bw/d and 0.0002 mg/kg bw/d were defined respectively by Codex 2023 and the European Union in 2018. The ratios between estimated daily doses and acceptable daily doses for these different molecules were less than 1 (Table). The hazard quotient associated with fipronil in okra was 0.2 and that associated with deltamethrin in smoked mackerel and smoked sardines was 0.0026 and 0.0088 respectively. These values show that consumption of okra, smoked mackerel and smoked sardines contaminated with these molecules does not appear to present any health risks for consumers.

For arsenic, a metalloid that has been found in smoked sardines, INERIS has established toxicological reference values (TRVs) for chronic exposure to arsenic and the associated risks of cancer (United States, Canada) and proposes that the value of 1.5 g/kg/day be used for carcinogenic effects. The hazard quotient associated with arsenic in smoked sardine fish, which was 0.0014, was well below 1. This result shows that consumption of arsenic-contaminated smoked sardine fish does not represent a health risk for consumers.

			Hazard characterisation						
Matrix	**Contaminant**	**Molecules**	**MRL (mg/kg)**	**Quantity consumed (kg/d)**	**[C_a] mg/kg**	**AJE (mg/j)**	**F**	**DJE (mg/kg/d)**	**QD**
Okra	Pesticides	Fipronil	0,005	0,02	0,014	0,00028	1	0,000004	**0,02**
Smoked Mackerel		Deltaméthrine	30	0,056*	33	1,848	1	14,94	**0,0026**
Smoked sardine		Deltaméthrine	30	0,056*	110	6,16	1	0,088	**0,0088**
Smoked sardine	Trace metals	Arsenic	0,1	0,056*	2,69	0,15	1	0,002	**0,0014**

Risk is < 1

C_a : concentration in fipronil in the samples, AJE : daily intake (*apport journalier*), MRL : maximum residue limit, DJE : Daily exposure dose (*Dose journalière d'exposition*), QD : hazard quotient (*quotient danger*), F : frequency (1)