

Research Article

Fruit Preservation at the Dembé Market, N'Djamena, Chad: Steps towards Good Hygiene Practices

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Abstract

Good hygiene practices of fresh fruit are usually evaluated using a checklist of established concepts of food safety. In Chad, no checklist is available to monitor good hygiene practices and face health risk factors. The development of a checklist is a context-specific process complicated by the lack of specific information and the social, economic, and environmental reality in the hot and tropical climate of Chad. Starting from N'Djamena, the objective of this study is to describe the current Chadian scenario of fresh fruit vending towards the definition of a checklist.

A cross-sectional descriptive study design was adopted to depict the scenario of fruit (avocado, banana, guava, watermelon) sold at the popular market of Dembé in the 6th district of N'Djamena. Data were collected by observational, documentary research, and field survey approaches. The SPSS software was used to analyze data. Being predominantly females, most of the fruit vendors were unschooled or below secondary level. Fruit vendors were more likely to preserve bananas and avocado in cartons inside rooms, guava in cartons containing straw, and watermelon under trees or on wet sand on roadsides. Some of the vendors sell fruit next to unsanitary places like bins; some vendors display fruits on a table, usually clean, but fruits are unwashed. Poor hygiene has multiple negative consequences, spanning from i) ingestion of hazardous microorgan-

isms and toxins, ii) loss of nutritional value of fruit, iii) waste of fruit, iv) loss of possible consumers due to bad taste, and v) economical loss. By identifying measures adoptable in the short, medium and long run, this work highlights the role of top-down coordinated strategies spanning from formal training of retailers, effective control measures, and people education to daily consumption of fresh fruits.

Keywords: Diet; Food hygiene; Food safety; Street food

Introduction

In Chad, fruit consumption is still limited but increased [1], and expected to increase more [2,3], due to efforts to improve population awareness on the crucial role played by fruits in both country's nutrition security and economy. Chad is a fruit importing country (banana and avocado) but also produces on average 12,600 tons of fruit in Mandoul, Guera, Lac, and the two Logones regions. One of the objectives of nutrition-health programs is to increase the consumption of fruits by at least 5 servings per day as a means to achieve the WHO recommendation [4]. In the city of N'Djamena, the state of consumption of fruits (and vegetables) is affected by socio-economic difficulties, with only 20% of households respondents consuming one serving of fruits and vegetables per day (per person), and 39.31% consuming two portions [2]. In the context of urbanization and rising food prices, the high household size (45.51%, 1-5 people; 31.03%, 6-10 people) and the low daily expenses for food per households (11.03%, ≤ 1,5 \$; 24.13%, 1,5-3 \$; 28.27%, 3-4,5 \$) hamper the consumption of the 5 recommended portions [2].

Fruits provide the body with valuable substances such as carbohydrates, proteins, vitamins, mineral salts, dietary fibers, and trace elements. In countries, like Chad, with a poor or absent food safety system, the nutritional value of fruit and its microbiological safety can be compromised with subsequent increase in malnutrition [5]. In the absence of resources for refrigerated storage and transport, the high temperatures of the country increases the challenges to guarantee sufficient seasonal nutritious and safe fruit [6].

Further to nutritional aspects, in recent years, foodborne disease outbreaks have been strongly linked to pathogenic bacteria and parasites [7]. Many gastrointestinal diseases, whose prevalence is linked with the ingestion of pathogens in food and water contaminated by human or animal feces, are often associated with poor sanitation and low standards of personal hygiene.

Disruption of pectin, polyphenols and aromatic substances in fruits, which are crucial to improve the organoleptic characteristics of fruits and facilitate widespread consumption, is also due to poor preservation methods.

A previous study conducted in Cameroon highlighted the massive waste of fresh fruits in the post-harvest chain due to absence of formal training of retailers and nutrition education [8]. The main causes of fruit waste were mechanical damage during transport, storage conditions, inappropriate packaging, poor hygiene, but also failure to sell.

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Further to good practices for retailers, nutrition education of the general population is crucial in both promoting healthy life and facing the economic loss due to fruit waste.

Markets are the main supply of fruits and -when basic requirements for hygiene are absent- they pose a public health challenge due to the risk of fecal-oral transmission of gut pathogens. Even in main formal markets, the Hazard Analysis and Critical Control Point (HACCP) approach [9] is still to be adopted in Chad at any stage of food production, distribution, transportation, storage or handling. Fruits are often sold altered and contaminated, and very little is known about their preservation methods in Chad. In Chad, the production and commercialization's of fruits is still a developing activity.

In traditional cultures, context-effective risk analysis science allows to i) highlight main aspects of eating and producing, and ii) analyze people's preparedness and proactivity, as well as channels and tools for prevention [10].

By focusing on a popular market like the Dembé market in N'Djamena, this work aims at starting the process of developing a checklist for assessing good hygiene practices to preserve fruits, in particular banana, watermelon, avocado and guava. By approaching markets with a step-wise approach, our final aim is to provide public health authorities of Chad with tools to increase the availability of nutritious fruit all year long, reduce health risks for consumers, and boost the rate of fruit consumption.

Methodology

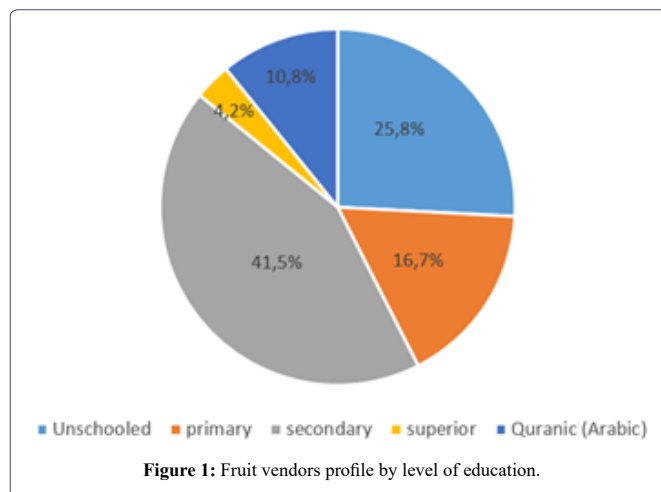
This study was carried out at the popular Dembé market, in the 6th district of N'Djamena, from December 2020 to January 2021. The targeted fruits were banana, watermelon, avocado and guava as seasonal fruit generally available in N'Djamena markets. Data were collected on daily basis from 9 AM to 1 PM and from 3 PM to 6 PM. A questionnaire was used to collect data from vendors that consented to take part in the study. Questions focused on vendors' sociodemographic data, fruit marketing (location, types of fruit sold, frequency of losses), fruit preservation (preservation methods, duration, color, taste). Thirty (30) vendors were randomly selected per fruit, giving a total of 120 interviewed vendors. The collected data was then entered into excel and analyzed using Statistical Package for the Social Sciences (SPSS).

Results

Vendors' Profile and Location

Among the vendors that took part in the study, 38/120 (31.6%) were men and 82/120 (68.4%) were female. When the fruit vendors were classified in accordance to their level of education (Figure 1), it was observed that 31/120 (25.8%) had never been to school (unschooling), 20/120 (16.7%) had been to primary school, 51/120 (41.5%) had been to secondary school, 5/120 (4.2%) had been to the university and 13/120 (10.8%) to a koranic school.

When the market's fruit vendors were classified according to their location, 23/120 (19%) were selling inside the market, 71/120 (59%) were roadside vendors (a part of the Dembé market is in a square, in the middle of the road) and 26/120 (21%) were selling on the streets to easily catch up with customers passing by (Figures 2 & 3). The market does not have latrines nor water sources nor bins. On Saturday, the urban waste disposal service and the market sellers clean the



piles of trash. During the week, some of the vendors sell fruit next to such unsanitary places like bins (21%) (Figure 4).

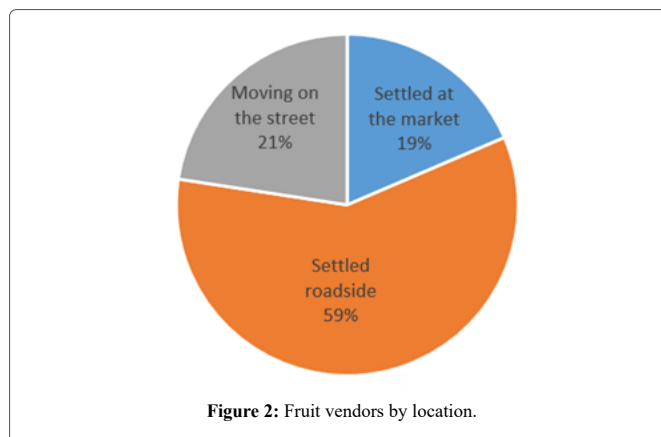




Figure 4: Vendors selling fruit next to unsanitary places, Dembé market.

Preservation and Follow Up

When the vendors were asked about their preservation methods, the following figures were obtained (Table 1). 66.6% of vendors preserve bananas in cartons inside rooms, 3.3% in rooms, 3.3% in cartons in the open air, and 16.6% in a box. 30% of them keep watermelon under trees' shade, 30% on the wet sand on roadside, and 10% in rooms on sand. Nine (30%) of the participants did not specify their preserving methods. A significant number of vendors preserve their avocado inside cartons in rooms (86.6%). 3.3% responded that they keep guavas in a box containing straw, 53.3% in cartons containing strew, and 30% in simple cartons and 4 (12.9%) participants did not mention their preserving methods. The majority preserved their guava in cartons containing straws. Some vendors display fruits on a table (45.2%), usually clean (80.6%), but most fruits were unwashed (71%).





	Preservation Method	No. Vendors	%
	Under tree's shadow	9	30
	On wet sand roadside	9	30
	On sand in a room	3	10
	Not specified	9	30
	In carton in a room	20	66.7
	In a wooden box	5	16.7
	In open air	3	10
	In carton in the open air	1	3.3
	In room	1	3.3
	In cartons in room	26	86.7
	Without preservation	4	13,3
	In carton containing straw	16	53,3
	In carton	9	30
	Without preservations	4	13.3
	In wooden box containing straw	1	3.3

Table 1: Preservation methods.

Table 2 report the number of days the fruits are preserved. Bananas were mainly kept for 2 days (83.8%). Watermelon is for 8 days (70%). The avocado is kept for 2 (60%) to 3 days (31.2%). The guavas are kept for 2 (83.9%) to 3 days (12.9%).





	Preservation Days	No. Vendors	%
	5	1	3,3
	6	1	3,3
	7	7	23,3
	8	21	70
	2	25	83.3
	3	2	6.6
	4	2	6.6
	7	1	3.3
	2	18	60
	3	10	33.3
	Without preservation	2	6.6
	2	25	83.3
	3	4	13.3
	Without preservation	1	3.3

Table 2: Preservation days.

When vendors were interviewed on the organoleptic properties of fruits, most of them acknowledged that preserved fruits change color and taste. Bananas become black and sweeter; watermelons become brown and less sweet; avocados black and acidic, and guavas brown and acidic (Table 3). After 6/7 days of storage, banana (67.7%) and watermelon (53.3%) become consistent, while avocado (84.4%) and guava (96.8%) rot and deformed.

Discussion

The “Hazard Analysis Critical Control Point (HACCP) decision tree” model is applicable in Chad to determine the Critical Control Points (CCP) as a method and a set of principles for the management of food safety [11]. Poor hygiene has multiple negative consequences, spanning from i) ingestion of hazardous microorganisms and toxins, ii) loss of nutritional value of fruit, iii) waste of fruit, iv) loss of possible consumers due to bad taste, and v) economical loss. In absence of appropriate preservation technologies [12], in few days fruits change their organoleptic properties. Fruit sold in bad conditions obviously negatively affect the market in terms of number of fruit consumers and fruit waste. Those consuming altered fruits will benefit of changed nutritional properties. For instance, as the ripeness increases, the bananas will be sweeter but the quantity of mineral salts and vitamins decreases; green bananas have a low glycemic index but are slightly less digestible than riper bananas. The fruits' microbiological safety is also rising concern as an emergent foodborne vehicle [13]. Fruit may expose consumers to a risk of foodborne infection, as they are not treated before consumption. Microbial spoilage also result in huge economic losses. Contamination can take place at any step of production, retail, and consumption.

Indeed, fruit senescence and fungus-induced rot affect post-harvest safety, quality, and security in Chad. By approaching markets





					No.	%
Colour						
Black	0	24	23	0	47	39.1
Dark yellow	0	4	0	2	6	6
Green	5	2	4	1	12	10
Yellow	0	0	0	3	3	2.5
Brown	25	0	0	23	48	40
Others	0	0	3	1	4	3.3
Taste						
Acidic	0	1	24	18	43	35.8
Sweet	5	27	0	1	33	27.5
Bitter	3	0	1	0	4	3.33
Less sweet	22	0	0	8	37	30
Others	0	2	5	3	10	8.33

Table 3: Change in organoleptic properties.

with a step-wise approach, a checklist can be provided to public health authorities of Chad. Since the transmission of pathogenic microorganisms (viruses, bacteria, fungi, parasites) and toxins (e.g. mycotoxins as secondary metabolites produced by fungi during growth, Ladeira et al. [14] in the market is associated with i) inadequate fruit transportation, handling, storage and displaying, ii) poor sanitation due to lack of appropriate and sanitized water resources and toilets, and iii) vendors' low health-risk perception [15], the following measures in the short, medium and long run should be implemented in Chad.

What is Feasible in the Short Run: Training on good hygiene practices is required at vending in order to avoid shortcomings and ensure hygiene. The majority of vendors kept banana in cartons inside rooms, watermelon either under trees on the ground or on the wet sand roadside, avocado in cartons inside rooms and guava in carton containing straw.

Climate and sunlight are hazards for fresh fruits in Chad, due to rapid bacterial growth. Most fruits have short shelf life due to high water content and easy damage during picking, transportation, and storage. Technologies for delaying post-harvest senescence of fruits and control the reproduction of microorganisms (and therefore of fungi and toxins) [12], are generally scanty accessible in Chad. Mechanical damage can favor the contamination with microorganisms, which increase the risk of spoilage. Indeed, transport by pick-up trucks or public transportation or wheelbarrow is widespread, depending on the distance, thus exposing fruit to the risk of microbiological, chemical and physical contamination [16]. Physical sorting to remove spoiled is proved to be effective in reducing fungal infection [12]. Cleaning and sorting can significantly reduce fungal infection and mycotoxin contamination. Avoiding mechanical damage during storage (at home or at the market's stand overnight) and displaying of fruit is a main factor to preserve them (Figure 5).



Figure 5: Currently, fruits are generally placed on the ground on handcrafted wooden plates that are non-washable.

What is Feasible in the Medium and Long Run: Being predominantly females, most (42,5%) of the fruit vendors were unschooled or below secondary level in terms of education. Education of food vendors and consumers on i) good hygiene practices, ii) risk of food- and waterborne diseases, and iii) nutritional value of fruit will increase fruit consumption and both improve the market of fruit and the nutritional security of consumers, while abating the health risk linked

to bad practices. Measures in primary prevention should cover, e.g., periodic training of vendors and education of consumers on good hygiene practices. Further to retailers and vendors, according to Himeda et al. [2], the majority of consumers in N'Djamena (93.79%) do not respect hygienic practices when handling fruit. Storage and preservation approach are increasingly important for postharvest fruit.

Good practices include personal hygiene, like: correct hand-washing after using the toilet and after touching contaminated surfaces or deteriorated food; hand drying; avoid contamination by sneezing, spitting, coughing, blowing nose, manipulating money; use personal protective equipment when sick or injured. Hygiene practices include the environment as well, like: cleaning and care of contact materials and surfaces; protection from dust (e.g., displaying stands should be separated from the floor at least 1m); protection from vehicular traffic; use of safe packaging; collection and disposal of garbage to avoid bad smell and attraction of insects and animals; paying attention to the safety and quality of water sources (e.g. avoid water from boreholes or artisanal sources). Vendors should be aware that investing in good hygiene practices will lead to less waste and more sales.

A routine control by health agencies, can be effective when a prerequisite program is available including, e.g., clean water supply (running water and well-connected sewage connections without infiltrations, well-preserved, protected, and sanitized reservoirs and water facilities; analysis to verify water quality), toilets, sewage disposal system, municipal solid waste management (segregated and protected waste, stored in a place isolated from the food marketing area; proper sanitation of dumps and collectors, sufficient and adequate collectors and dumps), and urban/village planning (e.g. dumps and high traffic routes separated from market area) (Figure 4). Indeed, primordial and primary prevention should be combined and for effective development and implementation. For instance, with the provision of toilets, cleaning and sanitation of toilets should be assured; stakeholders should regularly collect trash and clean the market before opening to the public. Measures to control pests should be applied. While primary prevention focuses on individual/behavioral risk factors, primordial (or primal) prevention aims at establishing and maintaining conditions that prevent such risk factors and allow good practices [17].

Last but not the least, research on safe, non-toxic, broad-spectrum antibacterial and efficient natural storage approach and food package becomes the direction of development. Bioactive constituent of peels and seeds extracts of fruits can be used as effective, environment friendly and inexpensive nutraceuticals [18]. Scientific research should also focus on this aspect.

Conclusion

Climate and sunlight are hazards for fresh fruits in Chad, due to rapid bacterial growth. The fruit waste caused by improper preservation methods cannot be ignored. Microbial load should be prevented in the commercialization stage because there is no guarantee that the hygiene will be enough to eliminate biological hazards in the later stages.

This study highlights how fruit freshness, nutritional value and safety are a challenge in the poor hygiene conditions of food markets in Chad. A checklist will facilitate the education of vendors on minimum hygiene requirements and good practices to preserve safety and quality of fruits and avoid related health risks for consumers. It will also act as a tool for public health authorities to audit vendors and thus

increase the availability of nutritious fruit all year long, reduce health risks for consumers, and boost the rate of fruit consumption. Further surveys in population subgroups accompanied by nutrition education are needed in order to improve the consumption of fruits.

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Conflict of Interest

Authors declare no conflict of interests.

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