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A systematic review on the factors influencing adoption and consumption of orange-fleshed sweetpotato in sub-Saharan Africa

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Orange-fleshed sweet potato (OFSP) is a promising crop in combating vitamin A deficiencies (VAD) in sub-Saharan Africa (SSA)'s vulnerable populations and its adoption directly impacts potential benefits across the value chains. This review assessed OFSP adoption factors and advances in research for OFSP increased production across SSA countries. Scopus, Research for Life, and Google Scholars were searched to identify peer-reviewed studies published between 2000 and 2023 on the different objectives. The systematic search resulted in 22 and 53 studies, respectively, for the first and second objective that met inclusion criteria. Data extracted include author and year, study location, study population, methodology, results, and conclusion. Our study indicates that the adoption of OFSP in SSA is influenced by six primary factors: "Knowledge and awareness," "social factors and networks," "agronomic traits," "taste and sensory attributes," "health and nutrition," "market and economics." Furthermore, the review identified various studies highlighting the need to align breeding objectives with factors influencing OFSP adoption, implement optimal agronomic practices tailored to local contexts, and develop efficient value chains and targeted marketing strategies to increase OFSP production and commercialization across sub-Saharan African countries. This review underscores the importance of formulating breeding objectives, production techniques, and commercialization strategies in line with stakeholder needs and adoption factors to ensure successful OFSP integration for combating VAD in SSA. With these insights into factors affecting adoption and consumption of biofortified crops, new research and development roadmap is required to address evolving challenges influencing widespread OFSP adoption.

KEYWORDS

orange-fleshed sweetpotato, adoption, vitamin A, sub-Saharan Africa, food security, breeding

1 Introduction

Malnutrition has become a palpable concern affecting populations worldwide, particularly in low- and middle-income countries, such as those in sub-Saharan Africa (SSA). These regions often experience undernourishment, resulting in deficiencies of essential nutrients and micronutrients, impacting the health and well-being of their populations. According to Ritchie et al. (2023), SSA faces the highest rate of undernutrition in the world. The most vulnerable groups affected by undernutrition are children and women. Shockingly, in 2022, 22.3% of children under the age of 5 years exhibited stunted growth, characterized by low height for their age. Additionally, approximately 6.8% children under age five suffered from wasting in the world, which refers to a low weight for height (UN, 2023).

The distribution of undernutrition within SSA reveals variations in the prevalence of different forms of malnutrition. According to UNICEF (2023), Middle Africa has a higher prevalence of stunting (36.8%) compared to Eastern Africa (32.6%), Western Africa (30.9%), and Southern Africa (23.3%). On the other hand, Middle Africa has a higher rate of wasting (1.9%) compared to Western Africa (1.4%), Eastern Africa (1.0%), and Southern Africa (0.7%). Undernutrition is a significant contributor to child mortality, accounting for 45% of deaths among children under the age of 5 years (Black et al., 2013). Additionally, it also has a substantial impact on overall health and well-being, contributing to 21% of disability-adjusted life-years (Black et al., 2008). Particularly, vitamin A deficiency (VAD) is reported as one of the most widespread consequences of malnutrition, and it is a major public health problem in developing countries, particularly in SSA where it affects millions of people (Ohanenye et al., 2021). VAD leads to various health issues, including blindness, stunted growth, and weakened immunity, it is also associated with significant morbidity and mortality from common childhood infections and is the world's leading preventable cause of childhood blindness (WHO, 2009; Low et al., 2017). The impact of VAD on child health in SSA is profound, with an estimated 48% of children suffering from the deficiency (Stevens et al., 2015). This places them at a greater risk of dying from infectious diseases, respiratory illnesses, and diarrheal diseases (Imdad et al., 2011; Awasthi et al., 2013). In the absence of effective interventions, approximately 43.2 million children under 5 years old in SSA (42.4% of this age group) remain at risk for VAD (Aguayo and Baker, 2005). The deficiency alters the immune system, making children more susceptible to infections and reducing their ability to fight off diseases. For this reason, the World Health Organization (WHO) has classified VAD as "a public health problem" affecting about a third of all children aged 6 to 59 months globally (WHO, 2009).

The agricultural sector provides several solutions, including improving availability of and access to nutrient-rich foods (Ruel and Alderman, 2013; McDermott et al., 2015; Pandey et al., 2016) such as orange-fleshed sweetpotato (OFSP). OFSP is widely promoted in the context of the fight against VAD diseases, due to its higher content of beta-carotene (β-carotene) compared to white varieties, and has also been the subject of much genetic improvement in recent years (Low et al., 2000; Mwanga et al., 2009), some OFSP cultivars combine drought tolerance and ease of cultivation (Low et al., 2007a).

OFSP has gained significant attention in SSA due to its potential to address VAD and improve food security (Gurmu et al., 2014). From 2009 to July 2019, the Sweetpotato for Profit and Health Initiative contributed to the release of 132 improved varieties of sweetpotato, including 93 OFSP varieties, reaching 6.2 million households across 16 countries in SSA (Okello et al., 2018; Low and Thiele, 2020).

Several government programs, interventions, and breeding initiatives have further supported the expansion of OFSP in SSA. For instance, the Technologies for African Agricultural Transformation (TAAT) program, funded by the African Development Bank, has worked to enhance the production and dissemination of OFSP through the promotion of improved agricultural practices and innovative technologies (Okello et al., 2018). In addition, CIP has collaborated with local governments and organizations like the SASHA project in Kenya and the VISTA project in Tanzania to develop and distribute OFSP varieties specifically adapted to local growing conditions and aligned with consumer preferences (Girard et al., 2021). In addition, CIP collaborated with local governments and organizations to implement different projects such as the Sweetpotato Action for Security and Health in Africa (SASHA) and the Viable Sweetpotato Technologies for Africa (VISTA) to develop and distribute OFSP varieties specifically adapted to local growing conditions and aligned with consumer preferences (Girard et al., 2021).

Beyond OFSP, other vitamin A–rich sources available in SSA include vitamin A maize, dark green leafy vegetables (such as spinach, kale, and amaranth), carrots, and pumpkins. While these foods contribute to dietary vitamin A intake, they often face challenges related to affordability, seasonal availability, and cultural acceptance. In contrast, OFSP is not only rich in beta-carotene but also relatively easy to cultivate, resilient to climate change, and can be processed into various value-added products, ensuring year-round availability and greater consumer acceptance (Lividini et al., 2024). These characteristics make OFSP a sustainable and reliable source of vitamin A, particularly for smallholder farmers and vulnerable populations.

However, the success of vitamin A rich or biofortified crops in general heavily relies on the acceptance of these newly bred varieties by consumers and producers (Saltzman et al., 2013). Producers' adoption is influenced by factors like yield, disease resistance, drought tolerance, and market appeal. On the other hand, consumers' willingness to adopt new crops is influenced by changes in sensory traits, such as the color change seen in provitamin A-rich crops like OFSP.

In recent years, numerous articles from different countries have delved into the determinants of acceptance of OFSP in SSA, both among producers and consumers (Low et al., 2007a, 2007b; Naico and Lusk, 2010; Okwadi, 2015). Simultaneously, various studies have reported on the genetic improvements observed in new OFSP varieties developed in SSA (Mwanga et al., 2007, 2009, 2021b). However, reviews have been scarce in providing a comprehensive overview of the factors influencing the adoption of new varieties in general, particularly focusing on vitamin A-rich crops, and how crop improvement aligns with the satisfaction of these factors.

Therefore, the primary aim of this review is twofold. Firstly, it aims to synthesize the key factors that contribute to the adoption of vitamin A -rich cultivars in SSA, using OFSP as a case study. Secondly, the review will assess the influence of the identified factors on value chain interventions for OFSP in Sub-Saharan Africa, and their implications for increased adoption, production and consumption. By addressing these critical aspects, this review will offer valuable contributions into the broader adoption of biofortified crops and contribute to enhancing nutritional outcomes in SSA.

2 Methods

We conducted this review using the guideline from Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021).

2.1 Search strategy

The study selection process involved the following steps:

For the first objective, which focuses on factors contributing to the adoption of OFSP in SSA countries, relevant keywords including "Orange-fleshed sweet potato," "OFSP," "Adoption," "Factors," and "Sub-Saharan Africa" were identified. These keywords were combined using Boolean operators and expanded through the inclusion of synonyms and related terms such as ("Sweet potato" AND ("Orange-fleshed sweet potato," OR"OFSP), AND "adoption" AND "sub-Saharan Africa," OR "SSA"), (("Determinants" OR "Drivers") AND ("OFSP"OR "orange-fleshed sweet potato") AND "adoption"), (("OFSP"OR "orange-fleshed sweet potato") AND "adoption" AND "farmers" AND "children" AND "women" AND ("sub-Saharan Africa," OR "SSA")), and ("Adoption" AND ("Dis-adoption" OR "limitation") AND ("OFSP"OR "orange-fleshed sweet potato") AND ("sub-Saharan Africa" OR "SSA)).

For the second objective, which focuses on value chain intervention efforts of OFSP in SSA, relevant keywords such as "Orange-fleshed sweet potato," "OFSP," "Breeding efforts," "Breeding programs," "multi-environment," ("resistance" OR "tolerance,") "weevil," "virus," "yield,"" Dry matter," "β-carotene," "Market," Marketing "commercialization," "transformation," "products," and "Sub-Saharan Africa" were identified. These keywords were combined using Boolean operators and expanded through the inclusion of synonyms and related terms such as ("OFSP" AND "breeding" AND "sub-Saharan Africa"), ("weevil" OR "virus" OR "drought" OR "Dry matter" AND ("resistance" OR "tolerance") AND "improvement" AND ("orange-fleshed sweet potato" OR "OFSP") AND "breeding" AND ("SSA" OR "sub-Saharan Africa")), ("Genetic" AND "improvement" AND "OFSP" AND "sub-Saharan Africa") ("release" AND "improved" AND "OFSP" AND "sub-Saharan Africa," ("participatory" AND "breeding "AND "selection" AND "OFSP" OR "orange-fleshed sweet potato" AND "Farmers" AND ("SSA" OR" sub-Saharan Africa"))).

The search was limited to studies published between 2000 and 2023 to focus on recent research relevant to the study objectives. Three databases, namely Scopus, Research for Life, and Google Scholar, were selected as they provide access to a wide range of scholarly literature across various disciplines.

Advanced search features and filters were utilized, including language filters to include only English language articles for efficient comprehension and analysis. Filters for study types, such as empirical research and case studies, were applied if applicable to refine the search results.

In addition to the database searches, relevant journals in the fields of agriculture, crop science, and rural development in SSA were hand-searched to identify additional studies. The reference lists of relevant articles and review papers were also reviewed to uncover any additional relevant studies that may have been missed in the initial search. Duplicates were identified and removed using Mendeley Desktop (Version 1.19.8) to ensure that each article was considered only once.

2.2 Eligibility criteria

As presented in (Supplementary Tables 3, 4), we used six criteria to determine eligibility for inclusion: geographical relevance; topic relevance; publication quality; language; publication years; study evaluation method, with specific targeted population. For the first objectives study the target populations were farmers, consumers, children, caregivers, pregnant women, or household members in general. The second objective was related to genetic population of sweet potato among which OFSP genotypes have been evaluated.

2.3 Data extraction

Two researchers screened article titles and abstracts independently to find relevant ones, applying inclusion and exclusion criteria strictly. Discrepancies were resolved through discussion or by involving a third reviewer. Relevant articles underwent thorough full-text evaluation by two researchers. During data extraction, articles were carefully examined, and evidence tables were created to systematically extract data. Senior researchers reviewed extracted data and evidence tables for accuracy and completeness, ensuring quality control. Their involvement maintained a rigorous review process.

Factors influencing OFSP adoption and consumption in SSA, were assessed using the following outcomes: (i) driving factors and hindrances identified; (ii) factors of importance in decision-making evaluated. The influence of identified factors on OFSP value chain interventions and implications for increased adoption and consumption were assessed with the following outcomes: (i) the impact on breeding priorities, varietal development, and dissemination strategies assessed; (ii) the influence on production practices, constraints, and scaling opportunities analyzed; (iii) the effect on commercialization strategies, market dynamics, and value chain development examined.

2.4 Data collection

The data collection process for this study involved gathering pertinent information, including publication details, study design, study population, data collection method, data analysis, and outcomes. To ensure accuracy and reliability, the first two authors independently extracted data from 25% of the studies for each objective. Subsequently, the first author continued with data extraction for the remaining studies, while the second author carefully reviewed the extracted data for accuracy and completeness. This rigorous approach ensured the quality and integrity of the collected data for analysis.

2.5 Study quality assessment

In order to evaluate the potential bias in the articles included in this review, we employed specific quality assessment tools. For the first objective, we utilized a checklist adapted from the Critical Appraisal Skills Programme (CASP) for qualitative studies (Critical Appraisal Skills Programme, 2018a). For the second objective, we employed an adapted checklist based on the Critical Appraisal Skills Programme (CASP) specifically designed for randomized control trials (Critical Appraisal Skills Programme, 2018b).

The assessment of study quality was conducted independently by two reviewers, and each study was evaluated against nine criteria for the first objective (Supplementary Table 5) and seven criteria for the second objective (Supplementary Table 6). The risk of bias was then rated using a scale, which categorizes scores between 8 and 9 as low, scores between 5 and 7 as medium, and scores below 5 as high for the first objective. Similarly, for the second objective, the scale categorizes scores between 6 and 7 as low, a score of 5 as medium, and scores below 5 as high.

2.6 Concept clarification

The review revealed that the factors influencing the adoption of the OFSP for its production and/or its consumption are very diversified. To facilitate the analysis, we grouped the different factors by affinity. This allowed us to create six major categories of factors, namely (Knowledge and awareness; Social factors and networks; Agronomic traits; Taste and sensory attributes; Health and nutrition; and Market and economy).

- *Knowledge and awareness*: this category includes factors such as awareness of the nutritional benefits of OFSP, participation in training or education programs related to OFSP, and access to information sources such as radio or extension agents. This category refers to all the factors relative to cognitive aspects of OFSP adoption, enabling farmers and other stakeholders such as consumers, processors, traders, in the OFSP value chain to learn about OFSP and its advantages. For example, a farmer may become aware of OFSP through a radio program or a training session, and then gain knowledge about how to grow and cook OFSP.
- *Social factors and networks:* this category is related to factors that are linked to the social context and interactions of farmers and other stakeholders, which can influence their decisions and behavior towards OFSP adoption.These factors include social networks and network effects, nutrition support between mothers, nutrition-focused health talks, participation in groups, as well as peer influence and learning.
- *Agronomic traits:* this category puts together factors that influence agronomic performance and profitability of OFSP varieties for farmers. This includes factors such as yield, disease resistance, early maturity, drought tolerance, storage quality, seed quality.
- *Taste and sensory attributes:* this category include factors such as the taste and sensory attributes of OFSP, such as sweetness, texture, flavor, color preference, cooking quality, and processing potential. These factors influence consumer acceptance and demand for OFSP products, which in turn can impact the marketability and profitability of OFSP for farmers and other stakeholders in the value chain.
- *Health and nutrition:* this category is about how OFSP affects their bodies and well-being specifically the physical effects that result from eating OFSP regularly. The category includes factors such as improved skin and eye health, better birth outcomes, increased vitamin A intake, reduced malnutrition, and micronutrient deficiencies.
- *Market and economy:* this category includes factors such as market demand and supply, availability and availability of OFSP options, pricing and profitability, market competition and value chain.

Here, we defined "*Knowledge and awareness*" as the mental processes that enable farmers and other stakeholders to learn about OFSP and its advantages. For example, a farmer may become aware of OFSP through a radio program or a training session, and then gain knowledge about how to grow and cook OFSP. "*Health and nutrition*" are the physical effects that result from eating OFSP regularly. For example, a farmer may experience improved skin and eye health, or reduced anemia, due to the increased intake of OFSP.

3 Results

3.1 Study selection

Through an extensive search of bibliographic databases, a total of 947 adoption studies (n = 544) and advances in OFSP research studies (n = 403) were retrieved, corresponding to each specific research objective, respectively. After meticulous screening and removal of duplicates, we identified 265 and n = 174 unique records from the electronic databases, respectively. This rigorous process led to the final inclusion of (n = 20) articles that delved into the various factors influencing the adoption of OFSP in SSA. Additionally, our analysis encompassed (n = 50) studies focused on the efforts and progress in OFSP production within SSA (Figure 1). To supplement our findings, we also explored the gray literature, unearthing valuable information. This search yielded (n = 2) and (n = 3) contributing to a comprehensive understanding of the OFSP adoption landscape.

3.2 Study characteristics

Of the 22 items collected, five were obtained by consulting the list of references (snowball method), 19 of these studies were conducted in East Africa while the rest (n = 3) were done in the western part of the continent (Figure 2A). Kenya, Tanzania, Mozambique, and Uganda are the countries reported with the maximum number of studies, while countries like Malawi, Zambia, Ethiopia, and Nigeria recorded the lowest number of studies. Two studies were recorded in Ghana.

To provide further clarity, the studies collected for the second objective were categorized into two groups. The first group encompasses studies related to breeding efforts for OFSP (Figure 2B), while the second group comprises agronomic intervention and commercialization efforts (Figure 2C). As for the second objective, three of the 53 articles used were identified from the references list. A total of 43 studies were carried out in the eastern part of Africa while only six were carried out in the West (Figures 2B,C). Here, the country with the highest number of studies was Uganda (n = 17),

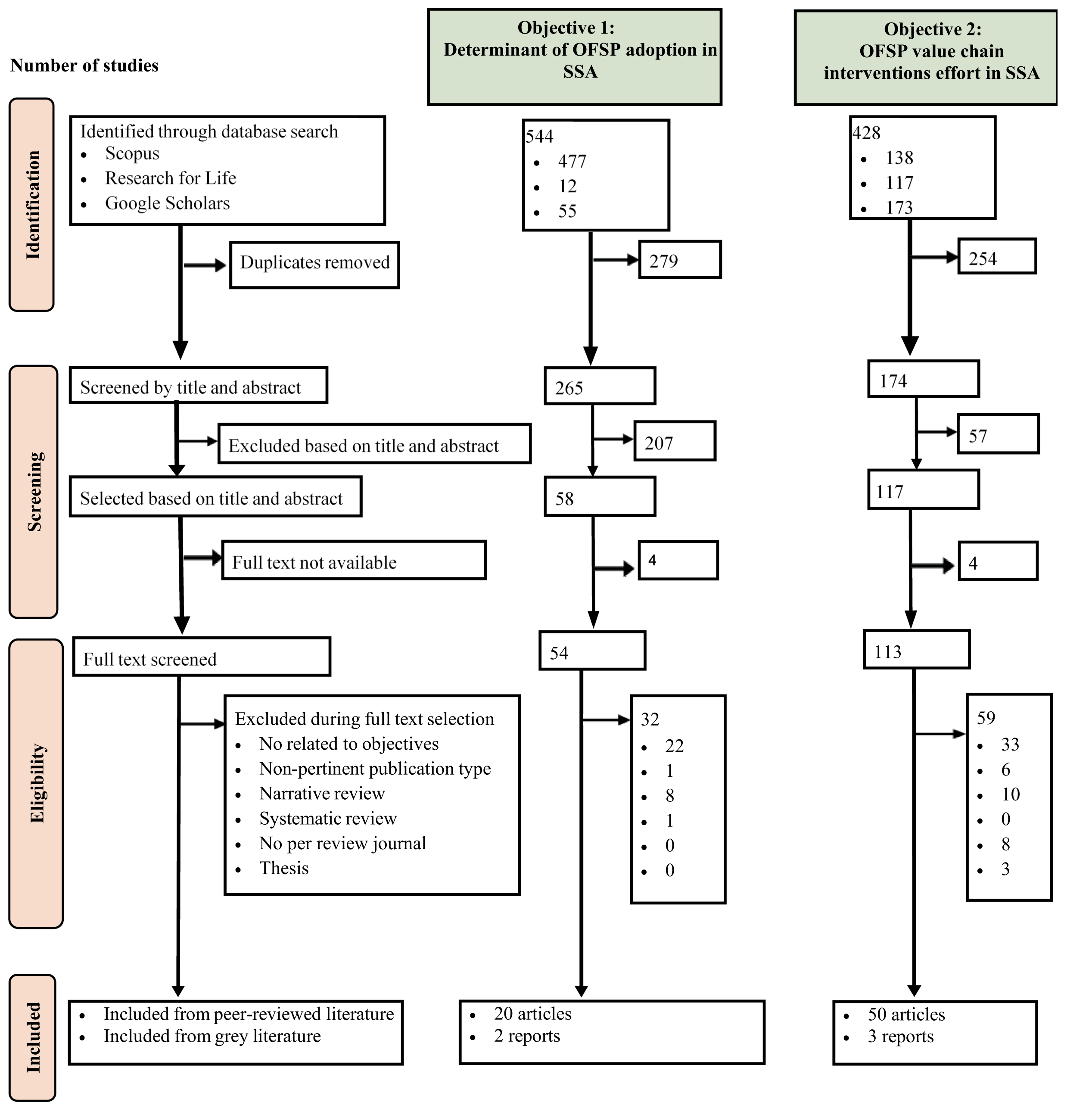

FIGURE 1
PRISMA flow diagrams for the two systematic literature searches conducted for this review.

while the lowest was observed in Rwanda ($n = 2$). Further details on study characteristics are provided in Supplementary Tables 1, 2 for each objective, respectively.

3.3 Factors driving OFSP adoption in SSA

Overall, factors related to knowledge and awareness group were the most predominant with 13 studies referring to one or more factors belonging to this group, followed by agronomic traits ($n = 7$), taste and sensory attributes ($n = 6$), social factors and networks ($n = 6$), market and economic ($n = 4$), and health and nutrition ($n = 1$).

3.3.1 Knowledge and awareness

Thirteen studies on knowledge and awareness on adoption of orange fleshed sweet potato were found (Naico and Lusk, 2010; Behrman, 2011; Chowdhury et al., 2011; Kaguongo et al., 2012; Okello et al., 2017, 2015; Lagerkvist et al., 2016, 2020; Sakala et al., 2018; Adekambi et al., 2020a; Caeiro and Vicente, 2020; Gilligan et al., 2020) (Figure 3A). Only three study concerned caregivers of children under 5 years or/and pregnant women (Lagerkvist et al., 2016, 2020; Caeiro and Vicente, 2020).

In Uganda, and Kenya, three out of four studies reported one or more factors belonging to this category as being very important, and in Tanzania and Mozambique, two out of four studies were reported in this category.

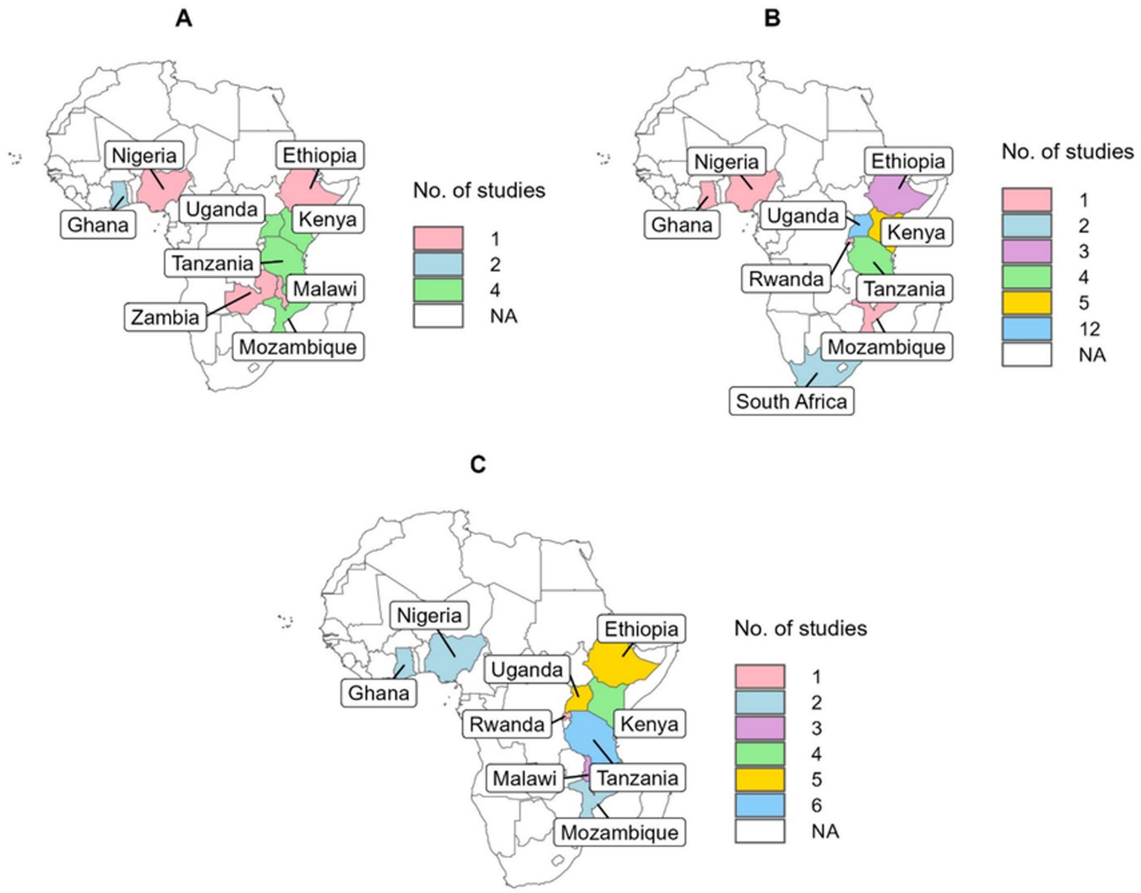

FIGURE 2
Distribution of studies reviewed across SSA countries. **(A)** Determinant of OFSP adoption in SSA (n = 22). **(B)** OFSP Breeding intervention in SSA (n = 30). **(C)** Agronomic and commercialization interventions in SSA (n = 24). NA, Not available.

3.3.2 Agronomic traits

It represents the second group of factors mentioned in literature, reported in seven (Behrman, 2011; Kaguongo et al., 2012; Jenkins et al., 2018; Adekambi et al., 2020b; Mwiti et al., 2020; Jogo et al., 2021; Hendebo et al., 2022) (Figure 3A). Effects of agronomic traits on OFSP adoption is directly linked to the stability and performance of OFSP varieties in different agroecological conditions. The agronomic traits that can determine adoption of this variety vary across different countries and regions, depending on the availability and adaptation of OFSP varieties. Two studies out of four in Mozambique have reported factors related to agronomic traits as very important (Jenkins et al., 2018; Jogo et al., 2021); one out of two was reported for Ghana (Adekambi et al., 2020b).

3.3.3 Social factors and networks

One or more factors belonging to this category were reported in a total of six of the studies collected (Behrman, 2011; Mudege et al., 2017; Caeiro and Vicente, 2020; Gilligan et al., 2020; Lagerkvist et al., 2020; Ndaula et al., 2021) (Figure 3). Social factors and networks influence on OFSP adoption can be observed trough effect of diffusion of information and innovations, social learning, peer pressure, belief, and cooperation. Depending on the structure and dynamics of social groups and institutions, effect of this category can vary. In Uganda three out of four of the studies have shown the importance of social factors and networks group in OFSP adoption. According to Ndaula et al. (2021), the probability of OFSP acceptance rises as more farmers within the Uganda community have been cultivating OFSP for over 6 months. For Caeiro and Vicente (2020), farmers contribute to the spread of OFSP adoption within their social networks by exchanging planting material with other farmers. This practice facilitates the dissemination of OFSP adoption among farmers. While for Lagerkvist et al. (2020) the intention to integrate OFSP into children's diets was higher among pregnant women compared to women with children. The dissemination of information and resources on OFSP through farmers' groups played a significant role in fostering a sense of camaraderie and community among members. It facilitated knowledge sharing, mutual assistance, and, in some instances, collective selling of vines (Behrman, 2011).

These studies revealed that strong and supportive social ties and interactions facilitate OFSP adoption and diffusion among target population, by enhancing the access and exchange of information, seeds, and skills about OFSP, as well as the collective action and coordination among OFSP stakeholders. Despite similarities in the adoption of OFSP across these countries, differences exist in the type and influence of social groups and institutions. In Uganda, farmers belonging to a groups were more influential than non-farmer groups (Behrman, 2011) and Ndaula et al. (2021) show the importance of farmers social relationship in OFSP adoption; and Gilligan et al.

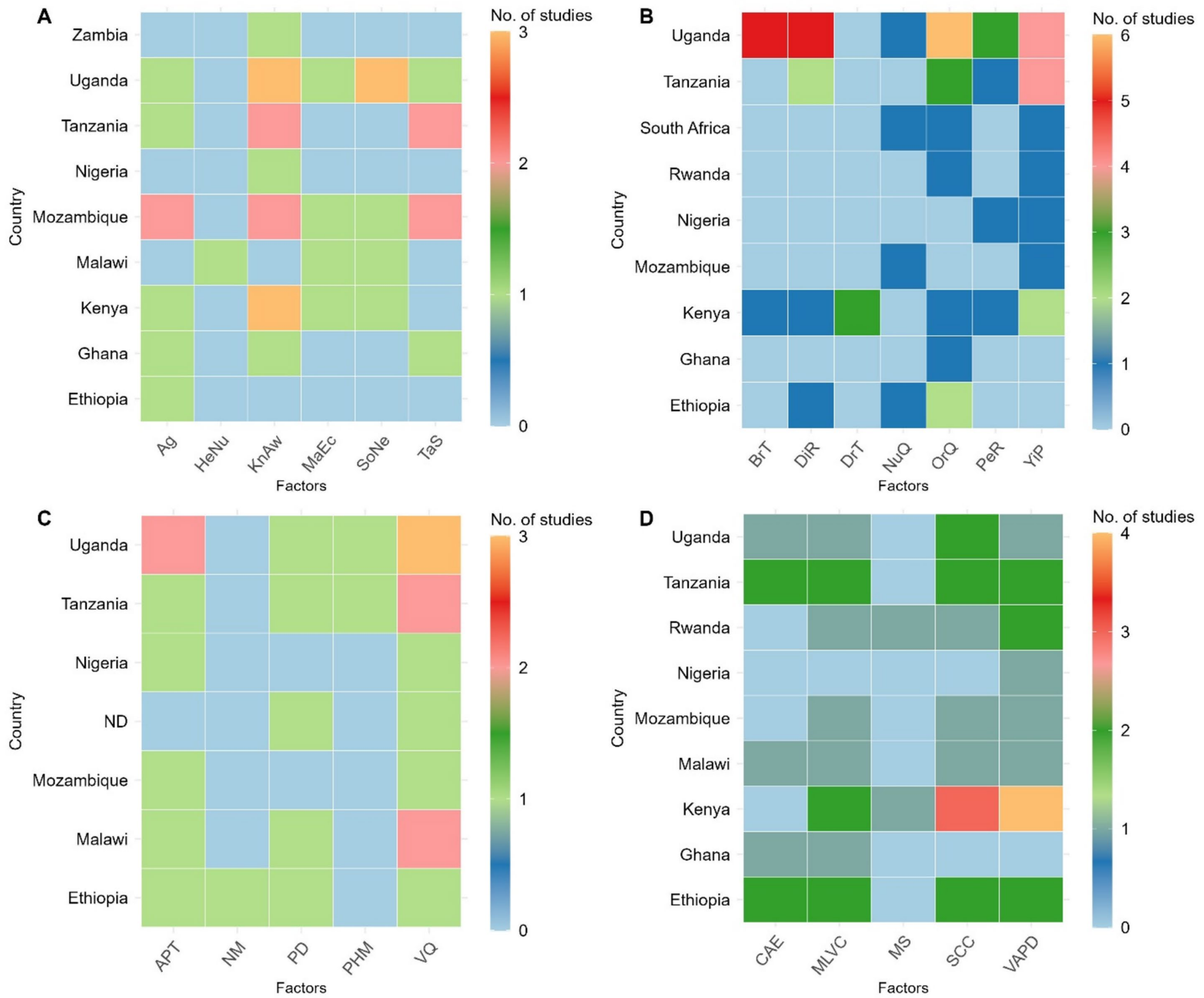

FIGURE 3
Heatmap of the number of papers collected by country and by the category of factors for **(A)** the determinant of OFSP adoption in SSA, **(B)** the OFSP breeding effort in SSA, **(C)** OFSP production, and **(D)** the OFSP commercialization. KnAw: Knowledge and awareness, SoNe: Social factors and networks, Ag: Agronomic traits, TaS: Taste and sensory attributes, HeNu: Health and nutrition, MaEc: Market and Economic; YiP: Yield performance, OrQ: Organoleptic quality, PeR: Pest resistance, DiR: Disease resistance, DrT: Drought tolerance, NuQ: Nutritional quality, BrT: Breeding tools, VQ: Vine quality, PD: Pest and disease management, NM: Nutrient management, PHM: Post-harvest management, APT: Agronomic practices training, VAPD: Value addition and product diversification, SCC: Supply chain challenges, MLVC: Market linkages and value chain coordination, MS: Marketing strategies, CAE: Consumer awareness and education.

(2020) demonstrated the role of women in this process; in Malawi, women's groups were more influential than men's groups (Mudege et al., 2017). However according to Sakala et al. (2018) social factors such as age, sex, household size did not affect the OFSP adoption in Zambia.

3.3.4 Taste and sensory attributes

Taste and sensory attributes represent six of study recorded (Naico and Lusk, 2010; Chowdhury et al., 2011; Okello et al., 2015; Jenkins et al., 2018; Adekambi et al., 2020b; Mwiti et al., 2020). (Figure 3A). This category of factors can influence OFSP adoption by affecting organoleptic preference and acceptance by consumers. The main traits of this group affecting OFSP adoption varies according to the countries. For example, two out of four of the studies in Tanzania (Okello et al., 2015; Mwiti et al., 2020), and Mozambique (Naico and Lusk, 2010; Jenkins et al., 2018), and one out of two in Ghana Adekambi et al. (2020b), reported taste and sensory attributes as very important for OFSP adoption, which means that for the studied population of these countries, organoleptic characteristics of OFSP varieties such as good taste, texture, color, aroma, and appearance positively influenced OFSP adoption for production and consumption by increasing the demand and satisfaction for OFSP. However, the importance of level of sensory attributes that influenced OFSP adoption also differ among these countries. For example, in Tanzania, good OFSP taste has been reported to be a key attribute in decisions to adopt and consume OFSP (Okello et al., 2015). In Mozambique, root dry matter content (Naico and Lusk, 2010) and taste of leaves (Jenkins et al., 2018) were the most important quality attributes influencing OFSP adoption. However, in Ghana, taste and dry matter have notable collective effect on adoption of an OFSP variety (Adekambi et al., 2020b).

3.3.5 Market and economy

Market and economy represents the fourth category with four study related to it (Behrman, 2011; Kaguongo et al., 2012; Mudege et al., 2017; Jenkins et al., 2018). Those studies highlighted that the potential benefits that could arise from selling OFSP roots and/or vine cuttings influence adoption of OFSP. Only one study in Uganda, Malawi, Kenya and Mozambique referred to factors linked to this group (Figure 3A). The study of Mudege et al. (2017) suggested that farmers were willing to adopt OFSP when the root and vine market was guaranteed. Economic benefits are an important consideration for farmers before they decide to grow OFSP roots and/or vines. For example, some farmers mentioned that they were interested in planting OFSP vines because there was a readily available market (Mudege et al., 2017).

3.3.6 Health and nutrition

This category was reported only in Malawi study (Mudege et al., 2017), it represents the last category with only one study (Figure 3A). Farmers or consumers experience on OFSP health benefit can considerably influence OFSP adoption in SSA. This has particularly importance among Malawi famers (Mudege et al., 2017). In this study, women pointed out that their bodies (particularly skin and bodies of their children) had improved and looked healthy, since they started to eat OFSP. Also, they mentioned the important role of OFSP consumption for pregnant women, birth outcomes improvement and in HIV positive people weight improvement.

3.4 Research advances for increased production of orange-fleshed sweetpotato

3.4.1 Orange-fleshed sweetpotato breeding in SSA

Of the 30 studies collected (Supplementary Table 2), 14 focused on OFSP yield performance improvement (Abidin et al., 2005; Kulembeka et al., 2005; Mwanga et al., 2007, 2009; Agili and Nyende, 2012; Karanja et al., 2015; Yada et al., 2017c; Andrade et al., 2017; Ngailo et al., 2019a, 2019b; Shumbusha et al., 2019; Kagimbo et al., 2019; Ebem et al., 2021; Gasura et al., 2021), 15 studies addressed the improvement of organoleptic qualities (Mwanga et al., 2007, 2009, 2016; Karanja et al., 2015; Baafi et al., 2016; Yada et al., 2017c; Gurmu et al., 2018, 2020; Ngailo et al., 2019a, 2019b; Shumbusha et al., 2019; Kagimbo et al., 2019; Banda et al., 2021; Gasura et al., 2021; Nakitto et al., 2022), 6 for pest resistance (sweetpotato weevils) (Mwanga et al., 2007, 2009; Karanja et al., 2015; Yada et al., 2017a; Kagimbo et al., 2019; Ebem et al., 2021), 11 referred to diseases including nine refereeing to sweetpotato virus disease (SPVD) resistance (Mwanga et al., 2002, 2007, 2009; Karanja et al., 2015; Yada et al., 2017b; Ngailo et al., 2019a, 2019b; Sseruwu et al., 2020; Abebe et al., 2023), and two for Alternaria disease resistance (Mwanga et al., 2009; Sseruwu et al., 2020), three of the studies tested OFSP's drought tolerance (Agili and Nyende, 2012; Kivuva et al., 2015; Musembi et al., 2015), four were on OFSP nutritional value improvement (Andrade et al., 2017; Yada et al., 2017c; Gurmu et al., 2020; Naidoo et al., 2021) (Figure 3B). Moreover, six studies had the objective of developing tools such as molecular markers that can help or facilitate breeding activities as: identification of new genes useful for firmness improvement marker development (Banda et al., 2021); SNP for Quality assurance and control (Gemenet et al., 2020); SSR markers associated with storage root yield, dry matter, starch, and β-carotene content, respectively (Yada et al., 2017c); SSR markers for sweetpotato weevil resistance (Yada et al., 2017a); SSR markers for SPVD resistance (Yada et al., 2017b); and a lexicon and protocol for descriptive sensory analysis (DSA) (Nakitto et al., 2022). Those studies were experimental; six of them were diallel evaluations (Mwanga et al., 2002; Musembi et al., 2015; Baafi et al., 2016; Gurmu et al., 2018; Ngailo et al., 2019a; Shumbusha et al., 2019), seven studies evaluated genotypes in a single field (Mwanga et al., 2007, 2009, 2016; Agili and Nyende, 2012; Kagimbo et al., 2019; Naidoo et al., 2021; Abebe et al., 2023); twelve studies used multi-environment evaluation for genotype selection (Abidin et al., 2005; Kulembeka et al., 2005; Mwanga et al., 2007, 2009; Karanja et al., 2015; Kivuva et al., 2015; Andrade et al., 2017; Ngailo et al., 2019b; Sseruwu et al., 2020; Gurmu et al., 2020; Ebem et al., 2021; Gasura et al., 2021); seven studies involved farmers participation in the evaluation [participatory variety selection (PVS), participatory breeding improvement (PPB)] (Abidin et al., 2005; Kulembeka et al., 2005; Kiiza et al., 2012; Karanja et al., 2015; Sseruwu et al., 2020; Gasura et al., 2021; Nakitto et al., 2022).

3.4.2 Agronomic practices and production techniques

This review revealed that 10 studies (Fuglie, 2007; Hotz et al., 2012; Namanda et al., 2013; de Brauw et al., 2018; Mudege et al., 2018; Shikuku et al., 2019a; Chah et al., 2020; Mwiti et al., 2020; Hendebo et al., 2022; Gatto et al., 2023) delved into agronomic practices and production techniques for OFSP cultivation across Sub-Saharan Africa (SSA). This body of work examined various critical dimensions. Nine studies (Fuglie, 2007; Hotz et al., 2012; Namanda et al., 2013; de Brauw et al., 2018; Mudege et al., 2018; Chah et al., 2020; Mwiti et al., 2020; Hendebo et al., 2022; Gatto et al., 2023) emphasized the pivotal role of utilizing high-quality planting materials, such as virus-free and well-sprouted vine cuttings or roots, to bolster OFSP yields and overall productivity. In-depth investigations explored the influence of fertilizer application on OFSP yields and root quality (Hendebo et al., 2022), providing insights into optimizing nutrient management practices for enhanced crop performance. Addressing the scourge of pests and diseases, three studies (Fuglie, 2007; Namanda et al., 2013; Hendebo et al., 2022) delved into effective management strategies targeting key threats to OFSP production in SSA, notably sweetpotato weevils and viral infections. Insights into harvesting techniques and curing practices were gleaned from one study conducted in Tanzania and Uganda (Namanda et al., 2013), shedding light on their impact on OFSP root quality, post-harvest storage, and nutrient retention. Furthermore, six studies (Hotz et al., 2012; de Brauw et al., 2018; Shikuku et al., 2019b; Chah et al., 2020; Hendebo et al., 2022; Gatto et al., 2023) underscored the critical importance of training programs aimed at equipping producers with essential skills and knowledge in OFSP cultivation techniques, ultimately enhancing yields and livelihoods. This collective body of research not only deepens our understanding of OFSP production dynamics in SSA but also underscores the multifaceted strategies required to optimize its cultivation for improved food security and nutrition across the region.

3.4.3 Existing research on the value chain development and marketing of orange-fleshed sweet potato

3.4.3.1 Value chain development

The review identified 11 studies (Stathers et al., 2015; Sugri et al., 2017; Bocher et al., 2019; CIP, 2019; Shee et al., 2019; Adetola et al., 2020; Girard et al., 2021; Moyo et al., 2022; Annette et al., 2023; Wangithi et al., 2023; Owuor et al., 2023) that explored various aspects of value chain development for OFSP in SSA. These studies examined opportunities for value addition, challenges in supply chain management, and strategies for improving market linkages.

Five studies (Adetola et al., 2020; Girard et al., 2021; Moyo et al., 2022; Owuor et al., 2023; Wangithi et al., 2023) investigated the potential for value addition and product diversification in the OFSP value chain. These studies highlighted the potential for processing OFSP into various products, such as flour, chips, baked goods, and purees, to increase shelf life, enhance marketability, and promote consumption. Adetola et al. (2020) explored the feasibility of producing OFSP-based complementary foods for infants and young children, addressing the nutritional needs of vulnerable populations. Two studies (Owuor et al., 2023; Wangithi et al., 2023) emphasized the importance of considering consumer preferences and market demands when developing new OFSP products.

Five studies (Stathers et al., 2015; CIP, 2019; Shee et al., 2019; Girard et al., 2021; Moyo et al., 2022) identified various challenges in the OFSP supply chain, including post-harvest losses, lack of storage facilities, limited access to markets, and inefficient transportation systems. These studies highlighted the need for investments in infrastructure, such as cold storage units and improved transportation networks, to reduce losses and ensure a consistent supply of OFSP to market. Other studies analyzed the importance of promoting collective action and strengthening farmer organizations to improve bargaining power and access to markets for smallholder OFSP producers (Shee et al., 2019; Girard et al., 2021). Four studies (Sugri et al., 2017; Girard et al., 2021; Moyo et al., 2022; Annette et al., 2023) focused on strategies for improving market linkages and value chain coordination in the OFSP sector. These studies emphasized the role of public-private partnerships, contract farming arrangements, and the development of inclusive business models to connect smallholder farmers with reliable markets and ensure a fair distribution of benefits along the value chain.

3.4.3.2 Marketing strategies and consumer awareness

The systematic review identified eight studies (Waized et al., 2015; Fofanah, 2013; Hudson et al., 2017; Bocher et al., 2019; Annette et al., 2023; Etwire et al., 2023; Owuor et al., 2023; Wangithi et al., 2023) that explored marketing strategies and consumer awareness initiatives for promoting the commercialization of OFSP in SSA. Four studies (Bocher et al., 2019; Annette et al., 2023; Owuor et al., 2023; Wangithi et al., 2023) focused on evaluating various marketing strategies for OFSP products. These studies examined factors influencing consumer purchasing decisions, such as pricing, packaging, and branding (Bocher et al., 2019; Wangithi et al., 2023); they found that attractive packaging and labeling with clear nutrition information could positively influence consumer preferences and willingness to pay for OFSP products. Annette et al. (2023) and Owuor et al. (2023) emphasized the importance of market segmentation and tailoring marketing strategies to target specific consumer groups, such as urban and rural consumers, or households with young children.

Four studies (Waized et al., 2015; Fofanah, 2013; Hudson et al., 2017; Etwire et al., 2023) investigated consumer awareness and education campaigns aimed at promoting OFSP consumption. These studies found that providing information on the nutritional benefits of OFSP, particularly its high vitamin A content, could significantly increase consumer demand and willingness to pay for OFSP products. Other authors (Fofanah, 2013; Hudson et al., 2017; Etwire et al., 2023) highlighted the effectiveness of using various communication channels, such as radio, television, and community-based events, in raising awareness and promoting behavior change towards OFSP consumption. Waized et al. (2015) emphasized the importance of involving key stakeholders, including healthcare workers, extension agents, and community leaders, in consumer education efforts to enhance credibility and reach.

4 Discussion

4.1 OFSP adoption determinants in SSA

The findings from the systematic review indicate several key factors that influence the adoption of Orange Fleshed Sweet Potato (OFSP) in Sub-Saharan Africa (SSA). These factors can be categorized into "knowledge and awareness," "agronomic traits," "social factors and networks," "taste and sensory attributes," "market and economic considerations," and "health and nutrition."

The systematic review highlights the importance of education and communication in boosting awareness of OFSP. Tailored educational initiatives are vital for conveying its nutritional benefits and role in food security. Targeting specific groups, like caregivers and pregnant women, is key to promoting OFSP adoption. Empowering these groups with clear information, especially about OFSP's high beta-carotene content and its conversion into vitamin A, facilitates informed decision-making (Neela and Fanta, 2019). Communicating the potential health benefits, such as improved eye health, enhanced immune function, and reduced risk of vitamin A deficiency, can be effective in promoting adoption. Additionally, highlighting the versatility of OFSP in various culinary applications and recipes can help dispel misconceptions and encourage experimentation with the crop as reported by USAID (2018).

The review uncovers diverse impacts of information types and sources across countries. Tailoring interventions to meet each population's specific information needs is crucial, given the varied factors influencing OFSP adoption. For instance, in rural areas with limited media access, community-based channels like local radio programs (Johnson and Rajadurai, 2020; Gatto et al., 2021), gatherings, and demonstrations (Ojwang et al., 2021) are more effective in engaging the audience. Clear and concise messaging is essential to communicate OFSP benefits without overwhelming potential adopters with technical details (Lagerkvist et al., 2016, 2020). Designing educational programs tailored to caregivers and considering country-specific preferences can enhance adoption efforts. Further research is needed to explore additional adoption factors and assess the long-term sustainability of knowledge and awareness interventions.

The agronomic traits of OFSP varieties significantly influence their adoption and success, including factors like yield performance, stability under diverse conditions, drought tolerance, and early maturity. Efforts should prioritize the development and dissemination of OFSP varieties with desirable traits such as drought tolerance, disease resistance, high yield potential, and early maturity to enhance adoption. Strengthening seed systems through partnerships between research institutions, seed companies, and farmer organizations is crucial for ensuring the availability and accessibility of high-quality planting material. Providing training on proper agronomic practices, including planting, irrigation, and pest management, can further boost OFSP adoption. Additionally, promoting the integration of OFSP into existing farming systems and highlighting its compatibility with other crops can incentivize farmers to adopt OFSP.

Social factors and networks play a significant role in OFSP adoption, including mechanisms like information diffusion, social learning, and cooperation (Rogers, 1962; Bakshy et al., 2012; Jenkins et al., 2015). Tailored interventions to local social contexts and understanding influential groups are crucial for promoting adoption.

Enhancing adoption involves strengthening social networks, facilitating knowledge sharing, and promoting collective action (Muller and Peres, 2019; Wang et al., 2020; Gatto et al., 2021). Encouraging the formation and engagement of farmer and women's groups facilitates information dissemination (Mudege et al., 2017). Platforms for exchange within these groups, like farmer field schools, have successfully promoted OFSP adoption in SSA countries (Stathers, 2005; Stathers et al., 2005). Involving influential individuals such as community leaders and respected farmers leverages their influence to drive adoption. Understanding social dynamics is crucial for effective interventions, with strategies focusing on strengthening social ties, fostering knowledge exchange, and promoting collective action.

Positive sensory attributes enhance OFSP demand and consumer satisfaction, influenced by cultural and culinary factors (Asp, 1999; Laurie et al., 2018). Developing varieties aligned with consumer preferences in each country, coupled with awareness campaigns, promotes adoption (Naico and Lusk, 2010; Okello et al., 2015; Jenkins et al., 2018; Adekambi et al., 2020b). Engaging local communities through taste tests and sensory evaluations guides breeding programs to improve OFSP varieties. Collaboration with food processors and culinary experts facilitates innovative OFSP-based recipes and products.

The availability of a secure market and economic benefits also drive OFSP cultivation among farmers. Market guarantees and stable linkages reduce production risks, while economic incentives and higher prices encourage adoption (Magesa et al., 2014; Fan and Brzeska, 2016). Strengthening market connections and providing access and information support adoption efforts. This involves partnerships with agribusinesses, processors, and retailers to ensure consistent demand and training farmers on post-harvest handling and storage. Additionally, integrating OFSP into school feeding and public procurement programs enhances market development and provides further economic incentives for adoption.

The potential health benefits of OFSP consumption, including improved general health and birth outcomes among pregnant women, are emphasized (Girard et al., 2017, 2021). However, further research is needed to establish stronger evidence supporting these associations. Incorporating diverse perspectives, such as those of farmers and consumers, provides valuable insights into the impact of health benefits on adoption rates. Future research should employ rigorous study designs to explore underlying mechanisms and identify specific nutrients responsible for the health effects. Long-term studies tracking OFSP consumption and its health impact can strengthen the evidence-base and inform adoption-promoting policies and interventions.

4.2 OFSP breeding and production systems

OFSP breeding, particularly in Eastern countries (e.g., Uganda), has significantly increased adoption rates. Uganda has excelled in OFSP improvement and release activities, developing numerous genotypes. Plant breeding focuses on "direct factors" (Figure 4) related to the crop itself, which greatly impact OFSP adoption (Mwanga et al., 2007, 2009). This includes enhancing agronomic, organoleptic, and nutritional performance, catering to local needs and preferences. Adapting new genotypes to local conditions involves considering factors like tolerance to biotic and abiotic constraints, and acclimatization to specific environmental conditions such as rainfall, temperature, and soil types. Environmental factors significantly influence sweetpotato yield compared to genotype-by-environment interactions. Breeding programs must develop OFSP varieties suited to specific agroecological conditions to ensure successful adoption by farmers.

Improving OFSP organoleptic quality, particularly dry matter content, has been a key focus of breeding efforts, notably in Uganda. Environmental effects on dry matter content among newly developed OFSP genotypes appear limited, indicating its stability across diverse conditions and the dominant role of genetic factors. Studies primarily assessed dry matter content, with few considering additional criteria such as sugar level, starch, and mouth firmness.

However, recent studies underscore the importance of these attributes in sweetpotato breeding and consumer preferences, crucial for meeting evolving market demands and enhancing the adoption of this variety.

For instance, Nakitto et al. (2024), using a decision tree scoring system, demonstrated that incorporating sensory attributes such as mealiness, sweetness, aroma, firmness, and the absence of fibrous texture would facilitate demand-led breeding, making varietal selection in sweetpotato breeding programs more effective. Similarly, Mwanga et al. (2021a) identified sweetness and firmness as key drivers of consumer acceptance for boiled and steamed sweetpotato in Uganda, with penalty analysis revealing that deviations from these traits significantly reduced overall liking. In parallel, Allan et al. (2024) found that variations in starch properties and sugar content significantly influenced the texture and sweetness of baked sweetpotato, key determinants of overall eating quality.

Highlighting the diverse components that contribute to sweetpotato quality, Amankwaah et al. (2024a) revealed that α- and β-amylase activity dynamically interacts with starch and sugars during post-harvest storage, with β-amylase showing positive correlations with sugar accumulation and β-carotene content. This finding emphasizes the biochemical complexity underlying culinary quality and supports the need to evaluate enzymatic activity as a predictor of post-harvest texture and sweetness, particularly in sweetpotato breeding. Complementing these insights, Amankwaah et al. (2024b) advanced rapid phenotyping by developing NIRS calibration models for efficiently quantifying sugar content (glucose, fructose, and sucrose) in baked sweetpotato, thus enabling high-throughput screening of this critical trait for consumer preference.

Collectively, these studies suggest that incorporating a broader range of quality indicators can enhance the effectiveness of breeding programs by aligning varietal development more closely with end-user preferences and market needs.

This underscores the importance of genetic factors and suggests potential gains through hybridization and clonal selection (Tomlins et al., 2004; Naico and Lusk, 2010; Laurie et al., 2013; Jenkins et al., 2015).

OFSP breeding targets multiple nutrients beyond β-carotene, including protein, iron, calcium, magnesium, zinc, fructose, sucrose,

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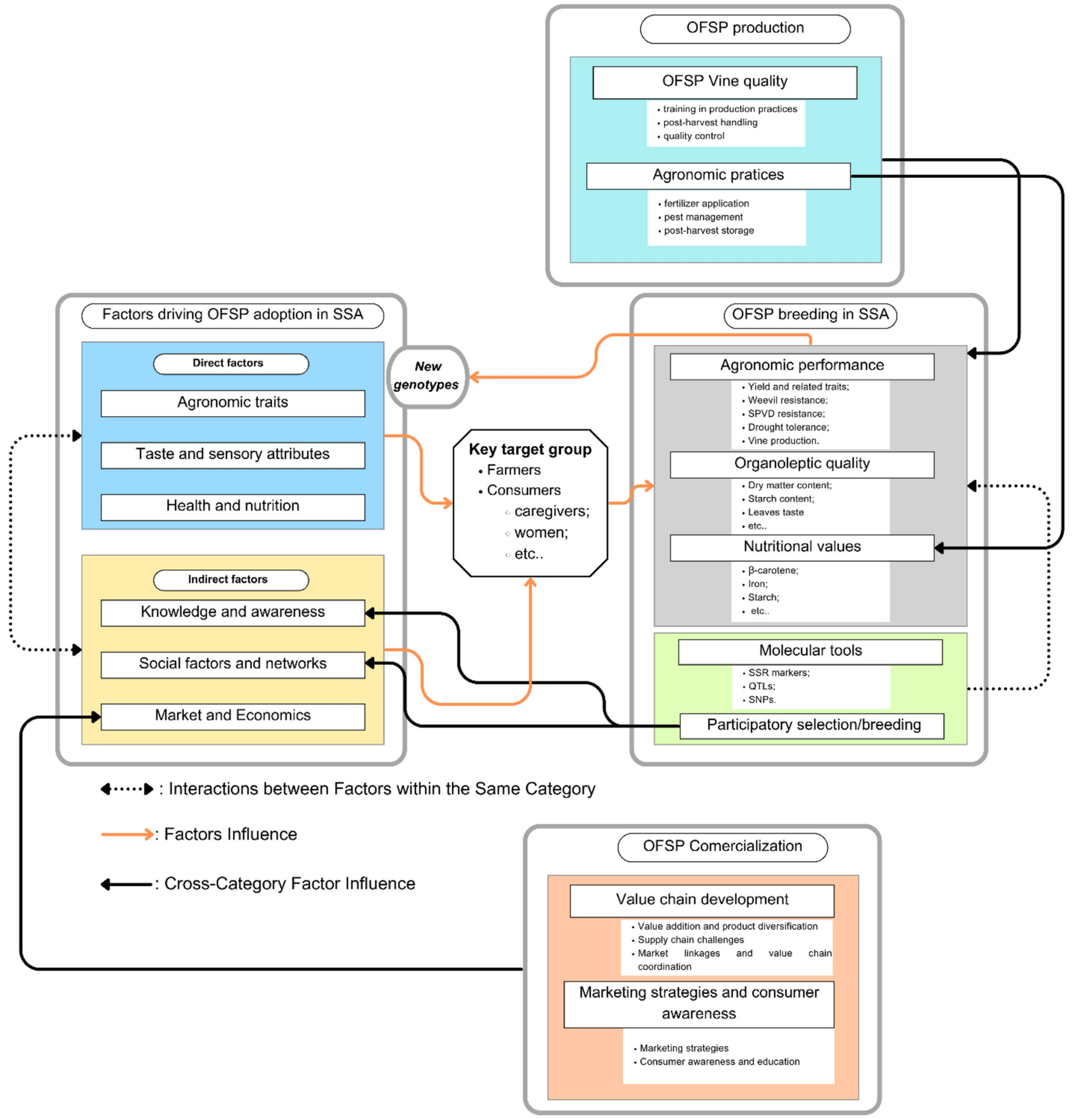

FIGURE 4
Interactions between different value chain actors and stakeholders in the development and diffusion of orange-fleshed sweetpotato (OFSP) in sub-Saharan Africa (SSA).

glucose, and starch. However, there's a negative genetic correlation between β-carotene and starch, indicating that enhancing β-carotene content may reduce starch content in OFSP genotypes (Tomlins et al., 2012). The β-carotene-starch trade-off poses a challenge in developing desired orange-fleshed cultivars in SSA (Yada et al., 2017c). However, positive correlations exist between β-carotene and glucose, protein, iron, zinc, and fructose, suggesting potential simultaneous improvement through targeted breeding. Conversely, starch negatively correlates with β-carotene and glucose, indicating a trade-off. Considering specific environmental conditions is crucial for β-carotene content breeding in different regions.

Identification of an Amyβ gene variant linked to reduced enzyme activity could serve as a marker for firmness in cooked sweetpotato. Selecting genotypes with specific Amyβ gene variants may aid breeders in developing varieties with desired texture attributes. SSR markers linked to these traits offer valuable guidance for breeders in selecting parental combinations. However, precise mapping of quantitative trait loci (QTL) associated with these markers is necessary for effective direct selection. Further research in this area will optimize molecular tools' use and expedite superior OFSP variety development, benefiting farmers and consumers with improved productivity, nutrition, and pest/disease resistance.

To enhance sweetpotato breeding programs further, various national initiatives are developing molecular markers to identify genes associated with consumer-preferred qualities in fried, boiled, or steamed preparations (Zhang et al., 2016; Ssali et al., 2025). Identifying and assessing candidate genes controlling desirable quality traits can accelerate selection efficiency through genomic-assisted breeding approaches including marker-assisted selection (MAS), genomic selection (GS), and gene editing techniques like CRISPR-Cas9. MAS and GS have already been applied to improve key quality traits aligned with consumer preferences (Ssali et al., 2025). Regarding CRISPR-Cas9, this technology has been successfully applied to root and tuber crops, including sweetpotato, to introduce precise genetic modifications (Divya et al., 2024). For instance, CRISPR/Cas9-based mutagenesis of starch biosynthetic genes in sweetpotato has demonstrated its potential in enhancing starch quality (Wang et al., 2019). These CRISPR-Cas technologies hold promise for further improving quality traits that meet specific consumer demands.

Participatory variety selection (PVS) and participatory plant breeding (PPB) actively involve farmers in the crop breeding process. PVS engages farmers in selecting new crop varieties suited to their local conditions, while PPB empowers them to choose the best genotypes for breeding (Begna, 2022).

In developing OFSP varieties, PVS and PPB are crucial for creating locally adapted varieties that meet farmers' needs. By involving farmers, OFSP varieties with improved adaptability, higher yields, and better nutrition can be developed (Bhargava and Srivastava, 2019). Farmers' participation allows for the rapid identification of promising genotypes, leading to significant advancements in sweetpotato breeding (Abidin et al., 2005; Ahoudou et al., 2025). Additionally, PPB gives farmers a stronger voice in selecting varieties suited to their needs (Bhargava and Srivastava, 2019). Farmer participatory varietal selection (FPVS) has led to the development of new OFSP varieties better adapted to local conditions and with higher yields in countries like Uganda, Kenya, and Burkina Faso (Christinck et al., 2016).

The production of OFSP in SSA faces significant challenges, particularly in maintaining and diffusing this variety among farmers. The primary issues revolve around the quality and accessibility of OFSP vines. Many OFSP varieties are susceptible to virus diseases, which can lead to significant yield losses or even total crop failure. This susceptibility hampers the introduction and breeding of orange-fleshed varieties into Africa (Kreuze et al., 2021). The quality of OFSP vines is another crucial factor. Poor quality vines can lead to lower yields and reduced farmer income (Girard et al., 2021), affecting their willingness to pay for them (Mwiti et al., 2020). Moreover, timely access to quality seed, which are actually cuttings from a vine rather than true seed, is a significant challenge (Nyirenda et al., 2023). A solution is to decentralize vine multipliers, fostering local capacities and motivating farmers to produce planting material for income. This includes training in production practices, post-harvest handling, and quality control (Takoutsing et al., 2014). Agronomic aspects like fertilizer application, pest management, and post-harvest storage are vital in OFSP production. Fertilizer boosts beta-carotene in OFSP, but balance is key to prevent excessive foliage (Mahmud et al., 2021). Pest and disease management is crucial to maintain yield and quality (Hendebo et al., 2022). The genotype and growing conditions largely determine OFSP root quality, influencing its adoption and retention (Jenkins et al., 2018). Post-harvest storage of fresh OFSP roots up to 4 months can ensure a constant year-round supply of high-quality OFSP roots for processing. However, there was higher rotting, with just 35 to 56% roots for puree after 4 months (CIP, 2019).

4.3 Commercialization, marketing strategies, consumer awareness and education

Value addition and product diversification are significant strategies for enhancing the OFSP value chain. Processing OFSP into various products such as flour, chips, baked goods, and purees can increase shelf life, enhance marketability, and promote consumption. As per Mohammed (2023), it is recommended to process OFSP into various forms to provide alternative sources of income. However, it is important to consider consumer preferences and market demands when developing new OFSP products (Figure 4). A deep understanding of consumer preferences is crucial for shaping effective marketing strategies (Phorbee et al., 2023).

Supply chain challenges, including post-harvest losses, lack of storage facilities, limited market access, and inefficient transportation systems, pose significant hurdles (Girard et al., 2021). To address these, investments in infrastructure like cold storage units and improved transportation networks are needed. Additionally, strengthening farmer organizations and promoting collective action can improve bargaining power and market access for smallholder OFSP producers.

Despite these promising value-addition and diversification strategies, overall OFSP commercialization in SSA has largely remained project-dependent. In many cases, once project funds expire, dissemination activities decline rapidly, often leaving little sustainable impact. This reliance on externally funded initiatives may be one of the key reasons why OFSP has not become as widespread as expected. While donor-driven projects play a crucial role in introducing and promoting OFSP, they often lack mechanisms to ensure long-term market integration and self-sustaining business operations.

However, there are notable exceptions where OFSP commercialization has emerged organically, independent of donor projects. For instance, in Kenya, small and medium enterprises (SMEs) processing OFSP puree have successfully integrated into commercial supply chains, supplying major retail bakeries in Nairobi (Bocher et al., 2017). These businesses have innovated by developing shelf-stable OFSP puree, reducing reliance on the cold chain and improving market accessibility (Bocher et al., 2017; Malavi et al., 2018). Similarly, in Eastern Africa, several SMEs have expanded their production of OFSP-based products, supported by tailored business models that enable them to scale sustainably (Annette et al., 2023).

Despite these successes, most OFSP commercialization efforts in SSA still operate in a project mode. This approach, while valuable for initial awareness and adoption, often lacks the continuity required for sustainable market growth (Low and Thiele, 2020). The absence of a strong business-oriented approach means that once funding ends, key activities such as production, marketing, and supply chain coordination may quickly decline. In contrast, businesses that emerge organically, though fewer in number, often demonstrate greater resilience, as they are driven by market demand rather than external funding (Begimkulov and Darr, 2023). These businesses typically succeed by securing investment, developing efficient distribution networks, and aligning their products with consumer preferences.

Identifying and supporting such successful models could provide critical insights into how OFSP can transition from a project-based to a business-driven commercialization approach. Facilitating access to financing, strengthening market linkages, and promoting business incubation programs tailored to OFSP enterprises may help ensure the sustainability and expansion of these efforts.

Insights from systematic reviews indicate the potential inefficiency of a one-size-fits-all approach, suggesting the need for tailored marketing strategies that target specific consumer groups (Annette et al., 2023). This approach could lead to a more efficient use of resources and potentially a higher return on investment. Stakeholders in the commercialization of OFSP should consider investing in market research to grasp the factors that sway consumer purchasing decisions, which may include aspects such as pricing, packaging, and branding.

Lastly, improving market linkages and value chain coordination is crucial for the success of OFSP commercialization. Strategies such as public-private partnerships, contract farming arrangements, and the development of inclusive business models can connect smallholder farmers with reliable markets and ensure a fair distribution of benefits along the value chain.

The role of consumer education in promoting OFSP consumption is another key insight from the review. Stakeholders should consider investing in awareness campaigns that underscore the nutritional benefits of OFSP. Such initiatives could potentially boost consumer demand and willingness to pay for OFSP products. The review also points to the effectiveness of various communication channels in raising awareness, suggesting that a multi-channel approach involving traditional media outlets like radio and television, as well as community-based events, could be beneficial. Involving key stakeholders in these efforts could enhance the credibility and reach of these campaigns, potentially leading to wider adoption of OFSP.

4.4 Implications for the adoption of other vitamin A–rich crops

The insights gained from OFSP dissemination provide valuable lessons that can be extended to other vitamin A–rich crops, such as biofortified maize, cassava, and legumes. These crops face similar challenges, where both agronomic performance and sensory characteristics play critical roles in determining their adoption and long-term sustainability. Successful adoption of vitamin A–rich crops hinges on robust agronomic traits, including yield stability, pest and disease resistance, and adaptability to local environmental conditions. For example, crops that exhibit consistent performance across diverse agroecological zones are more likely to gain widespread acceptance among farmers. Research by Omari et al. (2019) and Low and Thiele (2020) has shown that even nutritionally enhanced crops may face limited adoption if they do not meet farmers' expectations for yield and resilience, emphasizing the need for further investigation into crop-specific agronomic factors.

Consumer acceptance is heavily influenced by taste, texture, aroma, and visual appeal. Studies by Birol et al. (2015) and Timpanaro et al. (2020) reveal that even minor differences in flavor or texture can significantly impact household consumption and dietary diversification. While OFSP is widely promoted for its appealing color and health benefits, the successful adoption of other vitamin A–rich crops depend on aligning their taste and texture with local consumer preferences, a challenge that may vary considerably among crops.

Market dynamics also play a crucial role in the overall adoption of vitamin A–rich crops. Understanding consumer preferences and market demands is essential for developing effective marketing strategies. Tailored approaches that address specific consumer segments through appropriate pricing, packaging, and branding can enhance the appeal of these crops. Additionally, improved market linkages and coordinated value chain systems achieved through public-private partnerships, contract farming arrangements, and inclusive business models are necessary to connect smallholder farmers with reliable markets and ensure a fair distribution of benefits.

Integrating comprehensive agronomic evaluations with detailed sensory analyses and market research during the breeding and promotion phases is therefore crucial. Such an integrated approach allows for the identification and mitigation of crop-specific limiting factors, ultimately facilitating tailored interventions that enhance nutritional outcomes while meeting the practical, economic, and sensory expectations of both farmers and consumers. This holistic strategy could foster the broader adoption of vitamin A–rich crops and contribute to improved food and nutrition security across SSA.

4.5 Role of policy incentives, stakeholder engagement, and research support in promoting OFSP adoption

The insights gained from this systematic review have important implications for policymakers, agricultural organizations, and researchers involved in promoting OFSP adoption. Policymakers can play a crucial role in creating an enabling environment for OFSP adoption. Governments that provide subsidies or financial incentives for cultivating vitamin A–rich crops can significantly boost production. Additionally, integrating OFSP into national nutrition and school feeding programs can further stimulate consumption. Government incentivization can also include tax incentives for agribusinesses involved in the OFSP value chain and financial support for research and development initiatives aimed at improving OFSP varieties. Investments in infrastructure, such as storage facilities, transportation networks, and market access points, are essential for improving the distribution and availability of OFSP and other vitamin A–rich crops.

Engagement with stakeholders, including local governments, NGOs, research institutions, and the private sector, is critical for building robust value chains and ensuring the widespread dissemination of vitamin A–rich crops. Collaborative efforts can strengthen market linkages and foster infrastructure development, such as better transportation and storage facilities, which are essential for reducing post-harvest losses and increasing market access. Effective stakeholder engagement ensures that OFSP benefits reach a broader audience and addresses the challenges faced by smallholder farmers.

Research and extension services are also key drivers for the adoption of OFSP. Ongoing research to enhance OFSP varieties, combined with effective extension programs offering training and technical support, enables farmers to adopt new technologies with confidence. Demonstration plots, field days, and farmer-to-farmer exchanges have proven effective in building local capacity and accelerating the uptake of improved varieties (Emerick and Dar, 2021; Girard et al., 2021). Extension services that provide continuous support and knowledge-sharing empower farmers to overcome cultivation challenges and increase productivity.

To further accelerate the adoption of OFSP and other vitamin A–rich crops, future research should assess the impact of government policies and incentives on adoption, evaluate the effectiveness of stakeholder engagement strategies, examine the role of infrastructure and market access, and explore the influence of consumer awareness and education programs. Addressing these factors and gaps will provide valuable insights for promoting OFSP and developing strategies to enhance the adoption of vitamin A–rich crops in SSA.

5 Strengths and limitations

Our review study has several strengths. Firstly, we employed a comprehensive search strategy following PRISMA guidelines, which included searching multiple databases, hand-searching relevant journals, and reviewing reference lists. This ensured a thorough exploration of the literature. Secondly, we considered literature from various disciplines, such as agriculture, crop science, and rural development, providing a holistic understanding of the factors driving sweetpotato adoption. Our study selection process was rigorous, involving independent screening of titles, abstracts, and full texts by multiple researchers, minimizing bias. We also employed quality assessment tools to evaluate potential bias and ensure the reliability and validity of included studies. Additionally, our data extraction and review processes were systematic and meticulous, with independent extraction and review by multiple researchers.

In terms of limitations, our study had a language bias as we only included English language articles, potentially missing relevant studies published in other languages. Furthermore, we focused on SSA, which may have resulted in a geographic bias, overlooking relevant studies conducted in other regions. Additionally, our study included articles published between 2000 and 2023, excluding earlier research that could have provided important historical context. Publication bias is another limitation, our study relied on published literature, which may be subject to publication bias. Studies with negative or inconclusive findings tend to be published less frequently, leading to an overrepresentation of studies with positive results. This bias may affect the overall conclusions drawn from the review. Finally, while we made efforts to search multiple databases and journals, there is a possibility of missing relevant studies from other sources. These limitations should be considered when interpreting the findings of our review.

6 Conclusion

This systematic review allowed for the identification and categorization of the major factors influencing the adoption of OFSP genotypes across SSA. The intricate interplay of these factors, spanning knowledge, social dynamics, agronomic traits, sensory attributes, health benefits, and market forces, shapes the complex decision-making processes surrounding OFSP adoption. The review highlights the significance of aligning breeding objectives, production techniques, and commercialization strategies with these identified adoption factors. Integrating participatory breeding approaches that consider local knowledge and preferences, implementing context-specific agronomic practices, fostering efficient value chains, and executing targeted marketing campaigns are crucial for increasing OFSP production and consumption in specific regions. Effective diffusion strategies that recognize and leverage the influences of these categorized factors can tailor interventions to resonate with diverse community contexts and stakeholder motivations, enhancing the likelihood of widespread OFSP adoption. This comprehensive approach, harmonizing breeding efforts, production methods, and commercialization initiatives with the identified adoption factors, is vital for harnessing the potential to combat VAD and improve nutrition and well-being. Continuous research is essential to monitor evolving challenges, opportunities, and shifting dynamics within these identified adoption factors, ensuring sustainable scaling of OFSP interventions. This holistic pursuit, integrating stakeholder perspectives across the value chain, underscores the interconnected nature of the categorized factors and their collective impact on fostering improved nutrition through OFSP in SSA.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

IA: Conceptualization, Data curation, Formal analysis, Methodology, Visualization, Writing – original draft, Writing – review & editing. DS: Data curation, Formal analysis, Investigation, Methodology, Writing – review & editing. VF: Data curation, Investigation, Methodology, Writing – review & editing, Project administration. NF-F: Writing – review & editing, Methodology. IM-M: Funding acquisition, Project administration, Resources, Validation, Writing – review & editing. EA-D: Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2025.1545827/full#supplementary-material

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