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Consumers behavior, attitudes, and beliefs regarding baobab (*Adansonia digitata* L.) fruit and pulp consumption in Sudan

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There are growing number of empirical studies on the baobab value chain in Sub-Saharan Africa. Most studies focus on nutritional composition, traditional uses, the distribution of baobab trees, and collection. However, there are few studies on the marketing of baobab fruit pulp, especially on consumer behavior, attitudes, and beliefs regarding baobab fruit pulp. In this context, our study aims to explore consumer behavior, attitudes and beliefs regarding baobab fruit pulp. We also evaluate the market development potential of baobab fruit pulp in selected markets in El Obeid and Khartoum in Sudan. The study employs a mixed methods approach that includes a survey (*N*=499), focus group discussion (*N*=16), stakeholder interviews (*N*=2), and a SWOT analysis. The study shows that the consumption of baobab fruit pulp is common among Sudanese consumers. Consumers also show strong positive attitudes and beliefs, as well as social support for baobab consumption. Nutritional and health benefits tend to drive consumer interest in baobab fruit pulp. The study also identified high demand, export opportunities, and extraction of ingredients from baobab as opportunities to develop baobab markets. However, a lack of quality control, regulations, poor distribution, and insufficient fruit supply may limit exploration of these opportunities. Therefore, it is crucial to raise knowledge of the nutritional and functional properties of baobab fruit, as well as its ability to fight health-related diseases, to further develop local markets. Processors must also improve the quality and safety of their goods. Policymakers must also create a regulatory structure that supports Sudan's baobab value chain.

KEYWORDS

baobab value chain, consumer behavior, Sudan, local food systems, marketing opportunities, SWOT analysis, mixed methods

1. Introduction

Achieving the Sustainability Development Goals (SDGs) of "No Poverty" (SDG 1) and "Zero Hunger" (SDG 2) is a key policy priority for many countries in Sub-Saharan Africa. However, food insecurity and malnutrition are rising in many countries in Sub-Saharan. For instance, 34% (15 million people) of the Sudanese population is currently food insecure and this is expected to rise to 39% by the end of 2022 (World Food Programme, 2022). This is mainly driven by the climate-conflict nexus, characterized by political instability and climate shocks. This has been

exacerbated by global crises such as COVID-19 and the war in Ukraine (World Food Programme, 2022).

In Africa, urbanization is one factor driving food system transformation (de Bruin et al., 2021). In Sudan, rapid urbanization has been observed in the last three decades due to conflict, drought, and desertification, which force rural people to leave rural area (Young and Jacobsen, 2013). As a result, over 35% of the population now lives in urban areas (World Development Indicators: Urbanization, 2021). Many of the urban poor face challenges in accessing land and developing viable livelihood strategies. Urbanization further changes the food system such that an increasing share of the population depends on purchasing food (Babiker, 1982; Young and Jacobsen, 2013). In Sudan, the conflict in Darfur led to a large population flow from rural to urban areas, where security services are available. However, this migration pattern resulted in changes in food supply and availability, contributing to a rise in local food prices in urban areas with negative consequences for urban consumers (Alix-Garcia et al., 2012).

Sudan is characterized by high variability in agro-climatic conditions, which means that a wide range of different crops can be grown throughout the year (El-Shishiny and Ghabbour, 1989; Bashir et al., 2014). Efforts have been made to strengthen supply chains for major crops such as vegetables, grains, cereals, and fruits to improve food and nutrition security. This is because many people in Sudan depend on the local food systems for their livelihoods with little dependence on food imports. Agriculture is rainfed; hence, even little variability in rainfall pattern tends to adversely affect food supply in the country. For instance, fruits and vegetables in the southern and western states, in areas with high rainfall, are usually irrigated or grown with rainwater on a small-scale (Marzin et al., 2016).

To increase the resilience of the local food systems in Sudan, diversification into non-forest plant species that are more resilient to climate change and variability is an important option. Non-forest plant species such as baobab offer income-generating opportunities for many people in Sudan, contributing to food security (Aworh, 2015). The baobab tree (*Adansonia digitata* L.) is a multi-use, widely-used species, rich in nutrients in its leaves and fruits, and used daily by local populations in numerous African countries for food, medicines, and other purposes (Yazzie et al., 1994; De Caluwé et al., 2009; Gadour et al., 2017; Muthai et al., 2017). Pulp, seeds, leaves, root tuber, and bark have been studied for their properties and have been shown to have potential for pharmaceutical uses (Lisao et al., 2017). Baobab pulp contains high levels of vitamin C (Chadare et al., 2008), calcium (Osman, 2004), and antioxidants (Salih and Yahia, 2015). Baobab pulp is naturally dry and a purely organic food as it is collected from trees from the wild without the use of external inputs. It is a dietary source of fiber, potassium, calcium, magnesium, iron, and zinc (Muthai et al., 2017). Numerous researchers in different African countries have emphasized this indigenous fruit tree as a significance species for domestication and expanded use (Gebauer et al., 2016).

In Sudan, utilization of wild fruit mostly relates to environment crises such as drought, desertification, food shortages, and starvation, and particularly to the ongoing war in Kordufan and Darfur (Dirar, 1993; Salih and Ali, 2014). Baobab fruits and pulp play an important role in Sudan's food culture, and are consumed daily by local people, mostly as snacks without need of further processing, as beverages or prepared within porridges (Salih and Ali, 2014). Unripe baobab fruits are boiled and used as salad and the dry fruit pulp is either eaten fresh or dissolved in water or milk as juices, to serve tourists and hostels (Al Faki Adam, 2019). Baobab fruit pulp flour is used as a starter in the fermentation of the sorghum flour used for *Kisra* (pancake-like fermented flat bread) preparation (Makawi et al., 2019).

The collection of non-timber forest products is well-known in Sudan. Among non-timber forest products gathered and commercialized are *Adansonia digitata* Linn., *Balanites aegyptiaca* Del., *Tamarindus indica*, *Ziziphus spina-christi* (L.) Desf, *Grewia tenax* (Forsk) and Fiori (Adam et al., 2013). The baobab market chain in Sudan begins with the collection and gathering of baobab fruits in remote areas by local people (Elnasri, 2019). Baobab collection usually happens in the dry season, when farmers have limited agricultural activities and look for alternative sources of income (Adam, 2017). Collectors sell baobab fruits to village traders, who then sell them to wholesalers. In some cases, collectors travel to nearby villages or to the capital, Khartoum, to sell their products.

The majority of existing studies on baobab have focused on the analysis of nutritional composition (Osman, 2004; Chadare et al., 2008; De Caluwé et al., 2009; Gadour et al., 2017; Lisao et al., 2017; Muthai et al., 2017), while studies on collection and marketing are limited. For instance, Adam et al. (2013) analyzed the factors influencing the contribution of non-timber forest product (NTFP) livelihood strategies to household income in Sudan and found that income from sales of baobab fruits was influenced by internal and external factors. Kaimba et al. (2020) analyzed factors influencing baobab collectors' choice of marketing channels in Kenya and reported that human capital and transactional and institutional factors affect collectors' choice of marketing channel. Kaimba et al. (2021) investigated baobab pulp's response to price and non-price incentives in Kenya and found that baobab pulp supply and profits responded positively to price incentives but negatively to labor, transport, and packaging input costs. Meinhold et al. (2022) investigated how baobab fruit products overcame challenges encountered by most NTFPs in accessing global markets. They found that the rising demand for natural, healthy foods, increasing knowledge and appreciation for indigenous products, and rising numbers of entrepreneurs and development organizations were the main factors. Meinhold and Darr (2022) evaluated the implications of commercialization of baobab fruits on quality and supply chain organization in Malawi. They reported that the baobab supply chain has elongated with different actors participating in the chains: baobab collectors and traders collecting baobab fruits at source, microenterprises processing baobab fruits into ice-lollies for informal markets, or more formal processors targeting retail markets. However, baobab value chains in Sudan have received limited research and policy attention; hence, there is limited information on consumer behavior and attitudes towards processed baobab products in Sudan. Adam (2017) evaluated consumers' preferences and factors influencing demand for baobab fruits in Elobeid and Khartoum markets in Sudan using descriptive analysis and found that there is demand for baobab fruit and its secondary products. Adam (2017) also found nutritional value (vitamins) of the baobab fruits to be the main factor driving the demand. However, this study did not evaluate development potential and threats for marketing of baobab fruit/pulp markets. Hence, there is a lack of evidence in this respect.

In this context, this study aims to address the following research questions:

i. What are consumer behavior, attitudes, and beliefs regarding processed baobab fruits in Sudan?
ii. What are the strengths, opportunities, weaknesses, and threats to the market development of baobab fruits/pulp in Sudan?

By answering these research questions, this paper contributes to the existing literature on baobab in the following ways. First, we provide exploratory findings on consumer behavior, attitudes, and beliefs regarding processed baobab fruits/pulp, where consumer behavior is conceptualized as frequency of baobab purchase and place of purchase. We also provide findings on stakeholders' perspectives on strengths, opportunities, weaknesses, and threats to the development potential of the baobab markets in Sudan. This also complements the study by Adam (2017), which only focused on consumer preference without insights into opportunities and threats for market development of baobab. Our paper also complements previous studies (Kaimba et al., 2020, 2021) that have mainly focused on the marketing of baobab from collectors' perspectives and those (Meinhold et al., 2022; Meinhold and Darr, 2022) that have focused on the development of the baobab supply chain with little focus on consumer behavior. To gain better insights into the research questions, we use a mixed methods research approach.

Moreover, the findings of the study will provide stakeholders and policymakers with insights into threats and weaknesses to be overcome, as well as marketing opportunities and strengths that can be exploited in developing the baobab value chain in Sudan. Identifying marketing opportunities in the baobab value chain could attract investors to the sector. The development of the sector can contribute to improving food and nutrition security in Sudan, as many people derive their livelihoods from this sector. Development and marketing of innovative food products starts with consumers (Bogue and Sorenson, 2009; Bleiel, 2010). Therefore, a better understanding of consumer behavior, attitudes, and beliefs provides good guidance for the design of a long-term marketing strategy for baobab fruit and pulp products. A consumer-driven approach is an innovative strategy to advance functional food marketing. It is crucial to gain knowledge of consumer interests and to identify their behavior, needs, and desires in order to invest appropriately in functional benefits (Granato et al., 2020). Such information can help in formulating baobab fruit and pulp marketing and development strategies in Sudan.

2. Materials and methods

2.1. Research design and source of data

We conducted an exploratory mixed methods study to address the research questions. Both quantitative and qualitative studies were conducted concurrently in selected markets in two cities in Sudan. One rural market was selected from El Obeid and four markets from Khartoum, a capital city of Sudan. El Obeid (13° 18 N and 30° 22 E) is in the dry zone of central Sudan, North Kordofan State, and is approximately 600 km from the capital Khartoum. The population is about 340,940. The city is characterized by a thriving market for gum Arabic, the most important non-timber forest product in Sudan. Khartoum (15° 33 N and 32° 32 E) is the capital of the country with total population of 4,286,000. The selected cities provide a wide contrast in terms of their socio-economic and other demographics factors. Both cities are characterized by thriving markets for non-timber forest products and baobab fruit and pulp is frequency traded and widely consumed at both sites.

We used a non-probability convenience sampling procedure to collect quantitative data for this study. We selected 449 consumers, comprising 233 from four urban markets in Khartoum and 216 from the rural market in El Obeid. The two locations for markets were selected purposively as they: (i) are identified as the most important for non-timber forest products in Sudan; and (ii) constituted a large portion of baobab fruits and pulp marketing in Sudan. In both sites, respondents were sampled from traditional open markets, small supermarkets, and other outlets when they were in the process of purchasing baobab fruits and pulp. A survey questionnaire was used to solicit relevant information from the selected respondents. The questionnaire was structured into two sections. The first section captured information on demographic characteristics (gender, age, household size, education level, main occupation, and household income) of the respondents. The second section included items to measure key concepts such as beliefs, attitudes, behavior, and preferences for processed baobab pulp. Behavioral items captured the place of purchase, purchase frequency, and quantities. The questionnaire was first pretested on 22 people and necessary adjustments were made.

We also conducted a qualitative study to complement the quantitative study by providing additional information that could not have been collected using the quantitative study alone. In the qualitative study, we conducted two focus group discussions (see Appendix Table A1 for the interview guide for the focus group discussion) to gain deeper insights into an overview of consumers' general attitudes and consumption behavior on baobab fruit and pulp consumption. Two focus group discussions were carried out in El Obeid and Khartoum, with nine participants in El Obeid, and seven in Khartoum. The focus group discussions were conducted alongside a consumer survey in order to validate the survey findings. The focus groups included female and male participants, aged 18 and above. The participants were recruited according to their experience with baobab fruit and pulp consumption, and ensuring diversity of their age and gender. In addition, we conducted stakeholder interviews using semi-structured interviews (see Appendix Table A2 for the stakeholder interview guide). Field notes were also taken during field visits in the study areas.

The stakeholders included representatives from companies based in Khartoum that process indigenous fruit pulp and juice fruits (e.g., *Tamarindus indica* and *Adansonia digitata*), and representatives from relevant fruit/pulp juice industries in Khartoum. Only two interviews were conducted; two planned interviews did not take place due respondents' fears about taxes. The interview covered information about market trends in the baobab fruit pulp sector; the current position of baobab fruits, pulp, and juice in the market; and perceived prospects and problems regarding the current and further development of the business.

2.2. Measurement of concepts

The key concepts in the study include consumer attitudes, beliefs towards product attributes, social influence, product familiarity, and behavior. We adapted and used the general attitude scale from Sabbe

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TABLE 1 Scale of general attitudes, product attributes, and social influence.

Concepts	Items	Scale
General attitudes	I feel good/bad when I eat the baobab fruit pulp.	1 = bad, 2 = slightly bad, 3 = neither good nor bad, 4 = slightly good, 5 = good
	I feel satisfied/unsatisfied when I drink the baobab fruit juice.	1 = unsatisfied, 2 = slightly unsatisfied, 3 = neither satisfied nor unsatisfied, 4 = slightly satisfied, 5 = satisfied
	I feel pleasant/unpleasant when I eat the baobab fruit pulp.	1 = unpleasant, 2 = slightly unpleasant, 3 = neither pleasant nor unpleasant, 4 = slightly pleasant, 5 = pleasant
	I feel happy/unhappy when I eat the baobab fruit pulp.	1 = unhappy, 2 = slightly unhappy, 3 = happy nor unhappy, 4 = slightly happy, 5 = happy
	I feel well/awful when I eat the baobab fruit pulp.	1 = awful, 2 = slightly awful, 3 = neither well nor awful, 4 = slightly well, 5 = well
	I feel positive/negative when I eat the baobab fruit pulp	1 = negative, 2 = slightly negative, 3 = neither positive nor negative, 4 = slightly positive, 5 = positive
Beliefs of product attributes	I consider the baobab fruits pulp cheap/expensive	1 = expensive, 2 = slightly expensive, 3 = neither expensive nor cheap, 4 = slightly cheap, 5 = cheap
	I believe that baobab fruit pulp is available/not available.	1 = unavailable, 2 = slightly unavailable, 3 = neither available nor unavailable, 4 = slightly available, 5 = available
	I think that the baobab fruit pulp is ethical/not ethical.	1 = unethical, 2 = slightly unethical, 3 = neither unethical nor ethical, 4 = slightly ethical, 5 = ethical
	I consider that the baobab fruits pulp is safe/not safe	1 = unsafe, 2 = slightly unsafe, 3 = neither safe nor unsafe, 4 = slightly safe, 5 = safe
	I believe that baobab fruit pulp is nutritious/not nutritious.	1 = not nutritious, 2 = slightly not nutritious, 3 = neither not nutritious nor nutritious, 4 = slightly nutritious, 5 = nutritious
	I believe that baobab fruit pulp and juice has good taste/bad taste	1 = bad taste, 2 = slightly bad taste, 3 = neither bad nor good taste, 4 = slightly good taste, 5 = good taste
	I believe that baobab fruit pulp has good quality/bad quality.	1 = bad quality, 2 = slightly bad quality, 3 = neither bad nor good quality, 4 = slightly good quality, 5 = good quality
	I believe that baobab fruit pulp is sustainable/not sustainable.	1 = unsustainable, 2 = slightly unsustainable, 3 = neither unsustainable nor sustainable, 4 = slightly sustainable, 5 = sustainable
	I believe that baobab fruit pulp is healthy/not healthy.	1 = unhealthy, 2 = slightly unhealthy, 3 = neither unhealthy nor healthy, 4 = slightly healthy, 5 = healthy
	I believe that baobab fruit pulp is attractive/not attractive	1 = unattractive, 2 = slightly unattractive, 3 = neither unattractive nor attractive, 4 = slightly attractive, 5 = attractive
	I believe that baobab fruit pulp is specially/not specially.	1 = not speci1ally, 2 = slightly not specially, 3 = neither not specially nor specially, 4 = slightly specially, 5 = specially
Social influence	To what extent does your husband/wife influence your decision to eat baobab fruit?	1 = inhibiting factor, 2 = slightly inhibiting factor, 3 = neither inhibiting nor stimulating factor, 4 = slightly stimulating factor, 5 = stimulating factor
	To what extent do your children influence your decision to eat baobab fruit products?	1 = inhibiting factor, 2 = slightly inhibiting factor, 3 = neither inhibiting nor stimulating factor, 4 = slightly stimulating factor, 5 = stimulating factor
	To what extent does your family influence your decision to eat baobab fruit products?	1 = inhibiting factor, 2 = slightly inhibiting factor, 3 = neither inhibiting nor stimulating factor, 4 = slightly stimulating factor, 5 = stimulating factor
	To what extent do your friends influence your decision to eat baobab fruit products?	1 = inhibiting factor, 2 = slightly inhibiting factor, 3 = neither inhibiting nor stimulating factor, 4 = slightly stimulating factor, 5 = stimulating factor
	To what extent do your colleagues at work influence your decision to eat baobab fruit?	1 = inhibiting factor, 2 = slightly inhibiting factor, 3 = neither inhibiting nor stimulating factor, 4 = slightly stimulating factor, 5 = stimulating factor

Adapted from Sabbe et al. (2008).

et al. (2008), which is based on six items, to evaluate consumer attitudes towards processed pulp. Based on Sabbe et al. (2008), we also adapted and modified belief and social influence to assess consumer beliefs toward attributes of processed baobab products, as well as social influence regarding the consumption of processed baobab products. The measurement of the concepts is summarized in Table 1.

We further complemented the consumer perspective with a strength, weaknesses, opportunities, and threats (SWOT) analysis from the business perspective. SWOT analysis is a strategic planning method used to systematically evaluate the external opportunities and threats and the internal strengths and weaknesses of a project or business venture (Bernroider, 2002). The SWOT analysis was done in three sequential stages. First, the external market environment (i.e., opportunities and

threats) was evaluated using information gathered from the literature and consultations with stakeholders involved in the national baobab fruit/pulp industry in Sudan. Second, the internal strengths and weaknesses of baobab fruit/pulp and its respective production and supply chain were identified from a combination of observations during field visits and findings from a business stakeholder study on baobab fruits/pulp, which was performed both in El Obeid and Khartoum. Third, the collected information was synthesized in a SWOT-matrix and evaluated to determine the extent to which the identified facts constitute opportunities, threats, strengths, and weaknesses for the use of baobab fruits and pulp in the national baobab products industry. This analysis finally resulted in the formulation of key attention points for strategy development of baobab fruit/pulp products.

2.3. Data analysis

We proceeded with data analysis by first analyzing the quantitative data. We used descriptive statistics such as tables and graphs to analyze the quantitative data. Inferential statistics such as chi-square were used to compare the socio-demographic profiles between urban and rural consumers and t-test was used to compare urban and rural consumers' attitudes and beliefs regarding baobab fruits/pulp. We perform a preliminary exploratory factor analysis to check the internal reliability and dimensionality of the items measuring consumer attitudes and beliefs and the results are present later in Section 3. Second, we complemented the quantitative analysis with excerpts from the focus group participants as well as the industry interview.

3. Results

3.1. Quantitative results

3.1.1. Socio-demographic profile of baobab consumers in urban and rural markets

The comparison of socio-demographic profiles of urban and rural consumers of baobab are presented in Table 2. The results show that the proportion of males in the urban sample is less than that of the rural sample. However, there are more females in the urban sample than the rural sample. Urban and rural consumers have similar age groups, educational levels, and main occupations. However, more urban consumers earn higher incomes than rural consumers. In general, most consumers were reluctant to disclose the incomes.

3.1.2. Consumer behavior, attitudes, and beliefs toward baobab fruits/pulp

We find that most rural consumers purchased processed baobab fruits once a week while urban consumers bought them once every 10–14 days (Figure 1). Across the different consumers, small grocery stores were the preferred place of purchase for baobab fruits (Figure 2).

In Table 3, we show a cross tabulation between frequency of baobab purchase and demographic characteristics of the respondents. The results show that there is an association between frequency of purchase of baobab and education among urban consumers. However, with regard to rural consumers, age and education shows an association with frequency of baobab purchase (Table 3).

We performed a preliminary exploratory factor analysis to check the internal reliability and dimensionality of the items measuring consumer attitudes and beliefs. The internal reliability of the items was poor, as shown by low Cronbach alpha (under 0.60). The factor analysis did not reveal distinct patterns in the items, making it difficult to construct scores to represent consumer attitudes and beliefs. For this reason, we did not present the results for the factor analysis. This can be obtained upon request. This problem could be due to the quality of the questionnaire or the fact that baobab is a widely consumed food in the areas studied and equally popular among all consumer segments.

The general attitudes of consumers towards the consumption of processed baobab fruit products are presented in Table 4. In general, both urban and rural consumers express positive attitudes towards the consumption of baobab fruit pulp. For instance, they express positive outcomes such as feeling good, satisfied, pleasant, happy, well, and positive when consuming baobab fruit pulp (Table 4). However, rural consumers tend to have more positive attitudes towards baobab consumption.

The results of consumer beliefs about the attributes of baobab fruit pulp are shown in Table 5. We find that both urban and rural consumers express positive beliefs about attributes of baobab fruit pulp. They believe that baobab fruit pulp is cheap, available, ethical, nutritious, of good quality, good taste, sustainable, healthy, attractive, and special. However, they perceive baobab fruit pulp as less safe. We observe differences in perceptions of product attributes (especially price, safety, taste, quality, attractiveness) between urban and rural consumers, where rural consumers express stronger beliefs (Table 5).

In Table 6, we present the results on the extent to which social norms influence consumption of baobab fruit pulp. Urban and rural consumers perceive referents such as husband/wife, children, and family to be stimulating factors for the consumption of baobab fruit pulp. However, they are quite unsure as to whether friends and colleagues influence the consumption of baobab fruit pulp.

3.2. Qualitative results

3.2.1. Profile of focus group participants and baobab consumption

The group from El Obeid included participants between 25 and 68 years, whereas the group from Khartoum included seven participants aged between 18 and 61 years (Table 7). All participants recruited for the two focus group discussions were open-minded towards baobab fruit/pulp and they were knowledgeable about the baobab fruit/pulp as well. Participants' baobab fruit consumption patterns varied widely.

The baobab fruit/pulp is regularly purchased and consumed compared to other fruits, due to the health and nutrition value it provides. Further, focus group participants stated that baobab fruit/pulp is good medicine for disease such as malaria, diabetes, diarrhea, nephrotoxicity, and fever. All these diseases were mentioned by participants, who indicated that the baobab fruit/pulp is a treatment for the aforementioned diseases:

"I drink the baobab fruit/pulp juice when I become ill and am coughing; it's good for my body, and I recover, just when I drink a cup of it" (Man, age 48, married with four children, lives in El Obeid; FGD, 2018).

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TABLE 2 Socio-demographic profile of Urban and Rural consumers of baobab.

Variable	Urban consumer (*N*=233)	Rural consumer (*N*=216)	Pearson chi-square statistics	*p*-value
Gender			12.38***	0.00
Female	50	34		
Male	50	66		
Age			3.35	0.501
18–24	9	14		
25–34	18	20		
35–44	28	26		
45–54	25	23		
55–above	19	16		
Education level			5.99	0.200
Primary school	45	42		
High school	22	31		
Tertiary	33	27		
Main occupation			2.38	0.30
Employee	16	12		
Worker	20	18		
Farmer	64	70		
Household income			38.23***	0.00
750–1,449 USD	20	32		
1,500–2,249 USD	16	14		
2,250–2,999 USD	16	9		
3,000–3,749 USD	12	6		
3,750–4,499 USD	7	3		
4,500 – above USD	7	0		
prefer not answer	22	35		

*** = 1% statistical significance. The values presented are percentages. Exchange rate in 2018. 1USD = 20 SDG. SDG refers to Sudanese pounds, the national currency of Sudan.

"I have had diabetes since three years ago. I did not go to a doctor from that time until now, and I used to drink baobab fruit/pulp juice when I would feel my diabetes was rising. When I drink it, I feel better "(Man, age 68, lives in El Obeid, FGD, 2018).

Generally, participants reported that they purchase the baobab fruit/pulp on many occasions, such as celebrations, weddings, and when they receive guests for special occasions:

"I buy the baobab fruit/pulp when I receive guests at home" (Woman, age 27, married with three children, lives in El Obeid, FGD, 2018).

"I drink the baobab fruit/pulp especially when I make delicious food. After I eat a meal, I drink it as another food ingredient" (Woman, age 47, married with two children, lives in El Obeid, FGD, 2018).

"I make baobab fruit/pulp juice for festivals, because it's local food and it's fresh, so most people need it" (Woman, age 32, married with five children, lives in Khartoum, FGD, 2018).

With respect to the season, respondents stated that consumption of the baobab fruit/pulp juice increases seasonally, especially during Ramadan (fasting time). A cup of the baobab fruit/pulp juice is perceived to be cool and refreshing:

"I drink baobab juice every day in the morning, before getting food or other drinks" (Woman, age 61, married, lives in Khartoum, FGD, 2018).

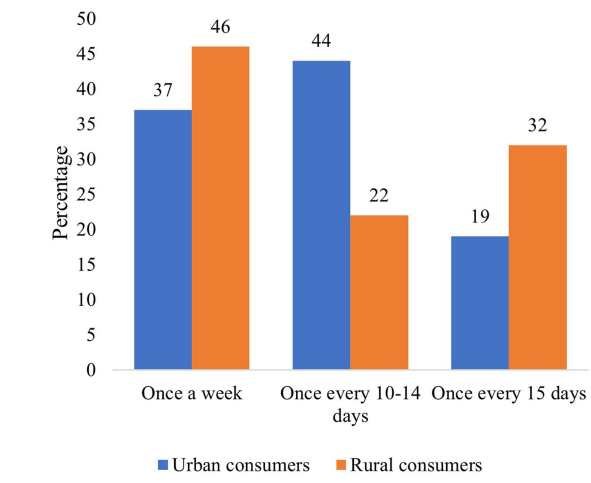

FIGURE 1
Frequency of baobab purchase.

"I prefer to drink baobab fruit/pulp juice especially in the month of Ramadan" (fasting time), (Woman, age 25, married with two children,

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TABLE 3 Cross tabulation between frequency of baobab purchase and demographic characteristics of consumers.

Variable	Urban consumers				Rural consumers			
	Frequency of purchase of baobab			Chi-square test	Frequency of purchase of baobab			Chi-square test
	Once every week	Once every 10–14 days	Once every 15 days	Value of *p*	Once every week	Once every 10–14 days	Once every 15 days	*p*-value
Gender				0.16				0.685
Male	19	58	39		46	34	63	
Female	25	44	48		23	14	36	
Age				0.978				0.058*
18–24	4	70	8		4	8	18	
25–34	7	19	15		16	8	20	
35–44	13	30	23		15	18	24	
45–54	9	25	25		24	7	19	
55 – above	11	18	16		10	7	18	
Education				0.371				0.070*
Primary school	21	7	16		33	12	45	
High school	44	29	29		22	17	29	
Tertiary	40	16	31		14	29	25	
Income				0.03**				0.885
750–1,449 USD	12	22	12		22	14	33	
1,500–2,249 USD	4	15	18		11	5	14	
2,250–2,999 USD	2	14	21		9	4	7	
3,000–3,749 USD	8	11	10		7	4	5	
3,750–4,499 USD	3	6	8		1	3	3	
4,500 – above USD	1	8	7		0	0	1	
Preferred not mention	14	26	11		22	18	36	

* and ** Denote 10 and 5% statistical significance level, respectively.

lives in El Obeid, FGD, 2018).

"In summer, when I go to a market and find the baobab fruit beverage, I buy and drink it because it lets me feel refreshed" (Woman, age 31, married with three children, lives in El Obeid, FGD, 2018).

"My father recommended I drink baobab fruit juice, so when I went to university, I found the shop for the baobab fruit beverage; I used to buy and drink it every day" (Student, age 18, lives in Khartoum, FGD, 2018).

Recurring themes reflected in conversations among the focus group participants are nutritional value, food safety, and pleasure-seeking. Furthermore, baobabs fruit/pulp has a special and festive character, which constitutes the main motives for purchase and consumption. One baobab participant confirms that quality is a strong issue in baobab powder, especially due to microbiological contamination.

"Baobab fruit/pulp juice is a special beverage to me, because it has a special taste and does not require a lot of preparation; it's easy to prepare it. Furthermore, Baobab fruit juice does not need more sugar" (Woman, age 37, married with four children, lives in Khartoum, FGD, 2018).

Other key motives for baobab fruit/pulp consumption are its perceived high nutritional value, unique taste, and health benefits:

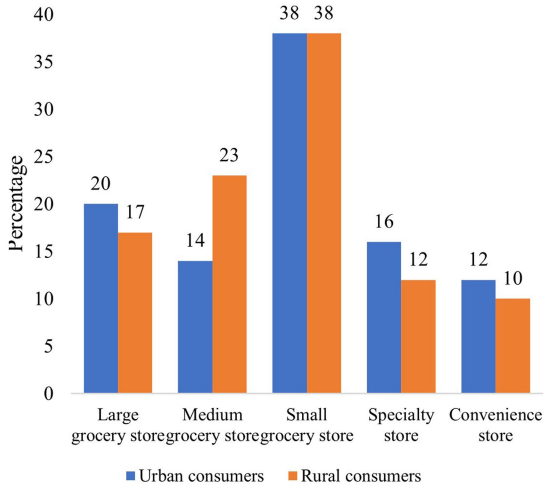

FIGURE 2
Place of purchase of baobab fruit products.

"Baobab fruit/pulp has a unique taste. The taste of baobab fruit/pulp juice is totally different from other fruit juices; it is an acidic taste"

TABLE 4 General attitudes towards baobab fruit products.

General attitude items	Urban consumer (*N*=233)	Rural consumer (*N*=216)	Mean difference	*t*-Test	*p*-value
I feel good/bad when I eat the baobab fruit pulp.	4.61 (1.02)	4.88 (0.56)	−0.27***	−3.33	0.00
I feel satisfied/unsatisfied when I drink the baobab fruit juice.	4.55 (1.14)	4.76 (0.84)	−0.21**	−2.20	0.03
I feel pleasant/unpleasant when I eat the baobab fruit pulp.	4.49 (1.15)	4.76 (0.82)	−0.27***	−2.80***	0.01
I feel happy/unhappy when I eat the baobab fruit pulp.	4.45 (1.18)	4.76 (0.86)	−0.31***	−3.13	0.00
I feel well/awful when I eat the baobab fruit pulp.	4.59 (1.03)	4.86 (0.66)	−0.26***	−3.21	0.00
I feel positive/negative when I eat baobab fruit pulp	4.67 (0.93)	4.76 (0.82)	−0.090	−1.09	0.28
Internal consistency (Cronbach alpha)	0.48	0.39			

The values in parentheses are standard deviations and those in front of the parentheses are mean scores. The items were measured on using a 5-point semantic differential scale. They include good/bad (1 = bad, 2 = slightly bad, 3 = neither good nor bad, 4 = slightly good, 5 = good), satisfied/unsatisfied (1 = unsatisfied, slightly unsatisfied, 3 = neither satisfied nor unsatisfied, 4 = slightly satisfied, 5 = satisfied), pleasant/unpleasant (1 = unpleasant, 2 = slightly unpleasant, 3 = neither pleasant nor unpleasant, 4 = slightly pleasant, 5 = pleasant), happy/unhappy (1 = unhappy, slightly unhappy, 3 = happy nor unhappy, 4 = slightly happy, 5 = happy), well/awful (1 = awful, 2 = slightly awful, 3 = neither well nor awful, 4 = slightly well, 5 = well), and positive/negative (1 = negative, 2 = slightly negative, 3 = neither positive nor negative, 4 = slightly positive, 5 = positive). *** and ** denote 1% and 5% statistical significance, respectively.

(Woman, age 57, single, lives in Khartoum, FGD, 2018).

"I consume the baobab fruit/pulp juice because I believe that it has some characteristics and properties and contains different vitamins" (Man, age 58, married with six children, lives in El Obeid, FGD, 2018).

"The color of baobab fruit/pulp is one of best characteristics that attracted me. If I am at a market and I see baobab fruit/pulp, I buy it directly, without hesitation, as it looks so nice and tasty" (Woman, age 41, with four children, lives in Khartoum, FGD, 2018).

"When I become pregnant, I used to drink and soak up baobab fruit/pulp and juice" (Woman, age 46, with five children, lives in Khartoum, FGD, 2018).

On the other hand, the low income of consumers and the perception of the baobab fruit/pulp as expensive constitute barriers to purchase and consumption:

"I prefer baobab fruit/pulp juice, but sometimes I do not have enough money to buy it or my circumstances do not allow me to purchase it regularly" (Man, age 50, married with two wives and seven children, lives in El Obeid, FGD, 2018).

In particular, its price is a limiting factor to more regular and frequent purchase routines:

"I used to buy baobab fruit/pulp early, before the season of harvesting finished, because in that time the price of baobab is lower. Otherwise, I ultimately find it too expensive" (Woman, age 42, married with five children, lives El Obeid, FGD, 2018).

3.3. Analysis of the development potential of baobab fruit/pulp markets

The results of the SWOT analysis are presented in this section and summarized in Figure 3. We treated strengths and weaknesses as all factors that are under control of the value chain actors including consumers while opportunities and threats are regarded as external factors outside the control of the actors.

3.3.1. Strengths

The stakeholder interviews reveal that baobab fruits/pulps are associated with many nutritional benefits such as being rich in dietary soluble and insoluble fibers, calcium, iron, potassium, and magnesium. Baobab fruits/pulps also have a unique taste (Figure 3).

3.3.2. Weaknesses

However, the interviewees mentioned that the baobab fruit/pulp value chain has many weaknesses, namely no standard formulation, a lack of proper packaging and storage materials, loss of vitamin C in the processing of baobab pulp, poor distribution, and insufficient supply of baobab fruits (Figure 3).

3.3.3. Opportunities

As indicated by the interviewees, many opportunities exist in the baobab fruit/pulp value chain in Sudan. These include high demand for the product, export opportunities, available technology to improve product quality, and the extraction of ingredient for commercial purpose (Figure 3).

3.3.4. Threats

Inadequate quality control and measures, a lack of marketing and regulations, and high barriers to exports are some of the threats to the development of the baobab fruit/pulp value chain (Figure 3).

4. Discussion

The findings reveal that consumption of processed baobab fruit products is common among consumers in urban and rural markets in Sudan. This result is consistent with evidence from Adam (2017) of a high demand for baobab fruits and secondary products in El Obeid and Khartoum markets in Sudan. Demographic characteristics such as age, education and income tend to influence

TABLE 5 Consumer beliefs regarding attributes of baobab products.

Belief items	Urban consumers (*N*=233)	Rural consumers (*N*=216)	Mean difference	*t*-Test	*p*-value
I consider the baobab fruit's pulp cheap/expensive	4.70 (0.94)	4.94 (0.27)	−0.24***	−3.63	0.00
I believe that baobab fruit pulp is available/not available.	4.95 (0.21)	4.97 (0.18)	−0.02	−0.78	0.43
I think that the baobab fruit pulp is ethical/not ethical.	4.96 (0.30)	4.96 (0.35)	0.00	0.00	0.92
I consider the baobab fruits pulp safe/not safe	1.54 (0.84)	2.35 (1.46)	−0.81***	−7.28	0.00
I believe that baobab fruit pulp is nutritious/not nutritious.	4.89 (0.45)	4.81 (0.67)	0.08	1.55	0.12
I believe that baobab fruit pulp and juice has good taste/bad taste	4.71 (0.66)	4.85 (0.43)	−0.14***	−2.65	0.01
I believe that baobab fruit pulp has good quality/bad quality.	4.94 (0.33)	5.00 (0.07)	−0.06**	−2.43	0.02
I believe that baobab fruit pulp is sustainable/not sustainable.	4.97 (0.21)	4.96 (0.30)	0.01	0.11	0.92
I believe that baobab fruit pulp is healthy/not healthy.	4.97 (0.18)	4.97 (0.24)	0.00	0.00	0.92
I believe that baobab fruit pulp is attractive/not attractive	4.92 (0.36)	4.98 (0.15)	−0.06**	−2.23	0.03
I believe that baobab fruit pulp is special/not special.	4.94 (0.40)	4.97 (0.24)	−0.03	−0.88	0.38
Internal consistency (Cronbach alpha)	0.25	0.07			

The values in parentheses are standard deviations and those in front of the parentheses are mean scores. The items were measured on using a 5-point semantic differential scale. Expensive/cheap (1 = expensive, 2 = slightly expensive, 3 = neither expensive nor cheap, 4 = slightly cheap, 5 = cheap), unavailable/available (1 = unavailable, 2 = slightly unavailable, 3 = neither available nor unavailable, 4 = slightly available, 5 = available), unsafe/safe (1 = unsafe, 2 = slightly unsafe, 3 = neither safe nor unsafe, 4 = slightly safe, 5 = safe), not nutritious/nutritious (1 = not nutritious, 2 = slightly not nutritious, 3 = neither not nutritious nor nutritious, 4 = slightly nutritious, 5 = nutritious), bad/good taste (1 = bad taste, 2 = slightly bad taste, 3 = neither bad nor good taste, 4 = slightly good taste, 5 = good taste), bad/good quality (1 = bad quality, 2 = slightly bad quality, 3 = neither bad nor good quality, 4 = slightly good quality, 5 = good quality), unsustainable/sustainable (1 = unsustainable, 2 = slightly unsustainable, 3 = neither unsustainable nor sustainable, 4 = slightly sustainable, 5 = sustainable), unhealthy/healthy (1 = unhealthy, 2 = slightly unhealthy, 3 = neither unhealthy nor healthy, 4 = slightly healthy, 5 = healthy), unattractive/attractive (1 = unattractive, 2 = slightly unattractive, 3 = neither unattractive nor attractive, 4 = slightly attractive, 5 = attractive), and not specially/specially (1 = not speci1ally, 2 = slightly not specially, 3 = neither not specially nor specially, 4 = slightly specially, 5 = specially). *** and ** denote 1% and 5% statistical significance, respectively.

the consumption of baobab. For instance, we find that most urban consumers in the lower income categories are more likely to purchase baobab frequently compared those in the higher income groups. However, evidence from Kiprotich et al. (2019) showed no relationship between consumer income and intensity of utilization of baobab products in Kenya. We also observe an association between frequency of baobab purchase and education among rural consumers, with less educated consumers tending to purchase baobab frequently compared to educated ones. This is consistent with existing literature showing that some educated Africans have a lower preference to consume traditional and indigenous African foods (Fungo et al., 2016; Kiprotich et al., 2019). In addition, we find an association between frequency of baobab purchase and age of rural consumers. The result shows that as consumers in older age categories tend to purchase baobab more frequent. The reason could be that older generations are more aware of the health benefits of baobab and therefore more inclined to buy it frequently. The most popular place of purchase for the population is small grocery stores because of the low price. The results also point out the integration of baobab fruit products into formal outlets such as large and medium-sized grocery stores. These results emphasize the potential for commercialization and upgrading of baobab value chains in Sudan.

Results from the qualitative and quantitative studies indicate that consumers, especially rural consumers, have positive attitudes towards the consumption of baobab fruits pulp. They perceive that the consumption of baobab fruit pulp is associated with positive outcomes such as feeling good, satisfied, pleasant, happy, well, and positive. This result is consistent with the findings of Kiprotich et al. (2019) on baobab fruit and the consumption of urban and rural consumers in Kenya, who also reported that consumers mostly have positive attitudes toward baobab fruits and pulp consumption. The findings are also consistent with those of Sabbe et al. (2008), who showed positive perceptions towards tropical fruits among Belgian consumers. This evidence may indicate the functional properties of baobab and its ability to positively shape people's moods.

Consumers also hold strong, positive beliefs about the attributes of baobab fruit pulp. The attributes are related to health (nutritious, healthy), sensory appeal (taste, attractiveness), safety and quality, and ethical concerns (sustainable, ethical). Nutritional and health benefits are the main motivating factors for consumption of baobab, which also supports the finding of Adam (2017) that nutritional value

TABLE 6 The extent social norms influence consumption of baobab fruit pulp.

Referents	Urban consumers (*N*=233)	Rural consumers (*N*=216)	Mean difference	*t*-Test	*p*-value
Husband/wife	4.94 (0.40)	4.94 (0.41)	0	0.00	0.99
Children	4.85 (0.61)	4.94 (0.38)	−0.09*	−1.85	0.06
Family	4.91 (0.35)	4.90 (0.39)	0.01	0.08	0.94
Friends	3.66 (1.82)	2.87 (1.96)	0.79***	4.40	0.00
Colleagues	3.43 (1.83)	2.54 (1.83)	0.89***	5.16	0.00

A 5-point differential semantic scale (inhibiting/stimulating factor: 1 = inhibiting factor, 2 = slightly inhibiting factor, 3 = neither inhibiting nor stimulating factor, 4 = slightly stimulating factor, 5 = stimulating factor) was used to measure the extent to which the referents inhibit or stimulate the consumption of baobab fruit pulp. * Denotes 10% statistical significance and *** denotes 1% statistical significance.

TABLE 7 Characteristics of focus groups participants.

Participant	Gender	Age	Frequency of consumption
Focus group 1 (*N*=9)			
1	Male	48	One time a week
2	Male	58	1–3 time a week
3	Male	31	Ramadan
4	Male	68	One time a day
5	Female	42	Multiple time week
6	Female	27	Two time a month
7	Male	50	2–3 time a day
8	Female	25	One time a month
9	Female	47	Multiple time a day
Focus group 2 (*N*=7)			
1	Female	41	Three time a month
2	Male	46	One time a week
3	Female	32	Two time a day
4	Female	37	1–2 time a week
5	Male	57	Multiple time a week
6	Female	61	More than three time a week
7	Male	18	Multiple time a year

(vitamins) is a stimulating factor for the high demand of baobab in Sudan. Sudanese consumers are concerned about healthy eating and food-related diseases, which is reflected in a growing interest in nutrient-rich and health-benefiting fruits. In addition, consumers look for natural fruits with health benefits. The baobab fruit/pulp industry needs to focus on innovation and to constantly search for natural food products with a healthy image. As reported in the qualitative study, baobab fruit pulp is used to treat health-related diseases. This is confirmed by previous studies that indicated that baobab is used for medicinal purpose in Ethiopia (Abere et al., 2022), Burkina Faso (Schumann et al., 2012), Malawi (Sanchez, 2011), Sudan and Kenya (Gebauer et al., 2016). Consumers also find baobab fruit pulp to be associated with good sensory appeal; that is, it has a good taste and is very attractive. This sensory appeal could motivate people to consume baobab locally. However, consumers express great concerns regarding the safety of baobab fruit pulp. This may be related to poor handling practices in the processing of baobab pulp. Baobab fruit pulp can become moldy, especially when collected during rainy season, and it can be contaminated by mycotoxins (Meinhold and Darr, 2022). In addition, consumers also believe that baobab fruit pulp is ethical and sustainable as its harvesting and processing are associated with minimum environmental impacts.

The SWOT analysis reveals internal strengths and opportunities, as well as weaknesses and threats to the development of baobab markets. In terms of strengths, the baobab fruit/pulp is well known as a domestic, natural product that is rich in dietary soluble and insoluble fibers, and which has been consumed by the local people for centuries. Recently, however, baobab fruit and pulp have attracted the interest of consumers at local level due to their high nutritional content and functional properties, especially vitamin C, natural sugar, and pectin (Yazzie et al., 1994; Gadour et al., 2017; Lisao et al., 2017; Muthai et al., 2017; Aragaw et al., 2021). The acidic taste is attributed to the presence of organic acids such as citric acid, tartaric acid, malice acid, and succinic acid. Baobab fruits have the potential to be stored for a long time; this distinguishes them from other garden fruits. The fruits can be stored before the fruit capsule is crushed: this is a unique feature of baobab fruits.

However, there are some weaknesses associated with baobab, which include no standard formulation, poor packaging and storage, poor distribution and lack of knowledge and technical skills to improve quality of product. In marketing of baobab, there are no standard measuring scale, which makes it difficult to estimate the actual quantities of baobab sold. Collectors also have very basic knowledge with respect to harvesting tools, packaging, and storage activity. Furthermore, the fruits are broken and opened by chimpanzees and baboons and can crack open if they fall on a stony surface. The quality of the products suffers as a result of the fruits being exposed to dust and sand during harvesting. Fruits are sometimes harvested unripe due to intense competition among collectors, resulting in a scarcity of quality, especially tasty fruits. There are also some issues with storage techniques, as insects attack the products, lowering their quality and, as a result, affecting their taste or appearance. There is a lack of processing industries, advanced knowledge, and technical skills to improve the processing technologies and to guarantee constant good quality of the final product. Baobab fruit/pulp is generally obtained by using traditional processing systems, crushing the capsule of fruit. Inadequate supply and inconsistent baobab fruit/pulp quality may hamper its use in the development of innovative fruit/pulp.

Many opportunities exist in baobab value chains, including high demand for the product, export opportunities, available technology to improve product quality, and the extraction of ingredients for commercial purposes. The local markets for baobab fruit/pulp and their juice have existed for centuries. Baobab business experts confirmed this finding, as they are seeking to meet the increasing

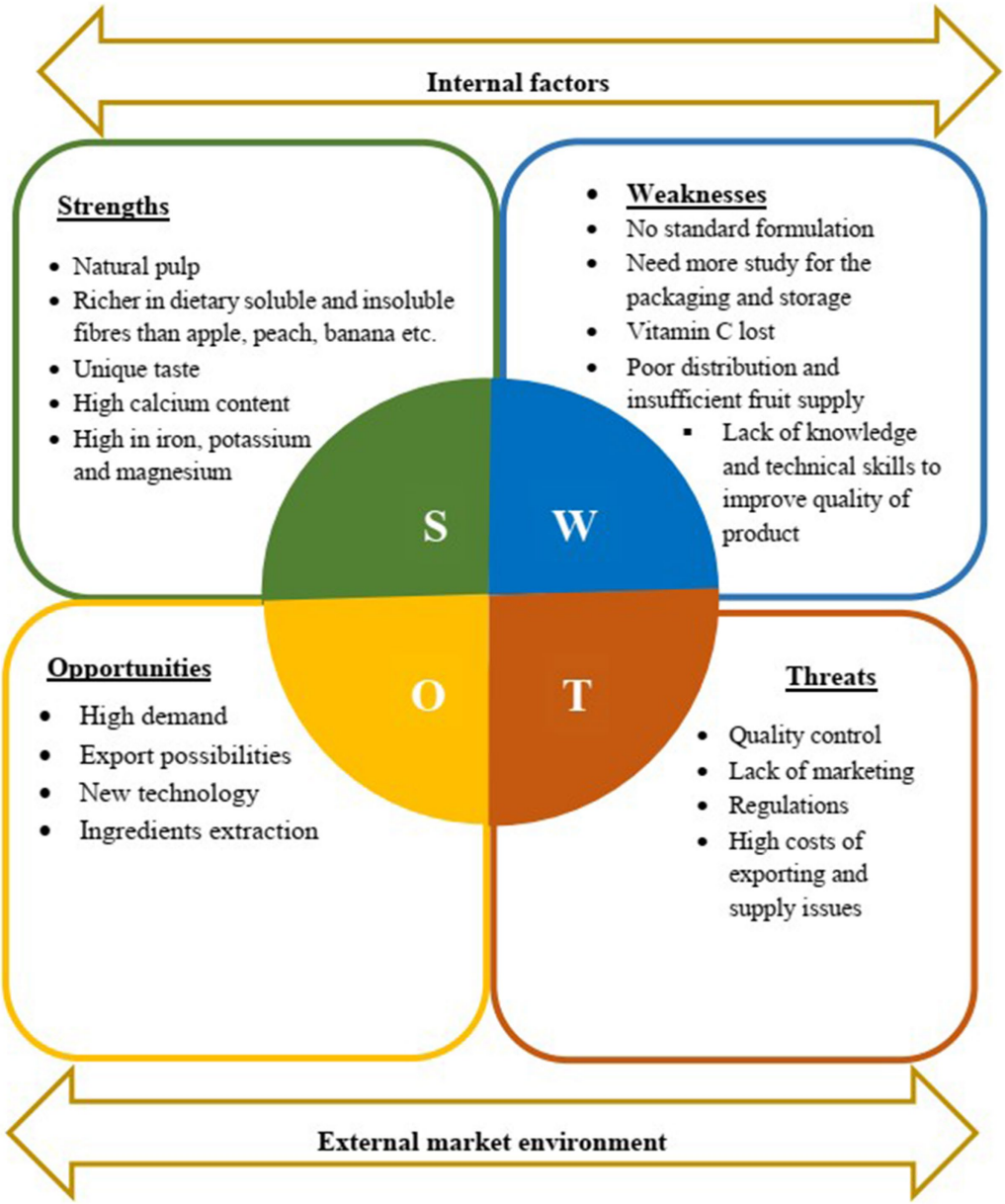

FIGURE 3
SWOT analysis of the baobab markets in Sudan.

demand through innovations, e.g., through adding new flavor. In addition, they mentioned that local consumers continue showing their preferences for the baobab fruit and pulp consumption as a traditional local food. The baobab fruit and pulp market can be expected to continue growing with opportunities for product differentiation. Significant opportunity lies in the growing demand for fruits due to outstanding nutritional characteristics, which provide health-related benefits. Further innovation may take advantage of the already existing local processing industries and hence practical knowledge about processing technologies and uses of baobab fruit/pulp. Experiences from national processing industries and well-developed domestic markets may eventually lead to international market environments. For example, profits realized on national markets may act as a buffer for the risks associated with the exploration of international markets with strict regulatory environments and end users that demand high quality. Advanced skills and knowledge about baobab fruit/pulp production, transportation, and processing issues are barely available to producers. In addition, the inconsistent quality of baobab fruit/pulp is a very relevant weakness when considered alongside the strict market access requirements regarding food quality and safety.

However, there are some threats which may hinder the exploration of the identified opportunities. Interviewees reported that there are many constraints associated with the *A. digitata* fruit/pulp industry. The main threat mentioned by business stakeholders of the baobab fruits/pulp juice industry was the costs of raw materials, due to the high price of the fruit. Due to higher demand for baobab fruits and pulp, and the low availability of the baobab fruit/pulp during the period of Ramadan (fasting time), companies still faced difficulties in consistent supply of baobab fruits and pulp. Further constraints mentioned by interviewees were high transportation costs and market access requirements due to taxation.

Stakeholders perceived compliance with good manufacturing practice from the International Organization for Standardization and the International Labour Organization as further threats to the growth of the business but agreed that those requirements should be met by suppliers in order to meet the increasing demands of consumers with respect to health, sustainability, quality, and safety issues. Another important constraint pointed out by interviewees was the seasonality in demand for baobab fruit and pulp products, with a sharp decline in demand after Ramadan. The existence of traditional traders of baobab fruit pulp and juice in marketplaces are perceived as strong competition for processing companies, since baobab fruit pulp and juice consumers prefer the fresh juice of baobab fruit/pulp over ready-to-drink processed baobab fruit juice.

5. Conclusion and recommendations

The present study was conducted in two market locations (urban and rural) in Sudan with distinct socioeconomics characteristics. The study combines results from a convenience sample of 449 consumers, as well as focus group discussions and an interview with a food industry expert. Results consistently show positive attitudes and beliefs regarding baobab consumption and its social integration and acceptance. In conclusion, further market development for baobab products seems promising in Sudan. For further development of local markets, marketing strategies need to be developed that highlight the nutritional and functional properties of baobab fruit and its ability to combat diseases. The marketing strategies could target lower income group, less educated people and older people while high income class, educated and young people need to be sensitized to the health and nutritional benefits of baobab. In addition, processors need to improve the quality and safety of the products to attractive more people to consume the products. Policymakers also need to develop a regulatory framework that supports the baobab value chain in Sudan.

This study's limitations are as follows. First, the study was mainly exploratory and did not analyze how consumer attitudes, beliefs, and social norms influence their behavior towards the consumption of baobab fruit pulp. We could not perform this analysis due to low internal reliability of the items measuring attitudes and beliefs. For this reason, we suggest further testing of the questionnaire in future research, which should also incorporate additional cities and marketplaces in Sudan and increase the sample size to strengthen the robustness of the results. Our study incorporated only a few focus group discussions and stakeholder interviews, which cannot represent the views and experiences of all stakeholders in the sector. Therefore, we recommend that future research should build on our study by increasing the number of focus group discussions and stakeholder interviews. Notwithstanding the seasonality of the product, and the fluctuations in supply and demand over different months in different years, the study's data refer to the study year only. In order to compensate for seasonality, we recommend conducting market analysis in different months and different years. The study's findings, especially the SWOT analysis, could be applicable to other African countries where baobab is present. However, further studies from other regions in Africa could facilitate the comparison and generalization of findings. Such studies would also contribute to analyzing how differences in culture and regions correlate with consumer attitudes and behavior towards baobab consumption.

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

HS: conceptualization, methodology, investigation, data curation, data analysis, validation, and writing of original draft. DM and YA: planning, and supervision of the study, funding and revision of manuscript. ED: revision of manuscript and data analysis. All authors contributed to the article and approved the submitted version.

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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.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2023.1118714/full#supplementary-material

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