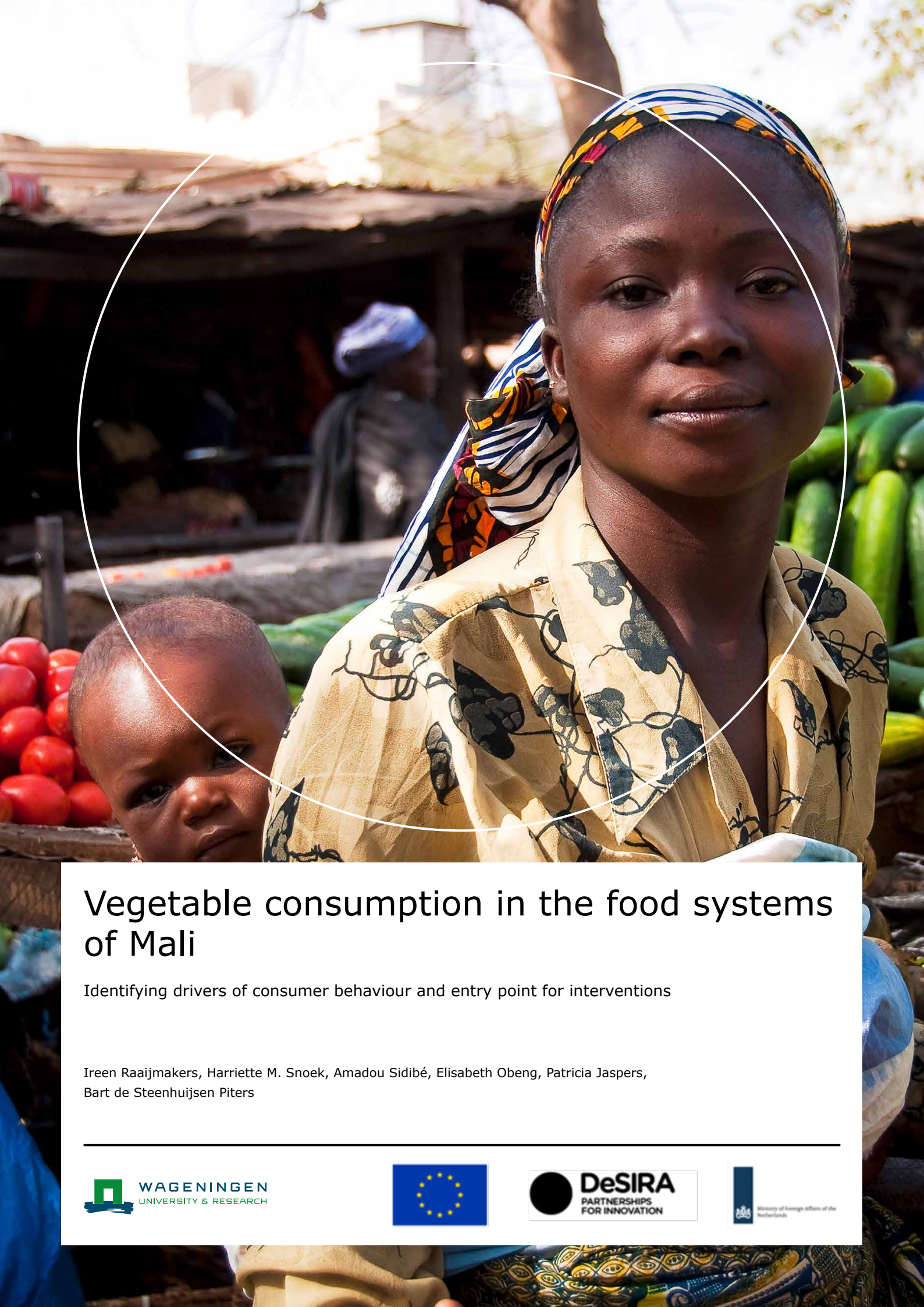

Vegetable consumption in the food systems of Mali

Identifying drivers of consumer behaviour and entry point for interventions

Ireen Raaijmakers, Harriette M. Snoek, Amadou Sidibé, Elisabeth Obeng, Patricia Jaspers, Bart de Steenhuijsen Piters

WAGENINGEN UNIVERSITY & RESEARCH

DeSIRA PARTNERSHIPS FOR INNOVATION

Vegetable consumption in the food systems of Mali

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Despite the health benefits that vegetables provide, their consumption in Sub-Saharan Africa is below recommended levels. This report is part of the larger SafeVeg project, aiming to pilot and scale innovative approaches within the food systems of Benin, Mali, and Burkina Faso, to improve consumption of safe vegetables. The goal of this report was to obtain insights into the vegetable consumption behaviours of urban consumers in Mali. For this purpose, a literature review was conducted – the results of which were reviewed and validated by relevant experts in the field of nutrition, health, and food safety in Mali. This report describes the results for Mali and identifies potential entry points for enhancing safe vegetable consumption.

Key words: fruits and vegetables, consumption, Mali, consumer behaviour, food system

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Preface

Safe Locally-Produced Vegetables for West Africa's Consumers (SafeVeg) is an action-research programme - launched in November 2020 and running until 2025 - and covers three West African countries – Benin, Burkina Faso and Mali. It was developed within the context of the EU initiative on Climate-relevant Development Smart Innovation through Research in Agriculture in developing countries (DeSIRA).

The Safeveg initiative aims to reduce undernourishment, improve the income and productivity of small-scale food producers – particularly for women and youth, and expand sustainable land use. The programme is implemented by the World Vegetable Center in collaboration with Wageningen University & Research (WUR) and CIRAD (French Agricultural Research Centre for International Development), and a multitude of national partners in the three focus countries.

The first year of the programme was dedicated to diagnostic research that explored barriers and opportunities for innovations across the vegetable value chain, including in production, marketing and consumption. Regarding vegetable intake, the research focused on why people do not eat enough of this nutritious food, which was overseen by the World Vegetable Center, University of Abomey-Calavi and WUR. The team carried out extensive literature reviews, consulted many different stakeholders in the three countries and implemented surveys among thousands of consumers.

The findings indicate that people in Benin, Burkina Faso and Mali eat far below the recommended daily amounts, which results in micro-nutrient deficiencies, including anaemia, and has negative impacts for child development. The research also concluded that safe vegetable consumption can be enhanced by reducing costs and increasing availability and acceptability among consumers.

Households can often not afford vegetables as they are simply too expensive. Also, people have little trust in the safety of vegetables due to a growing awareness that they can be produced with high dosages of agro-chemicals or undergo unhygienic handling, including washing with water infested with microbes.

In this publication series, we will share the results of the multiple studies and experimental interventions that have been undertaken to promote consumption of safe vegetables in the three focus countries. We hope these results will be of value to others also aiming to increase the availability and affordability of healthy diets in West Africa and beyond.

Ir. O. (Olaf) Hietbrink
Business Unit Manager Wageningen Economic Research
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Summary

The overall aim of the SafeVeg project is to pilot and scale innovative approaches within local vegetable food systems – to reduce malnutrition and improve the income and productivity of small-scale food producers in (peri-)urban Benin, Burkina Faso, and Mali. SafeVeg's Work Package 2 contributes to this by assessing current vegetable consumption levels and concerns among consumers regarding vegetables in the food environment: the availability and accessibility of vegetables and perceptions of vegetable food safety. The first step in achieving this objective was obtaining insights regarding vegetable consumption and the buying behaviours of urban consumers living in the focus countries. This was achieved by conducting an online literature search using multiple search queries. Articles found were then screened for relevance based on title and abstract. The main literature findings were validated with relevant knowledge holders in the field of nutrition, health, and food safety. This was important, as country-specific literature is lacking, so most relevant literature was placed in the larger context of West Africa. This report describes the results for Mali.

Promising role of priority nutrient-dense vegetables in decreasing nutrition deficiencies and overweight issues

Poor dietary habits, including low fruit and vegetable consumption, is a leading contributor to the burden of non-communicable diseases (NCDs). Recent, accurate, and reliable data on individual food intake, providing insights into diet quality and micronutrient deficiency, are lacking in Mali. Available data show that vegetables are among the most frequently consumed food group of urban Malian consumers; however, consumption remains below recommended levels. Their diets are largely cereal-based, and consumption of vitamin A, iodine, and iron is inadequate. Nutrient-dense vegetables, including green leafy vegetables and red, orange, and yellow vegetables, have a promising role in decreasing nutrition deficiencies and overweight problems.

Role of (leafy) vegetables in foodborne diseases and low awareness of actors in the food supply chain

Foodborne diseases (FBDs) are a major public health problem, significantly impacting the health and well-being of individuals living in Mali. Fruits and vegetables are an important source of contamination. Raw, fresh, and ready-to-eat leafy vegetables and fruits are considered most risky and the source of many disease outbreaks. The most common causes are cross-contamination, unhygienic handling by processors, use of organic fertiliser, and the use of sewage-contaminated water. There is low awareness among actors in the vegetable sector of hygiene issues and diseases associated with vegetable consumption. Food safety regulations are insufficient, despite the existence of the 'Agence Nationale de Sécurité Sanitaire des Aliments' (ANSSA) and Agence Malienne de Normalisation' (AMANORM).

Motives, drivers, and barriers to vegetable consumption were identified according to the motivation, ability, opportunity (MOA) framework

Health, taste, origin, and safety are the main motives behind West African consumers' vegetable purchases. Visible aspects, such as being damage-free, appearing fresh, being a good size and colour, and feeling firm, are the main considerations in vegetable purchasing. Malian consumers are aware of food safety issues regarding vegetables. However, the main constraints to buying safer vegetables are a lack of availability and inability to recognise safe vegetables.

Role of Malian food environment in making vegetable choices

The current spread of supermarkets and modern retail outlets in Mali offer a limited range of vegetable and fruit products compared to traditional markets, including street food vendors. Out-of-home cooked foods are easily available and commonly consumed in the country, especially by men. These dishes contribute few vegetables to the diet, though may contain tomatoes, onions, cabbage, or carrots in limited amounts.

Reliable information for consumers on the origin, production, and nutritional value of vegetables is lacking. As a result, consumers base their purchasing decisions on aspects such as price, appearance, or vendor relationships.

Importance of the identification of homogeneous consumer groups in promoting vegetable consumption

'Tailoring' is key in successful interventions and/or campaigns for improved vegetable consumption. Segmentation – the identification of homogeneous groups who share perceived preferences, needs, or wishes – can be a way to identify consumers. Correlational studies on vegetable consumption indicate the importance of sociodemographic, such as income, age, and gender, in identifying consumer segments. Income is particularly significant, as it is considered a constraining factor in vegetable accessibility.

The literature study and knowledge holder meeting identified that the entry points for enhancing safe vegetable consumption in Mali should focus on:

- Vulnerable low-and middle income groups, including young adults and women
- Both the at-home and out-of-home food environment
- The main food choice drivers, including health (including safety) and taste
- Accessibility within the local food environment
- Improving the ability (knowledge and skills) to recognise safer vegetables

1 Introduction

1.1 Background

The importance of vegetables and their downside

Currently, most low- and middle-income countries (LMICs) face a multiple burden of malnutrition: undernutrition, micronutrient deficiencies, and overweight/obesity (Popkin et al., 2020). Improving the quality and healthiness of diets, including consumption of micronutrient-rich foods, is viewed as a key strategy in preventing or overturning these forms of malnutrition (Brouwer et al., 2021). Vegetables are considered crucial in a healthy diet, due to their micronutrient density. Green leafy vegetables are particularly viewed as a priority micronutrient food source (Beal and Ortenzi, 2022). Yet, despite their healthiness, vegetables are not always safe or of a high quality. After animal-based products, vegetables are considered a source of many FBD outbreaks (see Box 1.1). This is especially the case with fresh and ready-to-eat vegetables, green leafy vegetables, and herbs (Berger, 2010; Rajwar et al., 2016).

Box 1.1 The major health impact of food borne diseases

The World Health Organization (WHO) estimated that, in 2010, 31 major foodborne hazards together caused 600 million foodborne illnesses, 420,000 deaths, and a loss of 33 million disability adjusted life years (WHO, 2015). As such, FBDs are a major public health problem, greatly impacting health and well-being worldwide – especially in LMICs and Africa (Havelaar et al., 2015; WHO, 2015). The highest burden per population was observed in Africa among children under 5 years of age (40% of the FBD burden).

Definition of FBDs
An FBD can be defined as a disease commonly transmitted through ingested food (WHO, 2015). Most FBDs are infections – caused by a variety of bacteria, viruses, and parasites, or toxins that naturally or chemically occur in food (Bashkar, 2017). Food hazards can develop at any stage of the food chain, from production and transportation to processing, sales, and consumption (Gizaw et al., 2019).

Emergence of foodborne diseases across different components of the food system

FBDs are likely to increase in LMICs, due to increased consumption of perishable foods, lifestyle changes, increased population, urbanisation, and the increasing complexities of food supply chains (Bashkar, 2017; Gizaw, 2019; Grace, 2015; Makinde et al., 2020; Mostafidi et al., 2020). All of these factors can occur across different elements of the food system, including food supply chains, food environments, and consumer behaviour, as well as through external drivers (e.g., biophysical and environmental, political and economic, and socio-cultural) that push and pull the system. Box 1.2 provides an overview of potential factors (found in literature) which cause FBDs and how these transpire across the food system.

Box 1.2 Activities within food system elements that can contribute to FBD outbreaks

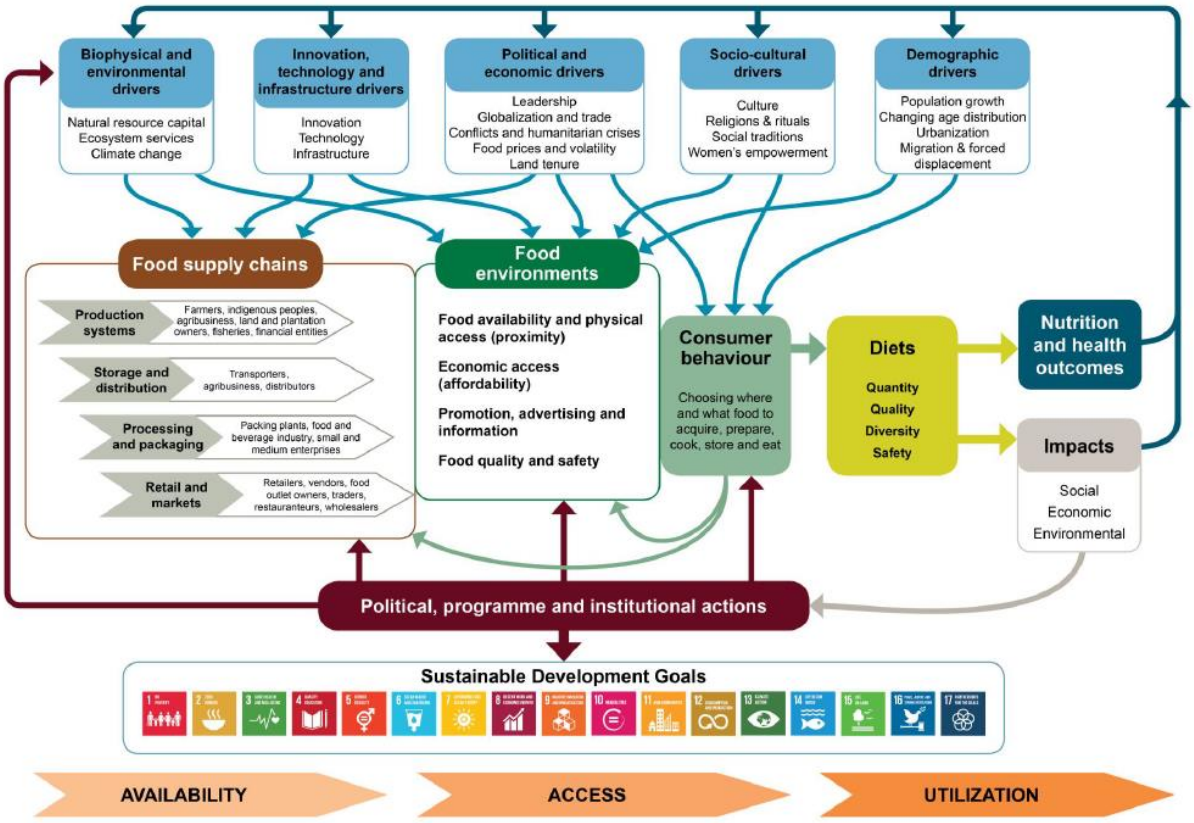

Figure *Conceptual framework of food systems for diet and nutrition; copied from HLPE (2017)*

Food supply chains
- Increased lengthening, broadening, and complexity of food supply chains
- Exposure to contaminated water (irrigation or flood)
- Contaminated soils and groundwater
- Use of fertilisers (crude or organic fertilisers, hygienic quality of fertilisers)
- Microbiological and chemical contamination of foods
- Poor food handling after harvesting (e.g., use of wrong/unhygienic harvesting and processing equipment, wrong/infected storage locations, transportation)

Food environment
- Availability of outdated foods/foods past their use-by-dates
- Availability/use of low-quality foods (adulterated foods, (visibly) affected foods)
- Mislabelling
- Unhygienic vending practices (poor personal hygiene, use of potable water, food is improperly processed/prepared, improper washing of vending utensils)
- Dirty surroundings

Consumer behaviour
- Use of low quality foods (adulterated foods, (visibly) affected foods)
- Unhygienic cooking practices
- Lack of insights and knowledge on the adverse effects of consuming contaminated food
- Lifestyle changes

Drivers
- Pollution of air, water, and soil
- New/other food technologies
- Non-existent or inadequately enforced regulations
- Poverty
- Urbanisation
- Industrial growth
- Economic development

Sources: Bashkar, 2017; Gizaw, 2019; Grace, 2015; Makinde et al., 2020; Mostafidi et al., 2020.

Considering the different elements of (local) food systems is crucial if the SafeVeg project is to achieve its aims.

Steering role of consumers within the food system
Local food systems are dynamic, complex, and constantly evolving. Consumers and their diets play a central role within these, as they can influence the system through demand. Meanwhile, consumers' food choices and perceptions are guided by physical, social, economic, and cultural structures within the food environment, together with other food environment characteristics (e.g., availability, affordability, advertisements, and food quality and safety), individual characteristics (e.g., attitudes, knowledge, demands, and barriers), and external drivers (e.g., politics, regulation, urbanisation). Having a better understanding of these drivers and the food environment will contribute to identifying and implementing interventions that can lead to greater access of affordable foods and the sustaining of healthy diets. This perspective is supported by Brouwer et al. (2021), who argue that taking a healthy diet perspective in food system transformation, instead of a production-focused approach, is essential to reversing current trends towards unhealthy and unsustainable diets. SafeVeg's Work Package 2 is also taking this stance: looking at current levels of vegetable consumption and consumers' concerns regarding vegetables in the food environment.

1.2 Research aim and research questions

The overall aims of the literature study and the knowledge holder meeting were to:
- Obtain insights into consumers' vegetable consumption behaviours in the three focus countries of the SafeVeg project: Benin, Burkina Faso, and Mali
- Validate the Mali-specific results evolved from the literature search
- Fill identified knowledge gaps
- Shortlist potential interventions

The following research questions were formulated:
- What are the vegetable consumption behaviours of (peri-)urban consumers living in the focus countries?
- What are the motives, drivers, and barriers for urban consumers to buy and consume (safe) vegetables?
- What are consumer perceptions of the health and food safety of vegetables?
- What level of awareness do consumers have on vegetable food safety?
- What is the interface between the consumer and the food environment?
- Where do consumers source information on food safety and what do they think about these sources?
- What consumer segments can support more targeted interventions?

1.3 Approach

This report on Mali includes the main results from the conducted literature search and knowledge holder meeting. A structured literature search was conducted in Scopus, CAP-abstracts, PubMed, and Psych-info, using search terms related to the region (including countries, cities, and regions – e.g. Sub-Saharan Africa) and vegetables (general and specific) (see Appendix 1). This search included all papers on vegetables in the research area, resulting in 2,011 results. These were checked for duplicates and then for relevance, based on title and abstract in relation to the research questions. The structured search was complemented with literature suggested by knowledge holders and by snowball technique. The knowledge holder meeting was held on 28 April 2022 at the World Vegetables office in Samanko, Mali, and comprised 11 experts and knowledgeable persons in the field of nutrition, health, food safety, food systems, policy, and research from different organisations (e.g. (local) governments, universities, research organisations, industries, and NGOs). Based on the main literature findings, two statements per theme were formulated. In total, five themes were discussed: the role of vegetables in the diet; safety of vegetables; motives, drivers, and barriers to vegetable consumption; food system drivers; and consumer segmentation. A separate report of this meeting was drafted.

1.4 Outline of the report

The remainder of this report is structured into two sections, which highlight vegetable consumption among urban consumers in Mali. Section 2 covers: the role of vegetables in the diet (Section 2.1); vegetables and FBDs (Section 2.2); motives, drivers, and barriers of vegetable consumption (Section 2.3); vegetables and the food environment (Section 2.4); and consumer segmentation (Section 2.4). Each subsection has the same structure: (1) Results of the literature search, applied as much as possible to the local context of Mali. However, it should be noted that results could be placed in the larger context of West African countries, as specific literature is lacking; (2) Reflection and validation of the literature results by the relevant experts and knowledgeable persons. Meanwhile, Section 3 provides overall conclusions and recommendations for further research and potential interventions.

2 Results

2.1 Nutritional deficiencies in Mali and the bridging potential of priority nutrient-dense vegetables

Key messages and outcomes:

- Recent, accurate, and reliable data on individual food intake providing insights into diet quality and micronutrient deficiency are lacking in Mali.
- Geographical area, residential area, age, education level, and employment status influence body mass index (BMI) levels. In Mali, underweight is an issue; however, overweight is increasing more strongly among adults, especially in urban areas.
- Vegetables are among the most frequently consumed food groups in Mali, although recommended daily intake levels are below recommendations and diets are largely cereal-based.
- Consumption of vitamin A, iodine, and iron is inadequate in Mali.
- Nutrient-dense vegetables, such as dark green leafy vegetables and red, orange, and yellow vegetables, have a promising role in overcoming the identified micronutrient deficiencies.

2.1.1 Main results from the literature

Recent, accurate, and reliable data on individual food intake providing insights in diet quality and micronutrient deficiencies are lacking

Recent, accurate, and reliable data on individual food intake level providing insights into diet quality and micronutrient deficiencies in LMICs, including Mali, are lacking (e.g., Afshin et al., 2019; Global Panel on Agriculture and Food Systems for Nutrition, 2016; Micha et al., 2015). Studies into individual food consumption are mostly limited, scarce, and non-recurring, meaning estimated consumption levels may deviate from actual consumption. Some of these studies are related to a selected geographical area or specific issues (e.g., food security or vulnerable target groups, such as children under 5 years of age and women of childbearing age). Moreover, study samples are not always representative and, due to the lack of standardised and validated dietary assessment methodologies, use different methods (e.g., dietary recall, 24H recall, Dietary Diversity Score (DDS)) to measure intake – and this makes comparisons difficult (Vila-Real et al., 2018). Due to the lack of data, surveys in the field of nutrition and intake (the Demographic and Health Survey (DHS), Nutrition Landscape Information System (NLiS)) and smaller studies conducted in Mali were used to obtain insights into food and vegetable consumption among the Malian, and to identify nutrition gaps in adults and women. Their findings are included in the subsections below.

Underweight is still an issue; however, overweight is increasing strongly

In a nationwide sample conducted in 2016, the average BMI of Malian men was 23.0 and 23.2 for women (Abarca-Gómez et al., 2017). Persons living in urban areas have a higher BMI than those in rural areas (Konaté et al., 2020; NCD Risk Factor Collaboration, 2019; Institut National de la Statistique, 2018). In 2017, the mean BMI level among men living in urban areas was 23.7 – and, in rural areas, this was 22.4. For women, the mean BMI level in urban areas was 25.6 and 22.3 in rural areas (NCD Risk Factor Collaboration, 2019). Konaté and colleagues found that almost one in three adult women is overweight or obese. In both genders and geographical areas, mean BMI levels are increasing.

Vegetables are among the most frequently consumed food groups in Mali, although recommended daily intake levels are not being achieved

Several small studies identified the food groups most often consumed by Malian consumers. The majority of these studies used different methodologies to assess intake of different target groups – either on a national level or in specific geographical areas – which makes comparison difficult. In general, the diets of urban Malian consumers are based on starchy staples (e.g. millet, sorghum, white rice), accompanied by a sauce typically made from vegetables and beef or fish. The composition and ingredients of the sauce varies across zones and

seasons (Kennedy et al., 2010; Konaté et al., 2020; Smale et al., 2020). Consumption of food groups differs between geographical areas and seasons. Malian urban households have a higher dietary diversity score than rural households. For both areas, dietary diversity scores are lower during the lean season compared to the harvest season (Smale et al., 2020). In cities, consumption of rice and tubers is more dominant, while vegetables, legumes, and seasonal fruits are less consumed (FAO, 2010; Konaté et al., 2020). Street food is becoming more important, especially in Bamako (Konaté et al., 2020; Tounkara et al., 2019)

Although vegetables are among the most frequently consumed food groups, a study conducted in 28 LMICs on fruit and vegetable consumption among individuals aged 15 years and older showed average vegetable intake was 2.46 servings per day (1 serving was estimated at 80 g) – meaning that intake doesn't meet WHO recommendations of '5 servings a day' (Frank et al., 2019). Vegetables are frequently consumed by urban Malian consumers, either on a daily basis or multiple days per week (Kennedy et al., 2010; Smale et al., 2020). The found literature only measured vegetable consumption frequency, but not consumption amount.

Priority nutrients in Mali are vitamin A, iodine, and iron

The prevalence of anaemia among women in reproductive age is high, at nearly two-thirds of women (Institut National de la Statistique, 2018, Konaté et al., 2020). Anaemia is more common in pregnant women compared to other women in the same age category. Additionally, prevalence of anaemia in women living in urban areas (52%) is lower than those living in rural areas (67%) (Institut National de la Statistique, 2018).

In LMICs, diets are often inadequate in iron, zinc, vitamin B11 (folate), vitamin A, calcium, and vitamin B12 (Beal and Ortenzi, 2022). This corresponds somewhat with results of studies conducted in Mali. For instance, a study conducted by Kennedy and colleagues (2020) among urban sample found that intake of folate, vitamin B12, riboflavin, niacin, vitamin A, and calcium were below recommendations. However, data on micronutrient status are not collected regularly and among a national representative sample.

Nutrient-dense vegetables have a promising role in overcoming micronutrient deficiencies in Mali

Foods provide the body with nutrients. It is important that diets include a variety of foods with a range of nutrients. Top sources of priority micronutrients in LMICs (iron, zinc, calcium, and vitamins B11, A, and B12) are animal-source foods, especially organs and small fish, and green leafy vegetables (Beal and Ortenzi, 2022). Vegetables are promoted as healthy foods due to their nutritional content, with their health benefits being well-known and reported. Table 2.1 provides an overview of the different vegetable sub-groups (including sentinel vegetables) most commonly consumed by a large share of the Malian population, together with their typical health associations.

Table 2.1 *Overview of the different vegetable sub-groups and their health associations*

Sub-group	Health associations	Sentinel vegetable types in Mali
(Dark) green leafy vegetables	Contribute to iron, vit C, vit A, and folate intake	Sweet potato leaves (Wosso boulou), Amaranth leaves (Bron boulou), Baobab leaves (Zira boulou), crin crin (Fakoye, jute mallow), shallot leaves (Diaba boulou), cowpea leaves (Shô boulo), cassava leaves (Banankou boulou), guinea sorrel leaves (bissap), bay laurel leaves, parsley leaves, celeri leaves
Red, orange, and yellow vegetables	Contribute to vit A and folate intake	Carrot, beet (betterave)
Cruciferous vegetables	Positive association with coronary heart disease and total cancer	Cabbage
Other vegetables		Bitter tomato (african eggplant), okra, okra pods, green sweet pepper, cucumber, courgette zucchini, lettuce, pumpkin, shallot, green beans, bay laurel leaves

Source: Sentinel fruit and vegetables (from the Dietary Quality Questionnaire).

2.1.2 Reflection by knowledge holders

The following statements match the main literature findings and were discussed during the knowledge holder meeting:

1. SafeVeg should focus on green leafy vegetables, as these are rich in nutrients – and thus can help reduce nutritional deficiencies and overweight problems.
2. Potential key vegetable types for SafeVeg are: amaranth, African eggplant, jute mallow, bitter leaf, cowpea leaves, cabbage, okra (fruit and/or leaves), sweet potato leaves, tomato, and onion. Indicators, such as the potential effect on health, consumption, accessibility, and acceptability, were identified to select the most promising vegetables for SafeVeg.

Both the above statements were validated by the Malian expert panel. Their discussions showed that:

- Stakeholders agree that leafy vegetables are rich in nutrients; however, consumption habits and cooking practices affect their nutritional value. Green leafy vegetables are not eaten fresh, but cooked for a long time (around two to three hours). Cooking practices destroy water-soluble vitamins, but do not affect fat-soluble vitamins.
- The above listed potential vegetables were endorsed. However, the leaves of the following vegetable types are also of interest as they are frequently consumed in Mali: sweet potato, cassava, squash, baobab, moringa, beetroot, ground nut, and green beans.
- Educating and informing consumers about the health benefits of these vegetables is important to enhance awareness.

2.1.3 Conclusions

Consulted stakeholders agreed on the need to promote vegetable intake in Mali, since these foods are nutrient dense and sources of priority micronutrients required to complement the mostly cereal-based diets. Nutrient-dense vegetables in particular, such as dark green leafy vegetables and red, orange, and yellow vegetables, have a promising role in helping overcome the identified micronutrient deficiencies (vitamin A, iodine, and iron) reported in literature. Promoting these specific types of vegetables is related to increased accessibility, acceptability, and food safety perceptions. In raising awareness about the (health) importance of vegetables, attention should be given to the vegetable types most commonly consumed.

2.2 Foodborne diseases and their relation to vegetables

Key messages

- Fresh and ready-to-eat vegetables, herbs, and fruits are particular sources of many disease out-breaks caused by cross-contamination or contaminated water.
- Pesticide residues were found in prepared food that included tomatoes and leafy vegetables.
- For chemical contamination, highest risks are among staples, peanuts, oils, and smoked fish.
- In general, there is a lack of food safety regulation and inadequate registration of outbreaks.

2.2.1 Main results from the literature

Raw and fresh vegetables are the most risky for cross-contamination

In developing countries, foodborne illnesses caused by contaminated fruits and vegetables are frequent – and, in some areas, account for a large proportion of foodborne illnesses (Grace, 2015). Fresh, perishable produce sold at informal markets and packaged ready-made foods are – despite their importance to health and food safety – considered to be at high risk of contamination (Grace, 2015; Makinde et al., 2020; Mostafidi et al., 2020). Much research into foodborne human pathogens has focused on transmission from foods of animal origin. However, recent investigations have identified fruits and vegetables, especially fresh and ready-to-eat vegetables, herbs, and fruits, as the source of many disease outbreaks (Berger et al., 2010). Makinde and colleagues (2020) reviewed papers on microbial contamination of ready-to-eat foods in LMICs and showed these foods are of great importance for health, but are also high-risk for contamination. Fruits and vegetables, particularly leafy greens that are consumed raw, are important vehicles for transmitting human pathogens that were traditionally associated with foods of animal origin. That said, the

frequency of gastrointestinal illness associated with fruits and vegetables appears to be low compared to products of animal origin (Rajwar et al., 2016).

Outbreaks have been reported involving a range of bacterial, viral, and protozoan pathogens (Rajwar et al., 2016). A major source of vegetable contamination is organic fertiliser and faecal contaminated water. Many parts of Sub-Saharan Africa rely heavily on ecosystem services for water, and sewage water and sludge are used in agricultural production. Peri-urban vegetable producers in West Africa often use sewage water for irrigation (Kitinoja, Saran, Roy, and Kader, 2011). Infrastructural deficits, including lack of potable water, result in food contamination that leads to illness. Almost any ready-to-eat fruit or vegetable that has been contaminated with pathogens – either from the environment, human or animal faeces, or through storage, processing, and handling – could potentially cause disease (Rajwar et al., 2016). In a review study by Makinde et al. (2020) on ready-to-eat foods in LMICs, contaminations were found to often be due to: poor personal hygiene of processors; poverty; lack of awareness into the adverse health effects that can arise from consuming contaminated foods; and non-existent or inadequately enforced regulations.

Chemical contamination and pesticide residues in the diet

WHO has published several reports and factsheets on the health hazards of pesticides. One line of research relates to setting maximum limits and good agricultural practices to protect agricultural workers that apply pesticides, along with those in the immediate area during and immediately after pesticides are spread at work, home, or in gardens.[1] Risk of consumer exposure to pesticide residues in food are monitored by the Joint Meeting on Pesticide Residues (JMPR), facilitated by the Food and Agriculture Organization of the United Nations (FAO) and WHO.

Box 2.1 Methodologies for defining health impact

Residue exposure calculations are made via a combination of pesticide residue concentrations in foods and individual food consumption – but are complicated by the unavailability of detailed, recent, and representative data in all countries. By combining such exposures with toxicological studies, the impact on health can be determined. However, determining the health effects of chemicals is very complex, due to various exposure routes and the multiple causes of health outcomes (Ingenbleek et al., 2020): 'Many food chemicals, including heavy metals, mycotoxins, pesticide residues, and industrial contaminants, are associated with a series of NCDs.'

An assessment of acute dietary exposure to 38 pesticides showed no appreciable risk among populations of adults and children in eight high-income countries (Crépet al., 2021). In contrast, the occurrence of risky levels of pesticide residues in vegetables was reported in a review on studies conducted in Africa (Olisah, Okoh, and Okoh, 2020). Further, a recent study on exposure to chemicals in Sub-Saharan Africa, including Mali, showed multiple risks (Ingenbleek et al., 2020). In this study, risks were calculated based on prepared foods that covered 90% of typical diets in Cameroon, Benin, Nigeria, and Mali. For many of the chemicals analysed, human dietary exposures were below levels of toxicological concern thought to present risk of adverse effects. High exposure to several mycotoxins, polycyclic aromatic hydrocarbons, lead, and aluminium were identified. Some artisanal kitchen utensils made from recycled aluminium are likely to increase the lead and aluminium content of foods, particularly when preparing acidic foods, such as tomato that will cause extra dissolving of metals to the food. Pesticide residues were found in a range of prepared foods, including tomatoes and leafy vegetables. However, the main food contributors to residues and chemicals in the diet were staples (maize, sorghum, rice, millet, cassava), peanut, oils, and smoked fish (Ingenbleek et al., 2020). Finally, a seasonal effect has been reported, with pesticides more frequently detected in samples collected during the wet season (Ingenbleek et al., 1999).

Lack of food safety regulations and a lack of registration of outbreaks

In addition to poor capacity for enforcing regulations, epidemiological traceability is difficult for fruits and vegetables as carriers of foodborne pathogens (Rajwar et al., 2016). Due to the lack of FBD investigation and surveillance in many LMICs, most outbreaks go undetected and the scientific literature reports only a few cases. In their review, Chatziprodromidou and colleagues (2018) found only two reported outbreaks in Africa.

[1] For instance, https://www.who.int/news-room/fact-sheets/detail/pesticide-residues-in-food.

2.2.2 Reflection by knowledge holders

The following statements match the main literature findings and were discussed during the knowledge holder meeting:

1. Leafy vegetables and tomatoes can contribute to FBDs (via micro-biotics and chemicals) in Mali. It is unknown if other vegetables also contribute (types/species of vegetables and treatment). It can be assumed there are no regional differences.
2. (Government) regulations on health safety are lacking in Mali.

Both the above statements were validated by the Mali expert panel. Their discussions showed that:

- Leafy vegetables and tomatoes can contribute to FBDs in Mali. However, this applies to all vegetables, especially those eaten fresh and raw. Production conditions, including the (intensive) use of chemicals and pesticides and contaminated irrigation water contribute to FBDs.
- Experts did not agree with the statement that regional differences do not exist – as they believe there are regional differences regarding production practices, choice of production sites, use of irrigation water, etc. The context of the production environment varies from one region to another.
- There is not high consumer demand for organic vegetables. Producers think there is no market outlet for products labelled as 'bio or organic'. In their experience, it's been easier to sell conventional produced products that have been grown using chemical fertilisers and pesticides (than organic produce) to different market outlets, due to price. It was assumed that consumers are not willing to pay a higher price for organic products.
- Health and safety regulations exist in Mali, but enforcement is lacking. Regulatory tools are developed by AMANORM, who lead many studies on standardisation, quality promotion, certification, and accreditation. Meanwhile, ANSSA) takes care of health and safety regulations enforcement – although implementation faces coordination issues. ANSSA aims to secure a healthy diet for the Malian population through the improvement of sanitary and phytosanitary quality.
- In addition to the enforcement of health and safety regulations, consumers need to be informed about the nutritional value and production place and method of products to allow them to make the best choice.

2.2.3 Conclusions

According to the literature, vegetables are not the main source of foodborne contamination. Yet, leafy vegetables and fruits still contribute to FBDs, especially in their raw or fresh state. Experts think there are regional differences in the contribution of vegetables to FBDs, as the production environment – including production sites and production practices – varies across regions. Additionally, it was thought by producers that there is no market outlet for bio and organic vegetables, as these are more difficult to sell to market outlets. Outlets and producers assumed that consumers are unwilling to pay a higher price for organic vegetables; something that was experienced by producers. Another finding in the literature, which was supported by the experts, is that (government) regulations on health and safety are insufficiently applied and/or monitored, despite the existence of AMANORM and ANSSA. Consumers need to be informed about the background of the product (production site, production method, and nutritional value) to make the best choices. Future research could explore consumers' views on the food safety risks of vegetables (see also Section 2.3), as well as trust in chain actors for producing and authorities for regulating vegetable safety.

2.3 Motives, drivers, and barriers

Key messages

- Effective behaviour change interventions combine motivation, opportunity, and ability (MOA). Therefore, the MOA framework was used to identify drivers of consumer vegetable intake.
- Research in Mali or other West African countries which compares motivations related to different vegetable types is lacking.
- Food choices are driven by personal values and preferences: for vegetables, appearance was the main motive for consumers, although safety and nutritional content were also important.
- Opportunity is related to accessibility, availability, and affordability; in general, access to safe vegetables is a constraint.

- Ability to recognise safer vegetables is related to knowledge and skills: consumers are aware of food safety issues, but lack the skills and information to put these into practice.

2.3.1 Main results from the literature

The motivation, opportunity, and ability framework was used to identify drivers of behaviour
One of SafeVeg's aims is to reduce undernourishment through increased vegetable intake – and this can be achieved by making them more accessible, acceptable, and safe. To provide input for the innovative pilots and scaling up of interventions, we include a framework for behavioural change: the MOA framework (ThØgersen, 1995; Flynn et al., 1999). According to this, people need the motivation and the environmental or contextual opportunity to perform healthy behaviours, such as eating healthily. Additionally, they need to be able to conduct the intended behaviour – making ability the third factor. Ability refers to skills and knowledge related to healthy behaviours. On one hand, these include more practical skills, such as cooking techniques for preparing vegetables; while, on the other, it includes more general knowledge on healthy diet (such as recommended vegetable intake, safety risks, etc). In this chapter, we review studies that included elements of the MOA framework. Outcomes are structured with motivation, opportunity, and ability separately, although there is interconnection and overlap between them. When possible, studies included focus on safe and healthy vegetable consumption in LMICs, but some more general studies were also included. Studies on organic foods were also included, since this is a widely researched category that is relevant to consider – as organic foods are free-from chemicals such as fertilisers (Vihotogbe-Sossa et al., 2012). Only a few studies specifically addressed Burkina Faso, and all in Ouagadougou; one on consumer motives for buying organic vegetables (Kini, Pouw, and Gupta, 2020), one on market access and major constraints to accessing fresh vegetables (Shafiwu, Donkoh, and Alhassan, 2018), one on willingness to pay more for safer vegetables (Shafiwu 2017), and one on organic vegetables and contamination risk awareness (Probst et al., 2012). Therefore, other studies in African populations and general review studies were also included.

Choosing vegetables: health, taste, origin, and safety are main motives for consumers; appearance is a main product attribute
Food choices are motivated by personal values and preferences, and are therefore closely related to how consumers value certain product attributes. An important factor is characteristics – such as appearance– which can be judged by looking at a product; while extrinsic attributes are those that can only be judged by experience, such as taste. With tomatoes, for instance, attributes, such as taste, colour, price, availability, nutrition, and health benefits are considered important by consumers in urban Benin when making choices (e.g., Adegbola et al., 2019). Interestingly, the importance of these variables is related to income or socio economic status (see Chapter 2.5). In Ouagadougou (Burkina Faso), demand for organic vegetables was higher if consumers prioritised their health. In other words, consumers who care more about the healthy attributes of food for consumption are more likely to be motivated to frequently buy organic food from production sites. The main reason respondents gave for buying organic foods were: health-related attributes, clean water used to irrigate the crops, and hygiene practices surrounding the production process (Kini et al., 2020). Similarly, in urban Mali, health value was a significant predictor of health behaviour identity, which was, in turn, related with attitudes toward behaviour and perceived barriers for fonio grain consumption (Fanou-Fogny et al., 2011).

In a study focused on tomatoes, six major attributes were posed to Beninese consumers during their decision to choose a product: colour, duration of conservation, conservation, taste, origin of varieties, and price (Adegbola et al., 2019). Origin and taste represented the two most important attributes, accounting for 27% and 23%, respectively, of the total preference. These were followed by the colour of the tomato, accounting for 22% of the total preference. The consistency of the varieties and their price were relatively less important (8% and 1% of the total preference, respectively). Four market segments were identified, based on the expressed preferences and the socioeconomic and demographic characteristics of the Beninese consumers. Two segments have a great preference for local tomatoes, and tomatoes that can be conserved over a long period. A third segment consisted of consumers that preferred tomatoes with a firm consistency, and another segment prioritised price.

Several consumer motivations to eat organically were reported in literature reviews: environmental concerns, health concerns, and nutritional value of organic foods; ethical concerns and animal welfare for organic meat; perceived food quality, including taste; food safety; and symbolism and status, such as a new lifestyle trend (Eyinade et al., 2021; Katt and Meixner, 2020; Pacho, 2020). Consumers also consider other aspects (motives) when choosing food, such as appearance and freshness (shelf-life) and information such as labels. For example, willingness to pay was higher when products had an organic label, were certified, and had a traceability label. The relevance of such motives for LMIC consumers was reviewed by Pacho (2020). They concluded that a main motive in developing countries for consuming organic foods is taste, in contrast to developed countries, where health concerns have been reported as the main motive. Most consumers are convinced that organic food tastes better. In addition to taste, freshness, the colour of fruits and vegetables, and the perception of high nutritional value positively influences willingness to purchase organic foods in developing countries. In a study conducted in urban Benin and Ghana on organic vegetables, consumer preferred vegetables that were damage free, and also selected vegetables according to freshness, size, colour, and firmness (Coulibaly et al., 2011). In a South African study, organic foods were also considered more environmentally friendly, safer, and of higher quality (see Pacho, 2020, for details). Finally, in a Tanzanian study, locality seems an important attribute, since organic tomatoes produced in their own country were preferred over imported ones from South Africa. Pacho (2020) concluded that, in general, interest around organic foods is rising in developing countries, partly because consumers have become more knowledgeable about food safety and health. Similarly, in a recent review study by Eyinade et al. (2021), human health, food safety, attitudes and perceptions, and willingness to pay for a price premium, are some factors influencing disposition to consume organic foods. Research comparing motivations related to different types of vegetables is lacking.

Opportunities for safe vegetable consumption: in general, access is a constraint for consumers
Opportunity is related to accessibility, availability, and affordability. In a study in Ouagadougou, the distance travelled by consumers and the expected utilisation of food were two major determinants of organic vegetable demand (Kini et al., 2020). Distance negatively affected demand, especially among women who are poorer and have fewer transportation options. In another study in Ouagadougou, urban consumers ranked six major constraints to accessing fresh vegetables, with inadequate supply being the most pressing (Shafiwu et al., 2018). The second-ranked constraint was lack of trust in market vendors: consumers perceive that vegetable vendors are driven by profit motives and charge high prices for vegetables under the pretence they are safe. The other constraints were: distance to the purchasing outlet/point of safe vegetables; higher prices; lack of adequate information on safe vegetables; cultural barriers. In a Ugandan study, the main reason pesticide-stained tomatoes were bought was because the majority of consumers (59%) lacked an alternative (Sekabojja et al., 2021).

Several studies have investigated demographic differences in willingness to pay. In general, willingness could not be related to a demographic profile - although in developing and emerging countries, a substantially higher share of studies found a positive association between income level and willingness to pay (Katt and Meixner, 2020). In a study in two cities of Benin, all consumers were willing to pay a price premium (average of 38%) for cabbage with minimal pesticide residues. Women, older, highly-educated consumers, and those able to distinguish cabbage qualities, were willing to pay the most (Vidogbéna et al. 2015). Willingness to pay premium prices for safer vegetables was also related to higher income-generating employment in Ghana (Cobbinah et al., 2018). In a study in Burkina Faso, a very high percentage of respondents (99%) were willing to pay more for safer vegetables. In this, safer was defined as being produced with clean irrigation water, pesticide-free, free-from agrochemical usage, and the soil was tested. For different types of vegetables, consumers were willing to pay between 59% and 100% extra. Willingness to pay for safer vegetables was significantly influenced by consumers' income, education, household size, and health concerns (Shafiwu 2017; Shafiwu et al., 2018). Similarly, in a study in urban Benin and Ghana, consumers were willing to pay a premium of more than 50% for synthetic pesticide-free vegetables, and willingness to pay was positively related to income level (Coulibaly et al., 2011).

Many urban consumers in Ougadougou buy vegetables at traditional markets (roadside and farm gate), but there has been rapid expansion of 'non-traditional' retail outlets – and research interest around these is building (Shafiwu et al., 2018). Most consumers in this study (53%) considered roadside markets the preferred outlet to buy safer vegetables, 31% preferred the supermarket, and the remaining 16% the farm

gate. This suggests that outlets other than traditional markets could be further explored as possible points of selling safer vegetables. Another option is through out-of-home consumption. Probst et al. (2012), studied consumers' willingness to pay for organic vegetables in urban Benin, Ghana, and Burkina Faso, and suggested concentrating marketing efforts on the educated 'elite' who frequent restaurants. However, restaurant owners in the study exhibited a lower preference for organic certification than lower-class food vendors.

Ability: consumers are aware of food safety issues regarding vegetables, but recognising safer vegetables is an issue

Awareness

Consumers only take food safety precautions when they perceive a risk. If they lack the awareness, knowledge, and skills to buy, prepare, store, and consume food in a safe way, they may be acting out of habit and make food handling mistakes because they lack 'cues to action'. Several studies have addressed the issue of awareness with regard to vegetable safety. Probst et al. (2012), found that, generally, awareness of chemical contamination risk was low in urban Benin, Ghana, and Burkina Faso. In contrast, Coulibaly et al. (2011) found that urban consumers in Benin and Ghana were aware of the heavy use of synthetic pesticides on vegetables. Awareness of chemical residues and health risks was also related to higher willingness to pay for organically grown vegetables, showing potential demand for synthetic pesticide-free vegetables. Similarly, in a study in urban Benin, results indicated that consumers are aware of the health risks associated with intensive pesticide use (Vidogbéna et al. 2015). In a recent study by Sekabojja and colleagues (2021) in Uganda, consumers generally had a negative attitude towards pesticide-stained tomatoes, with 67% of consumers disagreeing with a statement that tomatoes sold at the market are safe. Consumer risk perception was significantly associated with consumer awareness about residues in the tomatoes: consumers who were aware of the risk of pesticide stained tomatoes were 42.8 times more likely not to buy stained tomatoes compared to those who were not aware.

But ability to eat healthy foods is not only about awareness: consumers also require the knowledge and skills to act. However, not much research has been reported on this topic for vegetable consumption in our focus countries. Furthermore, consumers are only able to judge product safety to a certain extent, especially in relation to production processes. For example, in a study by Vidogbéna et al. (2015), respondents were unable to recognise the difference in quality between cabbages produced under nets and those on which pesticides had been used. At the same time, consumers were aware of pesticide health risks and those who felt able to distinguish cabbage qualities were willing to pay more for cabbages with minimal pesticide residues. One opportunity lies in building relationships with vendors, to increase insights around where vegetables were produced and thus increase trust in safety.

Consumer – vendor relationships, trust, and traceability

Maintaining loyal social ties with customers is a strategy used by vendors, especially small businesses, to better sell vegetables and perishable products in a highly competitive context (Adéchian et al., 2021). In addition to the social value that consumers appear to attach to vendors and production sites, the traceability and possibility of producer interaction also increases the likelihood of consumer demand (Kini et al., 2020). To ensure customer loyalty and improve their satisfaction, courtesy visits to market retailers and, in some cases, the establishment of credit based on future sales, are strategies utilised to maintain trust and links between producers and customers (Adéchian et al., 2021). In a study by Cobbinah et al. (2018), Ghanaian consumers willing to pay premium prices are those who trust traders and care about the use of untreated wastewater for irrigation. In a study in Ouagadougou, organic foods were bought directly by 98% of consumers, rather than through resellers or intermediaries. This shows that consumers value the quality and traceability of the food they eat. For instance, consumers asserted: 'Here, it is better because the products are directly harvested and sold at the farms compared to the market place', or 'It is because of the good quality of the food compared to what is sold at the market place, as it is difficult to know if the food there is organic or not' (Kini et al., 2020). Short food chains provide an opportunity to build producer-consumer relationships by giving clear signals about the origin (traceability) of food products.

2.3.2 Reflection by knowledge holders

The following statements match the main literature findings and were discussed during the knowledge holder meeting:

- Appearance is the main aspect on which consumers base their choices. Safety and nutritional content are also important, but more insights are needed about how consumers judge these and the differences between vegetable types.
- The most effective intervention combines increased vegetable availability with increased consumer ability to recognise safer vegetables. There is no need to enhance consumers' awareness or motivation.

Both the above statements were validated by the Malian expert panel. Their discussions showed that:

- Appearance is the main aspect on which Malian consumers base their choices. However, it is difficult for consumers to judge product quality as production information regarding safety and nutritional content is lacking.
- Producers are aware of the importance of product appearance and size – and, as a result, they use a lot of pesticides to make their products more attractive; e.g. without visible damage from insects or production tools.
- In contrast to the literature study outcome, knowledge holders emphasised the importance of creating and raising awareness. Providing product information about production, origin etc., and educating consumers about how to judge product quality are important, as they can motivate consumers to buy products of a better quality.

2.3.3 Conclusions

The MOA framework was useful in identifying and structuring drivers around consumers' vegetable intake behaviour. In literature, health and taste are reported as the main motives for West African consumers, as well as include safety and nutritional content. According to stakeholders, this partially applies for Malian consumers, as appearance is among the main aspects on which they base their choices. Appearance is the main aspect consumers can actually judge at an outlet and often base their choice on. Furthermore, the literature study showed that, in general, consumers are aware of food safety issues regarding vegetables. However, perceptions regarding specific foods and the related safety and health issues may vary between consumers. In the stakeholders' opinion, raising awareness around the benefits and side effects of vegetable consumption remains important – and doing so should take into consideration differences among consumers in terms of behaviour, social norms, and prejudice. Regarding level of opportunity, literature findings suggest that, in general, access to safe vegetables is a constraint – and this was validated by the experts. However, there is a gap in literature on consumers' ability (skills and knowledge) to recognise safer vegetables.

2.4 Role of the food environment in making vegetable choices

Key messages:

- Socio-economic drivers, including economic growth, political stability, and urbanisation, have influenced food environments in Sub-Saharan countries, subsequently contributing to changes in food outlets and consumer behaviour.
- In Mali, informal markets, such as traditional markets, street food vendors, and wet markets, are the main outlets for buying fruit and vegetables. Supermarkets are rising in importance, although they offer a limited range of vegetable and fruit products compared to traditional and informal outlets.
- Out of home, ready-to-eat food is commonly consumed, especially by men, and includes vegetables such as tomatoes, onions, cabbage, and carrots.
- Consumer information on vegetables is lacking and food advertisements rarely focus on vegetables.

2.4.1 Main results from the literature

Changing food environments in Sub-Saharan Africa as a result of socio-economic drivers
Food environment research seems to be more advanced for high-income countries compared to LMICs (Turner et al., 2018). However, regional insights on the current and possible future development of food environments have been explored and reported in academic and grey literature.

Food environments in Sub-Saharan Africa have been changing as a result of drivers such as steady economic growth, political stability, and urbanisation. This has stimulated the spread of new types of food outlets in major cities (e.g., Accra), such as supermarkets and modern food retail outlets (Aryeetey et al., 2016). As a result of these food environment changes, consumer behaviour has also been influenced – leading to a surge in the prevalence of obesity over the last three decades. Increasing obesity levels have also been driven by sedentary lifestyles, lack of access to healthy foods like fruits and vegetables, limited structures to support healthy and active lifestyles, and excess calorie consumption (through sweetened carbonated soft drinks and fast foods) (Dake, Thompson, Agyei-Mensah, and Codjoe, 2016). As a Sub-Saharan West African country, Mali is also experiencing a change in the food environment, which is represented by a rising number of local supermarkets and modern retail food outlets. Liza Market and Marina Market are the spread and biggest supermarkets in Mali. Less educated people and households without a vehicle are reportedly less likely to purchase food from supermarkets (Aryeetey et al., 2016).

Informal markets are the main outlets for buying vegetables; supermarkets are rising in popularity but offer a limited range of vegetables
While vegetables and fruits are sold at different outlets in Mali, the main outlets are informal markets such as traditional markets, street food vendors, and wet markets. The factors which drive preference for traditional markets are identified as: greater product variety, lower prices, and proximity to the source (Aryeetey et al., 2016). Products sold at traditional markets range from fresh foods to various processed foods. In general, Malian households purchase unprocessed foods with longer shelf lives and perishable foods (vegetables and fruits) from traditional markets, with the latter more often being a reason for sourcing groceries from this selling point (Aryeetey et al., 2016).

Formal markets, such as supermarkets, minimarkets, and convenience stores, hardly sell fresh products – and, if they do, quantities are limited compared to informal markets. In Mali, traditional vegetables are more available in peri-urban markets than urban markets, mainly due to preferences of local consumers and demand (Gbenato et al., 2010). The Sahelian region, including Mali and Burkina Faso, is considered as having difficulties in accessing vegetables – partly due to geography and road infrastructure (Ganry, 2009). In general, supply chains are organised depending on the locations and length of the supply chain, but the main actors are usually producers, (collectors, for the large-scale production sites), wholesalers, and retailers (Gbenato et al., 2010). In Mali, commercialisation of vegetables is mostly conducted by women under 30 years of age in rural areas and under 40 years of age in urban areas.

Among these outlets, there is also a difference in the type of vegetables consumed. In effect, vegetables differ per customer type as, for example, restaurant owners and small food businesses have a lower preference for organic certification compared to food vendors (Probst et al., 2012). The appearance and shelf life of fruits and vegetables are considered 'better' compared to organic products, and thus attract the attention of restaurant owners who associate higher quality with these characteristics. Thus, lower-class consumers might purchase more organic products than the educated 'elite'. Results from a study conducted by Dake et al. (2016) of outlets belonging to informal markets in Accra (Ghana), specifically in urban poor communities such as James Town, Ussher Town, and Agbognloshie, showed there is an abundance of out of home-cooked foods (ready to eat and street food vendors) compared to fruit and vegetables, for which selling points seem to be limited. There is also a high density of the same type of outlets in one single area. Street vendors' food is commonly available in the area at any time of the day, exposing residents to a wide quantity of ready-to-eat foods.

Modern outlets, such as supermarkets, can contribute to the increase in obesity prevalence, as these locations lack, or have a reduced number of, healthy alternatives such as fruits and vegetables.

Out-of-home, ready-to-eat food is commonly consumed, especially by men, and includes vegetables such as tomatoes, onions, cabbage, and carrots

As mentioned earlier, street food vendors are among the main food outlets in Mali. There are also fast food outlets, and restaurants, which are recognised as consumption channels for vegetables in West African countries (Ganry, 2009). These food outlets are mostly situated in open air spaces and managed by small-scale retail entrepreneurs (Aryeetey et al., 2016). Street food vendors mainly sell ready-to-eat food prepared in public places – which is eaten where prepared (for example, in informal outlets such as 'chop bars') or taken away in plastic bags, polystyrene packs, or leaves. These products are potentially more exposed to food contamination (e.g., oro-faecal pathogens), since they undergo a series of preparations and handling practices (e.g., water used, cutlery or equipment, hands, ingredients, bowls or storage containers, etc.) in the places they are cooked – such as school compounds, lorry stations, and alongside busy roads (Larbi et al., 2021).

In Ghana, the type of food sold by street food vendors is mainly boiled rice (fried rice, waakye, and jollof rice) and local staple foods (fufu, banku, and kenkey). These are accompanied by either different types of soups (mainly fufu) and fried fish and uncooked sauce (mixture between pepper, tomato, and onion), but also stewed sauce and soup (Dake et al., 2016). In the Dake et al. study, it was noted that out-of-home cooked food does not seem to contribute to residents' weight gain, as seen in other studies. These foods are made from whole unpolished ingredients, thus are less obesogenic. In the same Ghanaian study, where vegetable selling points were available (in lower-level compared to out-of-home foods), the main fruit products sold were oranges, pineapple, watermelon, apple, and blackberries. Vegetables are mostly tomatoes, onions, cabbage, and carrots. Fruits are sold cut into pieces and served in polythene bags or transparent plastic containers on the street, and are usually purchased from food vendors while consumers are stuck in vehicular traffic (Dake et al., 2016).

Consumer information on vegetables is lacking and food advertisements rarely focus on vegetables

The availability of fruit and vegetables is currently very low in sub-Saharan Africa, and the issue has been given little attention by governments and funding agencies (Ganry, 2009). Overall, it also seems that information on vegetables in lacking among both vendors and consumers. Among food vendors, the main sources of information are television and radio (Probst et al., 2012). In a study conducted in Accra city (Ghana) on food advertisements, results showed they rarely focus on vegetables and fruit: almost half of all advertisements were for sugar-sweetened beverages (48.3%), and there was also higher exposure to alcohol adverts than other items (28.5%) (Green et al., 2020). Consumers can base their decision of one vegetable over another for different reasons (see also chapter 2.3), and these reasons differ between consumer groups and among West African countries. For example, in rural areas of Benin, consumers typically buy certain vegetables for four main reasons: taste, ease of preparation, availability, and quantity of required condiments (Dansi et al., 2008). In peri-urban areas of Ghana, consumers base their decisions from which vendor to buy food products on price, vendor relationships, appearance of the environment, vendor appearance, taste, and accessibility. However, food safety and basic food hygiene were not a major concern or priority for either consumers or vendors (Larbi et al., 2021). Some regional differences were found; for instance, awareness of microbial contamination of vegetables was slightly higher in Cotonou and Ouagadougou than in Accra (Probst et al., 2012).

2.4.2 Reflection by knowledge holders

The following statements match the main literature findings and were discussed during the knowledge holder meeting:

- Supermarkets are rising in importance. However, due to their poor vegetable supplies, they contribute to less healthy diets. The supply of vegetables through these modern outlets should be improved.
- Out-of-home food consumption is increasingly important in (peri-)urban Mali. The main group of consumers are men. More information is needed about the quality (nutrition and safety, freshness of vegetables, use of organic products) of the dishes and whether they contain vegetables.

Both the above statements were validated and agreed upon by the Malian expert panel. Their discussions showed that:

- The vegetable assortment in supermarkets need to be diversified. Further, supermarkets need to sell fresh vegetables that matches the purchase power of the population.
- The quality of the food of out-of-home prepared meals differs and depends on the place and purchasing power of the consumers.
- Out-of-home prepared meals are generally considered to be of poorer quality than ones prepared at home, as they are less hygienic, contain little or no vegetables, and are less nutritious.

2.4.3 Conclusions

Literature shows that socio-economic drivers and changes have influenced food environments in Sub-Saharan countries, including Mali, and contributed to modifications in consumer behaviour. There is a current increase in supermarkets and modern retail outlets, resulting from factors such as urbanisation, but these offer a limited range of fresh produce compared to traditional outlets. In Mali, most vegetables are purchased at traditional markets. Knowledge holders mentioned that improving fruit and vegetable displays in supermarkets is an opportunity to explore – as, currently, the assortment is limited and do no match the purchase power of the population.

Information sources utilised by consumers seem to lack reliable data on fruit and vegetable production, availability, and consumption. Thus, Malian consumers base their purchasing decisions more on price, vendor relationships, appearance of environment, vendor appearance, and taste and accessibility of the food. Further, food advertisements rarely focus on vegetables and fruit. Stakeholders agreed that street vendors are important, but the quality of the meals served differs largely and depends on the place and purchasing power of consumers. Out-of-home prepared meals are considered to be unhygienic and less nutritious, due to the lack of vegetables. Increasing vegetable purchase through out-of-home food environments and supermarkets could be areas of intervention by SafeVeg.

2.5 Consumer segments

Key messages

- Segmentation is a useful tool to target the needs, wishes, and/or demands of specific consumer groups.
- Few to no segmentation studies are available on vegetable intake in our countries of research.
- Correlational studies provide entry points to define target groups based on income, gender, and age:
  - *Income*
    Income influences the accessibility of vegetables, especially short term income in some cases. Since a large group of people have a low or fluctuating income and are therefore focused on basic needs, this should be taken into account.
  - *Gender*
    Men should be influenced, because they make decisions about what to buy in a lot of households. However, women should also be targeted, because they actually buy the vegetables and have more nutrient deficiencies.
  - *Age*
    The average age of people is these countries is low. Therefore, when targeting the 'older' group, this is still – by western standards – a younger target group.

2.5.1 Main results from the literature

Segmentation is a useful tool to define specific consumer target groups

The food market is considered heterogeneous, with consumers having different wishes, needs, desires, and expectations. To improve vegetable consumption, it is important that vegetable products or interventions closely match consumer requirements. Segmentation, the identification of homogenous consumer groups who share perceived needs, wishes, or motivations, is considered a useful tool for successfully identifying markets, communication strategies, and interventions (e.g., Gunden and Thomas, 2012; Kotler, 2009; Steenkamp, 1990; Wedel and Kamarua, 2000). The identification of distinct groups is necessary to cater to

the particular needs, wishes, or demands of different segments. Four segmentation bases – the variables the segmentation is based on – have emerged in literature as the most popular: (i) geographic; (ii) demographic; (iii) psychographic; and (iv) behavioural. See Table 2.2 for more information about these segmentation bases. It should be noted that, although demographic segmentation is commonly used, it is considered an untrustworthy segmentation strategy. Demographic variables have been shown to be poor predictors of choice behaviour (Wansink et al., 2004). Consumers with the same demographic factors may greatly differ from each other in their behaviours, preferences, and attitudes. To positively influence vegetable consumption behaviours, it's important to knowing what influences consumers' behaviour. Psychographic segmentation is considered a more accurate strategy, as it attempts to create a better picture of the consumer segments. However, demographic variables are necessary to describe the emerged groups.

Table 2.2 *Overview of the most popular segmentation bases found in literature (e.g., Beane and Ennis, 1987; Kotler, 2009)*

Segmentation base	Explanation
Geographical segmentation	Consumers are divided into different geographical units, such as region (continent, country, neighbourhood), size of metropolitan area, population density, or climate.
Demographic segmentation	Consumers are divided into segments based on demographic variables, such as age, gender, family size, family life cycle, income, occupation, education, generation, religion, ethnicity, or social class.
Psychographic segmentation	Consumers are divided into different groups based on their values, personality traits, interests, lifestyles, activities, attitudes, beliefs, or opinions. This type of segmentation is also called 'lifestyle segmentation'.
Behavioural segmentation	Consumers are divided into different segments based on consumption or buying behaviours towards a certain product. It includes variables related to the sought benefits, usage, brand loyalty, user status, or readiness to buy.

Few to no segmentation studies are available on vegetable consumption in West Africa

Only two segmentation studies in the field of vegetable consumption in West Africa have been found: other segmentation studies focused on health interventions, behaviour in general, or covered other fields, such as HIV/AIDS innovations, and are therefore not included. Sodjinou and colleagues (2009) conducted a cluster analysis of the dietary patterns of urban Beninese adults, and revealed two types: transitional and traditional. These clusters differed in the food groups they consume, macro- and micronutrient intake, and socio-demographic variables. More specifically, 'transitional diet' subjects had a higher socio-economic status (SES), higher education level, and were more likely to be born in the city compared to 'traditional diet' subjects. The diet of transitional subjects was more diversified compared to the traditional subjects, and contained more animal products (e.g., meat, eggs, milk, and milk products), local roots and tubers, white bread and pasta, nuts and seeds, and sweets. Traditional consumers consumed more fruits. No significant differences were found regarding vegetable consumption. Adegbola et al. (2019) showed that, among urban Beninese consumers, the origin, taste, and colour of tomatoes were the most important attributes for purchasing, followed by duration of conservation, consistency, and price. Based on these attributes, four segments were identified, all consisting mostly of women. Only one group (the second segment in terms of size) spent a relatively high amount on tomatoes, with their primary criteria for choosing being the conservation duration; taste was rated second in importance and consistency last. Another segment had the same attributes pattern, with duration of conservation first and taste second, but spend less on tomatoes. For two other groups, the most important criteria for choice was tomato consistency, followed by conservation duration of tomatoes and taste.

Other studies have described consumer groups. For example, Hatch et al. (2011) divided African consumers into basic survivors, working families, rising strivers, cosmopolitan professionals, and the affluent. The results revealed different purchase patterns and expenditures in combination with (demographic) characteristics. However, unlike segmentation studies, the groups were based on high level groupings rather than statistical patterns.

Correlational studies provide entry points to define target groups based on income, gender, and age

Given the lack of segmentation studies, other studies addressing vegetable intake in relation to consumer (demographic) characteristics have been included to identify potential entry points for further research. Most studies used correlational analysis to determine associations between intake and consumer characteristics, and mainly included demographic variables, especially gender, age, and income.

Income

Many studies included income as a variable. It is found that income influences the accessibility of healthy foods, such as vegetables, and food variety (Custdoio et al., 2020; Djossinou et al., 2020; Torheim et al., 2004). A more diversified diet is better accessed by those with higher income and socio-economic status. A note here is that short-term income might influence the diet diversity score more than proxies used to determine groups with different socio-economic status (Custdoio et al., 2020).

Gender

Women seem to have more micronutrient deficiencies and a lower diet diversity compared to men (Djossinou et al., 2020; Levesque et al., 2015; Sodjinou et al., 2009). However, Brouwer et al. (2021) found that women are more inclined to eat healthy foods. Acceptability seems to be related not only to that by women, but also by her family, household head, and her husband. In many households, the household head and/or husband makes the most decisions regarding purchases, and mothers of young children are less mobile and rely on their family (Fanou-Fogny, 2011; Heckert, 2019).

Age

A few studies showed that the age of the household head was related to diet diversity (Custdoio et al., 2020; Tornheim et al., 2004). Diet diversity and vegetable consumption declines with age. It should be noted that the mean age of respondents in different Sub-Saharan African studies was quite low compared to study samples in Western countries.

2.5.2 Reflection by knowledge holders

The following statements match the main literature findings and were discussed during the knowledge holder meeting:

- Demographic groups to focus on:
  - Gender (male, *female*, decision-maker, vegetable purchase/meal preparation)
  - Income (*low, middle*, high)
  - Age (*younger*, older)
- Identifying consumer segments can be helpful for more targeted interventions. These segments are most meaningful when based on the importance of product attributes (such as taste, price, colour, consistency, conservation duration, and healthiness).

Both the above statements were validated and agreed upon by the Malian expert panel. Their discussions showed that:

- Interventions should target women, low- and medium-income groups, and young people.
- Women decide the vegetable types to be purchased and they prepare dishes for the whole family.
- Low- and middle-income groups have less access to a healthy, diversified diet and better quality foods than high income groups.
- Young people should be targeted because they are the majority and are more able to consume vegetables than the elderly.
- Identification of consumer groups is considered to be useful for more targeted interventions.

2.5.3 Conclusions

Segmentation is a useful tool to identify homogeneous groups of consumers but, so far, only a few studies have described segments of vegetable consumers in West Africa. Meanwhile, other correlational studies have mainly addressed demographic characteristics in relation to vegetable purchase and consumption. Based on the literature, focus might be placed on consumer groups of low- and middle-income, younger age, and both genders, but especially women. Knowledge holders consulted in this study agreed with this finding and supported the importance of income as restricting food choices in Mali. Low- and middle-income groups have less access to a healthy and diversified diet than high-income groups, as these foods are not affordable to them. In literature, age seems to be related to lower vegetable intake. Knowledge holders supported the targeting of young people as they are a large demographic – and by focusing on this group, a greater impact might be achieved.

3 Conclusions

The literature study supported the focus of SafeVeg by showing that – from both a nutritional point of view and in terms of safety – interventions are needed to promote safe vegetable consumption in urban Mali. In Chapter 2.1, the role of vegetables in dietary intake was reviewed. Although vegetables are among the most frequently consumed food groups in Mali, consumption still seems to be below recommendations. Vegetables that are nutrient dense and a source of priority micronutrients (iron, vitamin A) need to be promoted. Among other vegetable types, focus should be on green leafy vegetables due to their nutrient density and their potential contribution to decreasing nutrition deficiency and overweight problems.

Despite their healthiness, the literature shows that vegetables are not always safe or of a high quality. Vegetables are not the main source of foodborne contamination, yet raw and fresh leafy vegetables contribute to FBDs. Production environment and poor hygiene are also considered to contribute to FBDs. Different elements within, and drivers of, the local food system contribute to FBD outbreaks – as products such as pesticides and fertilisers are used to improve vegetable appearance and maximise yields and profits. However, this is at the expense of consumer health. Despite the existence of AMANORM and ANSSA, health and safety regulations are insufficiently applied and/or monitored in Mali. Reliable information sources for consumers in Mali on vegetable production and nutritional value are also lacking. Most vegetables are purchased at traditional markets, due to their product assortment, prices, and proximity to the source. Supermarkets are rising in numbers, but their vegetable assortment is very limited and prices do not match the purchasing power of the population. The out-of-home food environment, including street food vendors, is becoming more important, and street foods can make up a significant proportion of daily macro- and micronutrient intake. However, in Mali, street foods often supply limited amounts of vegetables and exist mainly of starchy foods. Further, they are typically of low quality and unhygienic, due the preparation methods used. Overall, the results support the importance of interventions that encourage increased vegetable consumption. However, such interventions are complicated by the fact that vegetables are acquired almost entirely through informal systems – and these lack monitoring and safety awareness among Malian supply chain actors, vendors, and consumers.

In this literature search, the MOA framework proved useful in identifying and the drivers of vegetable consumption behaviour and structuring them into motivational, opportunity, and ability-related aspects. Appearance is among the main motivational aspects that Malian consumers base their vegetable choices on. Safety and nutritional content are also important; however, it is unknown how consumers judge these and how perceptions and prejudices of specific vegetables differ between consumer groups. Accessibility is also relevant, as the lack of available safe vegetables is perceived as a constraint by consumers. Within the projects, providing access to safe vegetables and enhancing consumers' ability to recognise them could be important points of intervention.

When looking at the type of urban Malian consumers that should be targeted by the project, demographic variables, such as income, gender, and age, need to be considered. Income restricts food choices and influences the accessibility of vegetables. Interventions should therefore focus on vulnerable low- and middle-income groups. The results further suggest that interventions should focus on women, as they decide what food is bought, consumed, and prepared. It should be noted that out-of-home foods are mainly consumed by men. Further, young people should be targeted as this is a large group – and increasing their vegetable consumption behaviour positively influences their eating habits, in turn increasing impact.

We conclude that entry points for enhancing the consumption of safe vegetables in Mali should focus on:
- Vulnerable low- and middle-income groups, including young adults and women
- The main food choice drivers, including appearance, health (including safety) and taste
- Accessibility to safe vegetables within the local food environment, both at-home and out-of-home
- Improving consumers' ability (knowledge and skills) to recognise safer vegetables

We therefore suggest the following potential interventions:

- *Increasing the proportion of healthy vegetables in street food dishes.*
  Increasing the proportion of vegetables in street food dishes is likely to positively impact various types of consumers, especially the poorer segments. The consumption of out-of-home cooked food is becoming increasingly important in urban Mali, and these meals are currently generally deficient in vegetables. Moreover, this intervention may have positive economic impacts on street food vendors, which are mainly women, and their suppliers, traders, and producers.
- *Labelling the origin of vegetables.*
  The labelling of vegetables is likely to have a positive impact on various types of consumers, including the poorer segments, as the vegetables are sold at the traditional outlets (e.g., wet market). Applying labels to inform Malian consumers on the vegetable's origin makes them more capable and confident in recognising and selecting safer vegetables.

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Appendix 1 Search terms literature search

Scopus:
(TITLE-ABS-KEY (benin OR beninese OR burkina OR burkinan OR mali OR malian OR cotonou OR "Porto Novo" OR parakou OR ouagadougou OR "Bobo Dioulasso" OR koudougou OR bamako OR segou OR sikasso)) AND (TITLE-ABS-KEY (vegetable OR tomato OR onion OR amaranth OR "African eggplant" OR jute OR "bitter leaf" OR "cowpea leaf" OR cabbage OR okra OR gombo OR gboma OR gbolo OR "african basil" OR "sweet potato leaf" OR bean OR shallot OR roselle OR sorrel OR carrot OR "black nightshade" OR pumpkin OR squash OR "black-eyed peas" OR "cassava leaf" OR pepper OR peppers OR lettuce)) >> **688 results**

CAB:
(exp leafy vegetables/ or vegetable? or tomato*2 or onion? or amaranth? or African eggplant? or jute or bitter leaf or bitter leaves or (cowpea adj3 leaf) or (cowpea adj3 leaves) or cabbage? or okra or gombo or gboma or african basil or (sweet potato adj3 leaf) or (sweet potato adj3 leaves) or bean or beans or shallot? or roselle? or sorrel? or carrot? or black nightshade? or pumpkin? or squash or black-eyed pea? or (cassava adj3 leaf) or (cassava adj3 leaves) or pepper? or lettuce? or gbolo).mp. AND (Benin or beninese or Burkina or burkinan or Mali or malian or Cotonou or Porto Novo or Parakou or Ouagadougou or Bobo Dioulasso or Koudougou or Bamako or Segou or Sikasso).mp.>> **2035 results**

PubMed:
(vegetable[MESH] OR "vegetable*"[Title/Abstract] OR "tomato*"[Title/Abstract] OR "onion*"[Title/Abstract] OR "amaranth*"[Title/Abstract] OR "african eggplant*"[Title/Abstract] OR "jute"[Title/Abstract] OR "bitter leaf"[Title/Abstract] OR "cowpea leaf"[Title/Abstract] OR "cowpea leaves"[Title/Abstract] OR "cabbage*"[Title/Abstract] OR "okra"[Title/Abstract] OR "gombo"[Title/Abstract] OR "gboma"[Title/Abstract] OR "african basil"[Title/Abstract] OR "sweet potato leaf"[Title/Abstract] OR "sweet potato leaves"[Title/Abstract] OR "bean*"[Title/Abstract] OR "shallot*"[Title/Abstract] OR "roselle*"[Title/Abstract] OR "sorrel*"[Title/Abstract] OR "squash"[Title/Abstract] OR "carrot*"[Title/Abstract] OR "black nightshade*"[Title/Abstract] OR "pumpkin*"[Title/Abstract] OR "black eyed pea*"[Title/Abstract] OR "cassava leaf"[Title/Abstract] OR "cassava leaves"[Title/Abstract] OR "pepper"[Title/Abstract] OR "peppers"[Title/Abstract] OR "lettuce"[Title/Abstract] OR "gbolo"[Title/Abstract]) AND ("benin"[Title/Abstract] OR "beninese"[Title/Abstract] OR "burkina"[Title/Abstract] OR "mali"[Title/Abstract] OR "malian"[Title/Abstract] OR "cotonou"[Title/Abstract] OR "porto novo"[Title/Abstract] OR "parakou"[Title/Abstract] OR "ouagadougou"[Title/Abstract] OR "bobo dioulasso"[Title/Abstract] OR "koudougou"[Title/Abstract] OR "bamako"[Title/Abstract] OR "segou"[Title/Abstract] OR "sikasso"[Title/Abstract]) >> **210 results**

PsycInfo (gezocht in All text + Apply equivalent subjects)**:**
(vegetable OR tomato OR onion OR amaranth OR "African eggplant" OR jute OR "bitter leaf" OR "cowpea leaf" OR cabbage OR okra OR gombo OR gboma OR gbolo OR "african basil" OR "sweet potato leaf" OR bean OR shallot OR roselle OR sorrel OR carrot OR "black nightshade" OR pumpkin OR squash OR "black-eyed peas" OR "cassava leaf" OR pepper OR peppers OR lettuce) AND (benin OR beninese OR burkina OR burkinan OR mali OR malian OR cotonou OR "Porto Novo" OR parakou OR ouagadougou OR "Bobo Dioulasso" OR koudougou OR bamako OR segou OR sikasso)>> **6 results**

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The mission of Wageningen University & Research is "To explore the potential of nature to improve the quality of life". Under the banner Wageningen University & Research, Wageningen University and the specialised research institutes of the Wageningen Research Foundation have joined forces in contributing to finding solutions to important questions in the domain of healthy food and living environment. With its roughly 30 branches, 7,600 employees (6,700 fte) and 13,100 students and over 150,000 participants to WUR's Life Long Learning, Wageningen University & Research is one of the leading organisations in its domain. The unique Wageningen approach lies in its integrated approach to issues and the collaboration between different disciplines.