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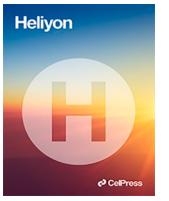

Hygiene practices of food of animal origin operators in primary schools in the Mono Department of Benin. A cross-sectional study

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A R T I C L E I N F O

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A B S T R A C T

Food of animal origin is an important source of proteins for human beings. However, they are subject to microbial contamination. It is essential to ensure the safety of food products intended for school children regarding their vulnerability to food poisoning. Good sanitary quality of these products requires the respect of good practices during their processing and distribution.

This study aims to evaluate the conditions of processing and sale of food of animal origin to school children in public schools, with or without canteens, in the Department of Mono in southern Benin.

In the Department of Mono in the Republic of Benin, 137 operators were interviewed in public schools, with one operator per school, using a questionnaire created on the Epicollect5 platform. The interview showed that the operators involved in the processing and sale of food to school children were women. Most of these operators had primary education and did not undergo a medical examination. They transported food of animal origin mixed with other types of food. Frying and cooking were used to prepare or process the food. Direct observation revealed that food is produced in an unhealthy environment. The operators did not wear gloves during food processing but some wore aprons. All the operators washed their hands with soap and water (tap or well water) after using the toilet. There was not an adequate handwashing facility. The majority of operators used wooden cutting boards. Overall, food operators especially in schools without a canteen do not follow good hygiene and manufacturing practices in the kitchen. To guarantee food safety for school children, training should be organized to make operators aware of good hygiene and manufacturing practices in kitchens.

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1. Introduction

Nowadays, street food takes a very important dimension due to the rapid urbanization of cities, its low cost, and the economic difficulties faced by consumers consisting of school children, pupils, students, and employees [1]. The operators involved in the processing and sale of street food are often the same ones who sold the food to school children. Street foods are known by the population because they are cheap, convenient, and attractive [2]. They are defined as "*food and beverages prepared and/or sold by vendors in the streets and other public places for immediate or further consumption without further processing or preparation*" [3]. This sector is defined by the FAO as "*the sector producing food and beverages ready for consumption, prepared and/or sold by vendors, especially in streets and other sanitary public places*" [4]. The food sold appears to be a real source of income as it allows many households to meet daily expenses for necessities [5]. However, the consumption of food of animal origin poses real health risks to consumers due to the lack of quality control of the food sold, the production environment, and the lack of hygiene at the level of food operators [5]. Therefore, foodborne diseases are increasingly recurrent and constitute real public health problems worldwide [6]. Food safety is a global concern with significant implications for human health [7]. For example, the World Health Organization estimates that at least 600 million people worldwide are subjected to illnesses caused by unsafe food each year [8]. At the African level, it is estimated that 91 million of the population are confronted with foodborne diseases among which 425 000 including 125 000 children die every year [9]. Indeed, in most cities in Asia, Africa, and Latin America, more and more people are choosing street food for their daily diet [5]. Thus, there is an increase in meal consumption in restaurants, snack bars, street food shops, and schools [10]. Among the prepared food, we distinguish those of animal origin. Food of animal origin is all products derived from an animal including honey and blood intended for human consumption [11]. Also are included in this category, bivalve mollusks, echinoderms, tunicates, marine gastropods intended for human consumption, and other animals intended to be prepared for supply to the final consumer. On the other hand, the observed inappropriate and poor conditions under which food of animal origin is produced and sold are of great concern to food safety agencies [12]. Indeed, this category of food because of its richness in protein, under the action of microorganisms can therefore be altered if its produced and sold under conditions where its growth is not perfectly controlled and inhibited (. Foodborne diseases caused by the food of animal origin are due to more than 200 agents, including bacteria, viruses, parasites, and even unconventional agents [13,14]. There are many routes of foodborne disease transmission such as water, person-to-person, direct contact with animals, or other routes following cross-contamination [15]. This type of contamination can occur during the handling of food of animal origin by catering staff or operators through contact with prepared or unprepared food, ready-to-eat dishes, or when they come into contact with dirty work surfaces or utensils in production centers, which represent important factors associated with foodborne outbreaks [16]. Controlling the conditions and environment of production and sale of food of animal origin is fundamental, as inadequate hygiene practices of handlers can lead to their contamination. In Benin especially in nurseries, hospitals, and schools poor practices are observed during the production and sale of food (Ahoyo et al., 2010). These are justified by several factors such as the lack of hygiene, the unavailability of potable water, and the unsanitary conditions of the environment of sale. Also, the promiscuity with the garbage dumps or waste evacuation sewers, which are a concern for the state services and civil society organizations in charge of protecting the health of the populations (Ahoyo et al., 2010). To guarantee maximum food safety and quality for the consumer, compliance with sanitary rules by food operators must be strictly regulated and subject to frequent controls, particularly for microbiological risks, and sources of foodborne poisoning.

The purpose of this study is to evaluate the hygiene, production, and sale conditions of food of animal origin in primary schools in the Department of Mono.

To our knowledge, no such study has been conducted in the Mono department. This study was carried out to contribute to the production of scientific data on which the central government could base its decisions in the area of school food quality control.

2. Material and methods

2.1. Material

This study was conducted in the public primary schools in the Mono Department. The Department of Mono is one of the twelve entities of the administrative division of the Republic of Benin. With an area of 3800 km^2, it is located in the southwest of the national territory between 6° 7′ N and 1° 2′ E. It is bordered to the northwest by the Department of Couffo, to the northeast by the Department of Zou, to the south by the Atlantic Ocean, to the east by the Department of Atlantic, and to the west by the Republic of Togo. It is a Department with six municipalities, namely Athieme, Bopa, Come, Grand-Popo, Houeyogbe, and Lokossa. Its municipalities are subdivided into 35 districts and 276 villages [17]. The size of the population in this county is 590 413 of which 301 673 are female and 288 740 are male. The size of the school-age population (primary level) is 152 410.

2.2. Methods

2.2.1. Operational definition of some terms

Public primary school with canteen (n=33): In abbreviation PS + C, is the set of schools of the elementary course owned by the government where the pupils are fed free of charge at the expense of the government.

Public primary school without canteen (n=100): In abbreviation PS-C, is the set of schools of elementary course owned by the government where school children buy food from food operators.

Private school (n=4): abbreviated as PRS, is the set of privately owned schools approved by the central government where school

children buy food from food operators. This type of school is not included in the study, but we surveyed a small number to serve as a basis for comparison.

Operators: This term refers to the women who prepared or sold food for school children in the canteen or not.

All the visited schools are mapped in Fig. 1.

2.2.2. Sampling

Before sampling, a few criteria (inclusion or exclusion) were defined:

Inclusion criteria: any elementary school in the Mono Department with or without a canteen was included in the study sample, as well as women who are allowed to sell food to school children.

Exclusion criteria: schools that are not located in the Mono Department, women who sell other kinds of food than prepared food.

For sampling, the method described by Ref. [18] was used. A sampling plan was defined. A simple random sample was taken. There were 486 public schools in the entire Department, based on data obtained from the Departmental Directorate of Nursery and Primary Education. The 486 schools were divided into 159 schools with canteens and 327 schools without canteens. A minimal coefficient of 1/5 was applied to the number of schools in the department. The same coefficient was applied to the number of schools in each municipality to determine the minimum number of schools to survey and the number of schools in the two types of public schools (Table 1). For the survey, one operator was chosen per school because there was at most one operator preparing food of animal origin in each school. The schools were selected at random using the random number table. Schools were surveyed based on the total number of schools in each municipality.

2.2.3. Data collection

Two different ways were used to collect data such as direct observation (especially hygiene practices) and interview based on a questionnaire created on an online data collection platform “Epicollect 5". It was a semi-open questionnaire. The questionnaire is subdivided into four main parts, including characteristics of food operators and school operators; food of animal origin; conditions of transport, production, and conservation of raw materials or prepared food; and hygiene of staff, the environment, and production equipment all divided into sub-parts composed of questions. It was addressed to the respondents in the form of an interview. The socio-demographic data of the operators were collected as well as those related to the food prepared and sold, their sources of supply, good hygiene, and manufacturing practices. The interviews with the respondents focused mainly on the staff involved in the production and sale of food, the production environment, the raw materials and methods used, and the quality of the utensils used for the production and sale of food.

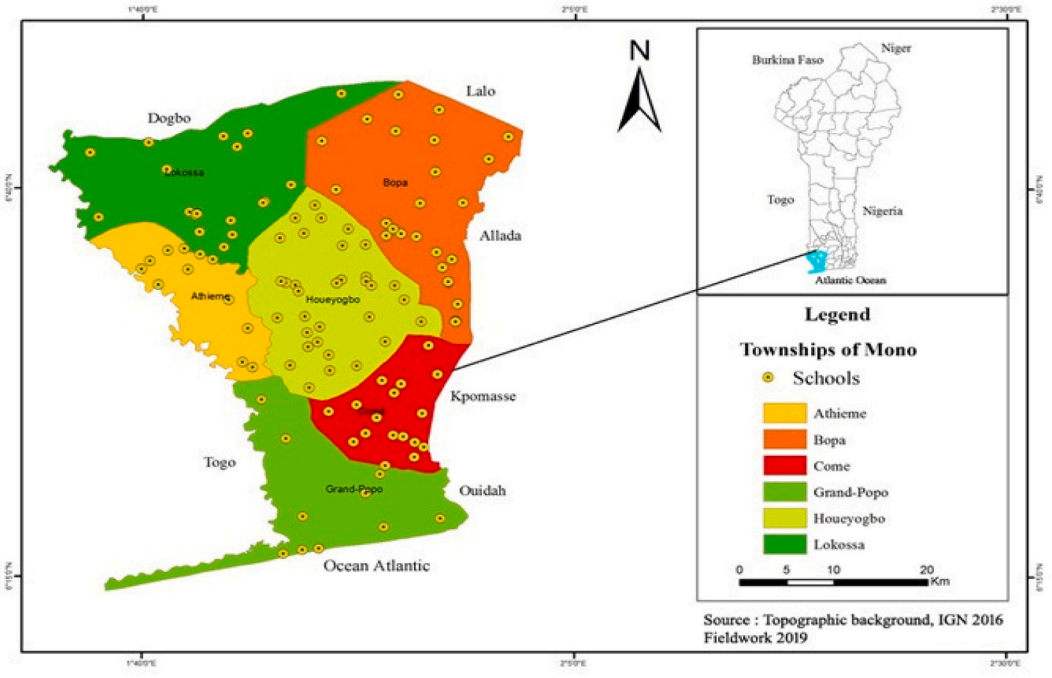

Fig. 1. Map of the study area, yellow dots represent all schools surveyed during fieldwork. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 1
Sampling of schools surveyed.

Variables	PS + C		PS-C	
	Total in municipalities	Sample surveyed	Total in municipalities	Sample surveyed
Athieme	29	6	37	12
Bopa	40	8	68	22
Come	20	4	80	23
Grand-popo	19	4	53	14
Houeyogbe	28	6	63	20
Lokossa	23	5	26	9
Total	**159**	**33**	**327**	**100**

Legend: PS + C: public school with canteen; PS-C: public school without a canteen.

2.2.4. Ethical statement

This study received approval from the ethics committee of the University of Abomey-Calavi of the Republic of Benin before the research was conducted. During the survey, respondents voluntarily gave their informed consent before beginning the interview. Participants were assured that the data would be collected anonymously and would only be used for the purposes of the study. They were under no obligation to participate in the survey. Participation in the survey was voluntary and free. They had the freedom to stop the interview at any time.

2.2.5. Statistical analyses

An analysis of variance was performed by the Proc GLM procedure of SAS for quantitative variables. The only variation factor considered in the analysis of the variance model was the school type effect. Fisher's F-test was used to determine the significance of the school type effect and comparisons between the means of each variable by school type were performed using paired Student's t-test. For categorical variables observed frequencies were calculated using the Proc FREQ procedure in SAS. The Chi^2 test was used to highlight the school type effect on the variables of interest and the comparison of relative frequencies between school types in pairs was done using a two-tailed Z test. For each relative frequency, a 95% confidence interval (CI) was calculated using the formula below, where P is the relative frequency and N is the sample size:

$$CI = P \pm 1,96\sqrt{\frac{P(1-P)}{N}}$$

3. Results

3.1. Characteristics of food operators and types of food from animal origin

3.1.1. Profile of food operators

To illustrate the profile of food operators six parameters were used to provide information on them such as age, activity, gender, level of education, availability of health care, and accessibility to the toilet room. Thus, the average age of food operators was 38 ± 7

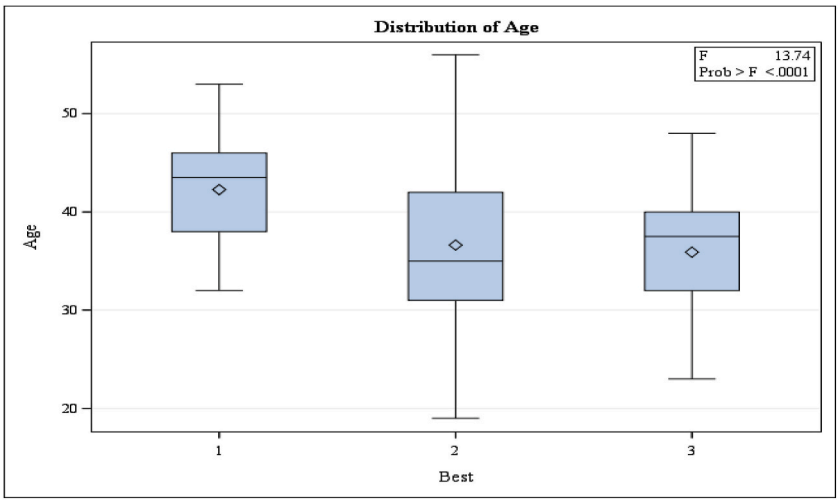

Fig. 2. Age distribution of food operators in each type of school (1 = PS + C, 2 = PS-C, 3 = average of PS + C and PS-C).

years. Within the types of schools, the average age was 42 ± 1 year PS+ C and 37 ± 1 year for PS-C, with ages ranging from 19 to 53 years (Fig. 2). Whether in schools with canteens (PS + C) or public schools without canteens (PS–C) or private schools (PRS), the actors involved in the production and sale of food to school children are all female. The level of education in the 137 operators surveyed was the primary level for 58% of operators in the PS + C, and 49% in the PS-C. In terms of health, 88% of operators in the PS + C stated that they had no medical check-up, compared to 94% of food operators in the PS-C. All schools visited had toilets rooms and the operators had access to these toilets rooms (Table 2).

3.1.2. Description of food from animal origin sold

During the survey, it was observed that all three types of food from animal origins such as egg products, sausage, and fish in PS-C, and PRS as food from animal origin and only fish in PS + C. The production and sale of fish were observed in all types of schools (100%) contrary to eggs products and sausage which were only produced in the PRS and the PS-C. The preparation of egg products was observed at 40% in the PS-C. The sausage was produced by 7% of operators in the PS-C. These two types of food were also produced in private schools (Table 3).

3.1.3. Purchasing and transport of raw materials

The operators purchased food of animal origin either at the market or from neighborhood retailers. Thus, it was observed that, depending on the food, 76% of operators in the PS + C bought from the market, compared to 97% respectively in the PS-C. After procurement, operators transported the animal products separately or mixed them with other food products. Thus, in the PS + C, 42% of operators transported separately foodstuffs, compared to 61% in the PS-C. It was also noted that 58% of operators transported animal food mixed with other types of products, compared to 39% in the PS-C. During transportation, the food was covered by most operators (Table 4).

3.1.4. Production and treatment of prepared food before selling the following day

Two forms of production were used to prepare food such as frying and cooking. Food operators fried their food 27% in PS + C and PS-C. They also cooked food by boiling 85% in PS + C and 49% in PS-C. Sometimes, not all prepared food is sold on the same day. Thus, they are either eaten by the food operators' families according to 88% of operators in PS + C, and 25% in PS-C, or kept to be sold the next day at 12% in PS + C, and 25% in PS-C. In addition, four methods were used to treat the remaining food, such as frying, and heating. They were also left at room temperature or kept in the freezer. Food operators frequently used frying 70% in PS + C, and 96% in PS-C to treat cooked food. They also used heating 18% in PS + C, and 28% in PS-C to treat the remaining food before selling it the following day (Table 4).

3.2. Hygiene of the production and sales environment

In most of the schools visited during the survey, it was noted that the food production environment was either clean or dirty. Thus, the production environment of the majority of schools was clean with 79% for PS + C compared to 80% for PS-C. In addition, garbage and household waste were disposed of in three ways: inside the kitchen, outside, or as soon as they were removed and thrown away. Thus 64% of the operators in the PS + C kept their garbage and household waste outside their kitchens or production environment, compared to 70% in the PS-C. There were food operators who evacuated and immediately disposed of household waste and garbage. These were represented in small proportions (30% in the PS + C, and 20% in the PS-C). Operators produce food in a barely clean environment (Fig. 3) and (Table 5).

Table 2
Characteristics of food operators.

Variables	PS + C (N = 33)			PS-C (N = 100)			Chi^2 test	PRS (N = 4)
	n	%	CI	n	%	CI		n
Activities of operators								
Vendors	0	0	[0–0]	100	100	[100–100]	***	4
canteen manager	33	100	[100–100]	0	0	[0–0]	***	0
Sex								
Female	33	100	[100–100]	100	100	[100–100]	NS	4
Study level								
Not in school	13	39	[22–56]	45	45	[35–55]	NS	0
Primary level	19	58	[41–75]	49	49	[39–59]	NS	4
Secondary level	1	3	[-3–9]	6	6	[1–11]	NS	0
Availability of health booklet								
Yes	4	12	[1–23]	6	6	[1–11]	***	3
Toilet room								
Present and accessible	33	100	[100–100]	100	100	[100–100]	NS	4

Legend: N = total number of respondents, n = number of respondents, NS= Not Significant (p>0.05), ***: significant (p<0.001), PS + C: Public Schools with Canteen, PRS: Private School, PS-C: Public Schools without Canteen, CI: Confidence Interval. The percentages of the same line followed by different letters differ significantly at the 5% threshold.

Table 3
Food of animal origin is produced and sold.

Variables	PS + C (N = 33)			PS-C (N = 100)			Chi^2 Test	PRS (N = 4)
	n	%	CI	n	%	CI		n
Fish	33	100	[100−100]	100	100	[100−100]	NS	4
Egg products	0	0	[0−0]	40	40	[31−50]	***	4
Sausage	0	0	[0−0]	7	7	[2−12]	***	2

Legend: N = total number of respondents, n = number of respondents, NS= Not Significant (p>0.05), ***: significant (p<0.001), PS + C: Public Schools with Canteen, PRS: Private School, PS-C: Public Schools without Canteen, CI: Confidence Interval. The percentages of the same line followed by different letters differ significantly at the 5% threshold.

Table 4
Purchasing, transport of raw materials, production, and treatment of prepared food before selling the following day.

Variables	PS + C(N = 33)			PS-C(N = 100)			Chi^2 Test	PRS(N = 4)
	n	%	CI	n	%	CI		n
Suppliers								
Market	25	76	[61−91]	97	97	[94−100]	***	4
Neighborhood retailer	28	85	[73−97]	73	73	[64−82]	NS	3
Freshness guarantee by the supplier								
Yes	28	85	[73−97]	100	100	[100−100]	***	4
Raw material transportation								
Separate	14	42	[25−59]	61	61	[51−71]	NS	2
Mixed	19	58	[41−75]	39	39	[29−49]	NS	2
Coverage of transported raw materials								
Yes	32	97	[91−103]	82	82	[74−90]	NS	4
Raw material treatment								
Frying	4	12	[1−23]	92	92	[87−97]	***	2
Ambient temperature	29	88	[77−99]	33	33	[24−42]	***	3
Freezing	0	0	[0−0]	100	100	[100−100]	***	1
Transformation state								
Washed with tap water	33	95	[88−102]	81	81	[73−89]	*	4
Washed with well water	5	15	[3−27]	42	42	[25−59]	*	2
Separation of raw material from the prepared food								
Yes	6	30	[14−46]	16	16	[9−23]	NS	1
Form of preparation								
Frying	9	27	[12−42]	100	100	[100−100]	***	4
Cooking	28	85	[73−97]	49	49	[39−59]	***	4
Sale of all production								
Yes	33	100	[100−100]	87	87	[80−94]	NS	3
The fate reserved for to rest of the food								
Sold the following day	4	12	[1−23]	99	99	[97−101]	***	3
Eaten by the operator's family	29	88	[77−99]	25	25	[17−33]	***	3
Treatment of the rest of the food before the following day								
Frying	23	70	[54−86]	96	96	[92−100]	***	3
Heating	6	29	[14−44]	28	28	[19−37]	*	3
Ambient temperature	4	17	[4−30]	5	5	[1−9]	NS	0
Freezing	33	0	[0−0]	0	0	[0−0]	***	1
Treatment of the rest of the food before selling								
Frying	9	27	[12−42]	100	100	[100−100]	***	4
Cooking	28	85	[73−97]	49	49	[39−59]	***	4

Legend: N = total number of respondents, n = number of respondents, NS = not significant (p>0.05), *: significant (p<0.05), **: significant (p<0.01) ***: significant (p<0.001), PS + C: Public Schools with Canteen, PRS: Private School, PS-C: Public Schools without Canteen CI: confidence interval. The percentages of the same line followed by different letters differ significantly at the 5% threshold.

3.3. Hygiene of staff and production equipment

At the staff level, aprons were worn by 79% and 72% of PS + C and PS-C operators respectively. They did not wear gloves during production (C, Fig. 3). All the operators washed their hands with soap and water (tap or well water) after using the toilet. There wasn't a sink for handwashing. The majority of operators did not have any skin sores. Aprons were washed at least once a week, in 52% of the PS-C and 61% of the PS + C operators. Production materials and surfaces were smooth and easy to clean. The spoons were regularly heated after each use. The cutting boards were made of wood in all schools. Operators always use tap water to prepare food (Fig. 3) and (Table 5).

A : Overview of a canteen kitchen

B : Food vendor surrounded by school children

C: Food vendor without an apron with dishes and spoons exposed to flies

D : food vendor wearing an apron with unzipped buttons and uncovered head

Fig. 3. Some observed unhygienic practices [18].

4. Discussion

This study on food from animal origin operators in public primary schools helped to understand the conditions under which they were bought, produced, and sold to school children. Indeed, this survey showed that the production and sale of food from animal origin for school children is the prerogative of women in the two categories of public schools considered for the survey. This is consistent with many studies [5,19,20,21,22,23,24]. All of them are between 19 and 53 years old, which were contrary to Refs. [5,22,25,26,27,28] where they were between 40 and 65 years old. This justifies the fact that it is a dynamic sector of activity that deserves special attention for its development. The two groups of food operators showed points of similarity. Indeed, it was found that at the group level the average age was close to forty. The production of fish for sale is common to all operators of any category of school combined. In PS + C, operators ensure that food is produced in good hygiene practices (e.g. regular hand washing). Educationally, food operators in canteen schools are more educated than those in other schools. This explains why they understand and apply food safety hygiene rules better compared to PS-C food operators. These results are similar to those of [29]for whom; respondents with a high school education are four times better at food safety hygiene practices than operators with a primary education or who have never been to school.

They also did or planned to do the medical examination unlike those of other schools. No women have received training on good hygiene and manufacturing practices (GHMP). Difficulties related to non-compliance with GHMP may be due to a lack of information, training, qualification, and awareness [5,30–36]. In addition, the storage conditions of raw materials and prepared food have shown that only in one private school refrigeration is used to preserve unsold prepared food. Still, regarding the treatment of raw material and prepared food, no operator, at the level of all schools, respects good hygiene and manufacturing practices because these two types of food (raw material and prepared food) must be separated during their conservation to limit the risks of cross-contamination by pathogenic microorganisms [37].

The study also showed that almost 100% of food operators, regardless of the type of school, and based on our observations; wash their hands back from the toilet before handling food. This result is contrary to that obtained by Ref. [5] who reported that 29% of operators washed their hands before serving the drinks but were compliant and above that obtained by Ref. [38] who explained that the respondents mastered the rules of food safety about hand washing [29]. also showed that school cooking food handlers washed their hands while cleaning their fingernails during meal cooking. The study showed a significant difference between PS-C and PS + C in hygiene practices. It was found that 79% of food operators didn't wear aprons or clothes reserved for food handling for PS + C, 50% for private schools, and 72% for PS-C. These results are close to those reported by Refs. [5,39] who mentioned that operators served their customers without special clothing and prepared and served drinks with their bare hands. Operators know that refrigeration can be

Table 5
Hygiene of staff, the environment of food processing and sales equipment.

Variables	PS + C (N = 33)			PS-C(N = 100)			Chi^2 Test	PRS(N = 4)
	n	%	CI	n	%	CI		n
Environment sanitation								
Good	26	79	[65–93]	80	80	[72–88]	NS	4
Bad	7	21	[7–35]	20	20	[12–28]	NS	0
Easy surface cleaning								
Yes	32	97	[91–103]	97	97	[94–100]	NS	4
Surface cleaning frequency								
Before and after each use	30	91	[81–101]	87	87	[80–94]	NS	4
More than three times a day	3	10	[0–20]	13	13	[6–20]	NS	0
Spoon's heating								
Yes	20	61	[44–78]	12	12	[6–18]	***	4
Aprons wearing								
Yes	26	79	[65–93]	72	72	[63–81]	NS	2
Frequency of aprons washing								
More than once a week	20	61	[44–78]	52	52	[42–62]	NS	2
Once a week	8	24	[9–39]	28	28	[19–37]	NS	0
Don't wear an apron	5	15	[3–27]	20	20	[12–28]	NS	2
Intact surfaces								
Yes	33	88	[77–99]	100	100	[94–100]	NS	4
Garbage and waste management								
Kept outside	21	64	[48–80]	70	70	[61–79]	NS	2
Kept inside	2	6	[-2–14]	10	10	[4–16]	NS	0
Removed and thrown away	10	30	[14–46]	20	20	[12–28]	NS	2
Refrigerator availability								
No	33	100	[100–100]	3	3	[0–6]	*	3
Refrigeration temperature knowledge								
No	33	100	[100–100]	1	1	[-1–3]	NS	4
Wearing a glove								
No	33	100	[100–100]	100	100	[100–100]	NS	4
Hand washing after toilet								
Yes	33	100	[100–100]	99	99	[97–101]	NS	4
Nature of cutting board								
Wood	33	100	[100–100]	100	100	[100–100]	NS	4
Aluminum	33	0	[0–0]	1	1	[-1–3]	NS	0
Smooth surfaces								
Yes	31	94	[86–102]	94	94	[89–99]	NS	4
Environment of Production								
Easy cleaning	25	76	[61–91]	55	55	[45–65]	*	4
Difficult cleaning	8	24	[9–39]	45	45	[35–55]	*	0
Cleaning other surfaces								
Once a week	0	0	[0–0]	19	19	[11–27]	*	0
More than once a week	29	88	[77–99]	72	72	[63–81]	NS	2
Every day	4	12	[1–23]	9	9	[3–15]	*	2
Water used for production								
Tap water	33	100	[100–100]	93	93	[88–98]	NS	4
Well water	0	0	[0–0]	14	14	[7–21]	NS	2
Fountain water	0	0	[0–0]	4	4	[0–9]	NS	0
Staff with a wound on the skin								
Yes	1	3	[3–9]	9	9	[4–14]	NS	0

Legend: N = total number of respondents, n = number of respondents, NS = not significant (p>0.05), *: significant (p<0.05), **: significant (p<0.01) ***: significant (p<0.001), PS + C: Public Schools with Canteen, PRS: Private School, PS-C: Public Schools without Canteen CI: confidence interval. The percentages of the same line followed by different letters differ significantly at the 5% threshold.

used to preserve raw materials or prepared foods, but have no refrigerators. Raw materials and prepared foods are often mixed together during storage. Operators do not wear gloves during raw material handling and food cooking. These results are not consistent with those of [29,37] who showed that operators used refrigeration to preserve prepared and unprepared food, did not mix raw materials with prepared foods during preservation, and often wear gloves during raw material handling and food cooking. It was also observed that the food production environment was more or less unsafe; the surfaces used for cooking and handling food are not all intact. These results are similar to those of [40,41,42] who showed that the environmental conditions in which food is prepared are inappropriate for food safety. The food preparation environment is improper, hygiene and manufacturing rules are not followed (poorly cleaned kitchen equipment). This situation would promote the development of pathogenic microorganisms that could subsequently contaminate food and make it unfit for consumption [5,10,23,36,43]. It is therefore crucial that the operators of food intended for school children must be trained in good hygiene and manufacturing practices to avoid contamination of food by pathogenic germs to ensure food safety for school children.

5. Conclusion

This study provided an understanding of the hygienic conditions under which food of animal origin is prepared and sold to school children. In most schools, food is prepared and sold under poor hygienic conditions and does not meet international standards. The study, therefore, suggests that government authorities should make greater efforts to improve the collective catering sector in urban, peri-urban, and rural areas, especially in schools. Operators of food in schools must be trained on good hygiene practices in collective catering. This training will enable them to improve their knowledge of food safety. The establishment of regulations based on requirements for each sector should support the training programs. The study also showed that operators in canteen schools have some knowledge of good hygiene practices and most have at least primary level education. Good hygiene and manufacturing practices appeared to be better in public schools with canteens than in other schools. For this reason, the government should install canteens in all public schools and at the same time put in place regular monitoring structures that will ensure the effective application of good hygiene practices in these schools. School principals can be made responsible for close monitoring. The government must be more involved to ensure the continuity of training programs for food operators. All this will help to avoid food poisoning in the schools Finally, our study was conducted in only one of the twelve departments in Benin. We therefore suggest that this study be extended to the other schools in the country. All schools will be surveyed using our methodology. The results obtained will serve as basic data to guide and facilitate the task of decision makers in their decision-making regarding the rules of hygiene and manufacturing to be respected in community kitchens and during the sale of street food to ensure food safety for school children.

Author contribution statement

Eustache C. Hounkpe: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Philippe Sessou, Souaïbou Farougou, Georges Daube, Véronique Delcenserie, Paulin Azokpota, Nicolas Korsak: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data.

Ignace Dotche: Analyzed and interpreted the data.

Data availability statement

Data will be made available on request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e17135.

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