



PORK SUPPLY CHAIN, CONSUMPTION AND RISK FACTORS FOR INFECTIONS OF CONSUMERS IN THE ABIDJAN DISTRICT (CÔTE D'IVOIRE)

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Abstract: *The ban on the consumption of game throughout Côte d'Ivoire by the emergence of Ebola haemorrhagic fever prompted consumers to turn to other sources of animal protein, such as pork. There is more frequent consumption of pork in more urban areas. It is in this context that a transversal and retrospective survey was performed in 12 communes of the Abidjan District with 3,200 people in order to assess pork supply chain, the level of consumption and environmental infection risks of consumers. Pork meat and pork products supply chain for marketing were revealed. Of the 3,200 people surveyed, 2,400 (75%) reported being consumers of pork at home and out-of-home. Pork was consumed smoked, fried and fresh cooked in sauce at home. Thus, male (63.6%) and female (44.9%) have a preference for smoked pork at home. Out-of-home, baked pork was the most consumed by women (41.3%). Consumers reported some infections of pork after consumption. Symptoms such as diarrhea was more common in men (47.9%) followed by abdominal pain (22.8%), fever (21.1%) and vomiting (2.5%). Thus, the conditions of transport, hygiene and the mode of consumption and handling of pork observed during the investigation could constitute risk factors for infections in the Abidjan District. Therefore, good hygiene practices in the processing of pork from farm to slaughter, transport, marketing and consumption can decrease the risk of infection. So, the best means of preventing the risk for pork consumers remains the compliance with good hygiene practices.*

Keywords: Pork consumption, supply, environmental infection risks, good hygiene, public health.

1. Introduction

Pork is the most widely eaten meat in the world, accounting for over 36% of the world meat intake, followed by poultry and beef, with about 35% and 22%, respectively [1]. Pork imports and exports in each country are now part of international trade rather than simply domestic pork supply and demand [2]. Pork, despite religious considerations and taboos, is one of the most widely consumed meats in the world in terms of

its cost and on the other hand, to its nutritive, taste and organoleptic qualities. Unfortunately, pork can be the source of thirty-five biological hazards to humans [3]. This obligation especially concerns foodborne zoonotic hazards transmitted to humans through pork consumption, such as thermophilic *Campylobacter* spp., *Listeria monocytogenes*, *Salmonella enterica* and *Yersinia enterocolitica* [4, 5]. Although pork is still only about 10% of

the meat consumed in Africa, the accelerated urbanization of the past two decades has given new impetus to its production. Indeed in 2005, 800000 tons of pork were consumed, compared with 500000 tons in 1990 [6].

In Côte d'Ivoire, pork consumption is increasing in the face of the high cost of other protein sources (beef, sheep meat, chicken meat, fish, etc.) on the market. Moreover, with the emergence of haemorrhagic fever in Ebola leading to a ban on the consumption of bushmeat throughout Côte d'Ivoire, the need for consumers to look for other sources of animal protein is necessary [7], thus increasing pork consumption.

A risk model is built that covers the food pathway from farm to fork comprising six modules as the model developed by [8]. The six modules are: (1) primary production, (2) transport and lairage, (3) slaughterhouse, (4) post-processing, (5) distribution and storage and (6) preparation and consumption [8]. Slaughtering of pigs remains an open process with many possibilities for contamination of the carcass [9]. Among foodborne infectious diseases, foodborne zoonoses are a public health problem. These biological hazards present in the food, which may have an adverse effect on health, are most often associated with inapparent carriage in animals [10].

Insufficient or non-existent information on the supply of pork sales outlets does not allow traceability of the production chain to consumers. In addition, understanding the supply chain for pork will identify the areas to be promoted in order to increase the availability and accessibility of this meat. In this context, the objective of this study is to assess pork supply chain, practices surrounding pork consumption and to estimate the environmental infection factors associated with pork consumption in Côte d'Ivoire.

2. Materials and methods

2.1. Study area

The study took place from June 2015 to November 2015 in Abidjan District.

A survey was carried out to describe the attitudes, practices surrounding consumption of pork, the supply and marketing system for pork.

Within this transversal study and retrospective survey took place in 12 communes in Abidjan District, namely Yopougon, Cocody, Treichville, Adjamé, Port-Bouët, Abobo, Marcory, Attecoubé, Plateau, Koumassi, Bingerville and Anyama (Figure 1). The areas have been chosen because Abidjan District cities are an important hub with regard to pork marketing and its supply with large quantities of pig carcasses from surrounding cities and also, the existence of public markets for pork and the presence of many restaurants specialized in pork consumption.

2.2. Data collection

2.2.1. Estimation of sample size

The sample size was determined by the following formula [11]:

$$n = \frac{p^*(1-p)}{\left(\frac{E}{1,96}\right)^2}$$

With n , sample size required; proportion of people surveyed in Abidjan District $p = 50\%$; and E margin of error at 5%; 1,96 at a confidence level of 95%.

In this study, n represents the proportion of people surveyed consuming pork or not. Given the lack of data on the level of pork consumption in Côte d'Ivoire, the prevalence of 50% was retained. The minimum size of surveyed required, estimated from this formula is 384.

However, in order to have a representative

sample size and maximize the finding of more consumers, the sample size within

the framework of this study was finally set at 3,200 for all the twelve (12) communes.

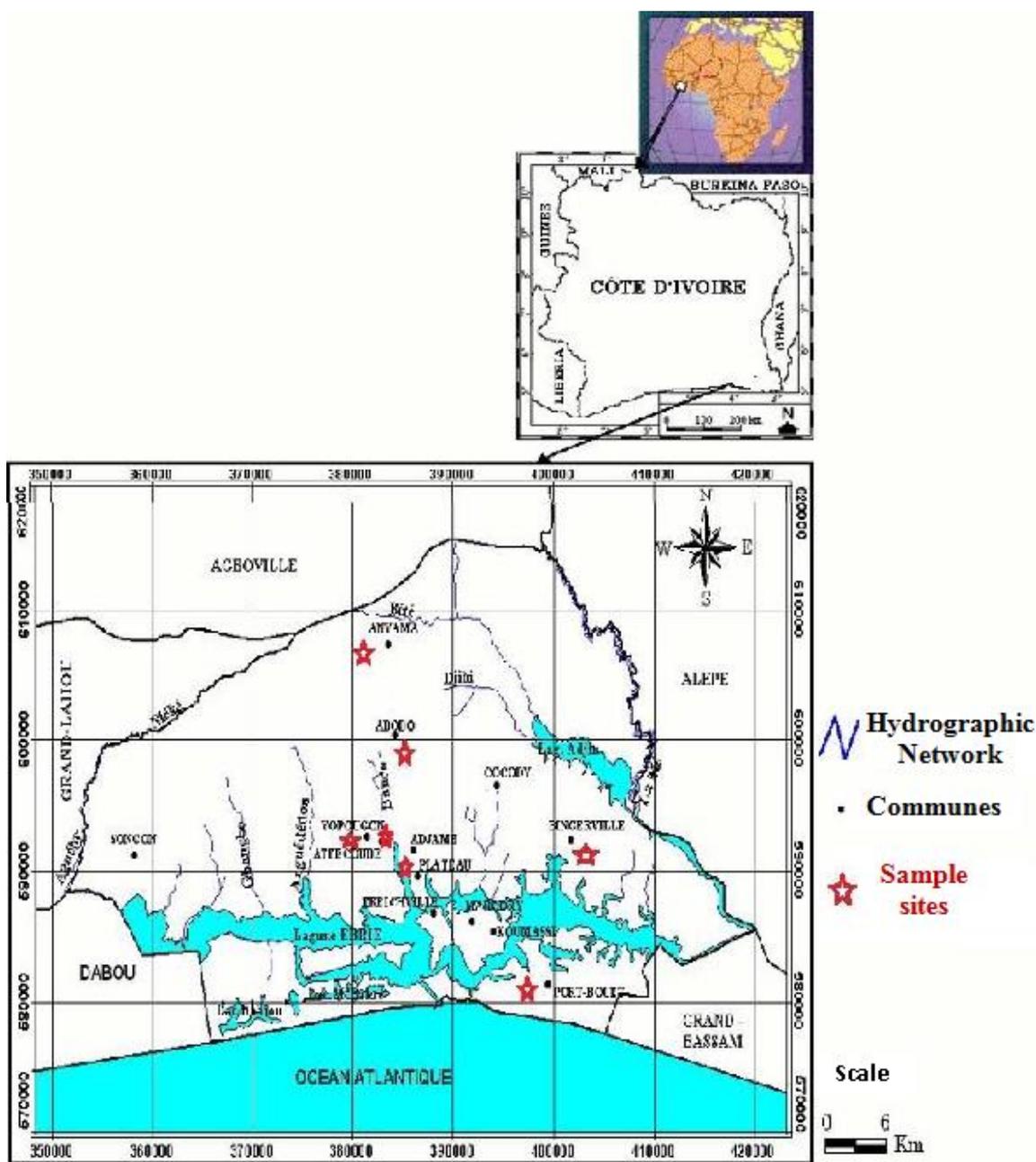


Fig. 1. Map of Abidjan District

2.2.2. Conducting the survey

Methods of collecting data were face-to-face interviews using standardized questionnaires (written surveys) for both to consumers or non-consumers. Written surveys allowed asking questions to consumers or not. The same questionnaire

was used for both consumers and non-consumers. The survey was conducted at home (in households) and out-of-home (in streets and market) in 12 communes in Abidjan District. In the selected sites, the people predisposed whether they were consumers or not, were randomly questioned. At home, interviews were

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carried out with the people in charge of cooking the family meal. The questionnaire focused on themes, namely the place of supply, eating habits of pork consumption, frequency of consumption, and diseases related to pork consumption. Socio-demographic information such as age, gender and level of education were also collected. In addition, sales and consumption practices were observed during the survey.

In order to determine pork supply, marketing and to investigate the factors that may lead to contamination of pork, a survey was carried out among breeders, at the slaughterhouse and meat sellers of pigs in the markets of each selected commune. The questionnaire survey was coupled with direct observation on the selected sites. The main objective of this survey was to determine the places of supply, distribution, means of transport, storage of pork and environmental infection factors.

2.3. Data analysis

Data collected was analyzed using the Statistical Package for Social Sciences (SPSS) version 20.0 (IBM Corporation) software to constitute the database. The descriptive statistical methods (Frequency, Mean) were used for the quantitative variables.

The Chi-square test was used to test the relationships between the variables. The difference between the variables was considered significant at $p < 0,05$.

3. Results and discussion

3.1. Pork marketing and supply chain

Pork supply and marketing are partly informal. The breeding pigs are slaughtered either directly in the farming areas (farms) or transported to be slaughtered at the slaughterhouse of SIVAC (Ivorian Society of Slaughter and

pork butchery). Pigs slaughtered in slaughterhouses by specialized agents are distributed by refrigerated trucks in swine processing factories and distributed to supermarkets in respect of the cold chain. Pork is also distributed on the wholesale and semi-wholesale market or in areas for the sale of pork (Figure 2). Pigs from traditional farms are slaughtered at the slaughterhouse or on the farm by breeders (sales slaughterers) who ensure their distribution on markets or in areas equipped for sale, without respect the cold chain. Pork is carried by means of load carriers ("rickshaws", wheelbarrows) or vehicles (motorcycle, taxi, tarpaulin, truck, etc.). Pork is subject to many sources of contamination (environmental contamination, cross-contamination, etc.) related to the types of transport.

Pork products are then stored and transported, frozen or chilled to wholesale, retail and catering facilities for ultimate sale to consumers. In addition, some breeders sell pork directly to sellers or consumers. Pork is consumed smoked, fresh or fried at home or out of home in the form of baked pork, braised, minced pork (Figure 2).

The inadequacy or lack of information on the supply of pork sales outlets does not allow traceability of the production chain to consumers. In addition, understanding the supply chain for pork will identify the areas to be promoted in order to increase the availability and accessibility of pork. While the food choices reflect the preferences and eating habits of the population, the composition of a meal also relies on the availability and accessibility of food sources.

The Ivorian pig sector is supported by a dense marketing network, with a large number of farms concentrated mainly on Abidjan District areas but also inside the country. With the advent of Ebola and the ban on game consumption throughout the

country, consumers would be looking for new sources of protein [8], leading to an increase in pork consumption. As a result, the quantitative and qualitative improvement in production could increase pork supply. The intensification of production through the creation of farms appears as an option to improve pork supply. The production-to-marketing route is partly informal. As a result, some breeders sell pork directly to consumers and sellers. Also in Abidjan District, the cold chain is not always respected when transporting pork meat, especially after traditional slaughter. Pork is transported either in refrigerated trucks for industrial slaughter for supermarkets or in taxis, sheeted boards or even in load-carriers called "rickshaws" for traditional slaughter for local markets. Similar reference [12] reported in a study conducted in Chad that most purchases of live pigs are made directly from producers due to the absence of a physical market. Pork is transported by vehicle (taxi, tarpaulin, truck etc.). It has been found that transport of pigs from production areas to consumption places is carried out by means of load-carriers, bicycles and mopeds when distances are low and in vehicles when they are far away [13, 14]. Moreover, the reference [14] showed that production in Côte d'Ivoire is dominated by modern livestock farming, which is aimed at profitability, compared to the traditional breeding farms in the country whose production is generally intended for self-consumption, saving.

3.2. Pork consumption

Of the 3200 people surveyed, 2400 said they were consumers of pork, i.e. pork consumption rate of 75% in Abidjan District and 800 (25%) were non-consumers. The global size of people survey to be investigated was distributed evenly communes selected, resulting in

200 consumers per commune. According to the data collected, 1554 (48,6%) consume pork at home. On the other hand, 846 (26,4%) respondents consume or prefer to consume this meat out-of-home (Table 1).

Table 1.
Distribution of consumers and non-consumers of pork surveyed in Abidjan District

	Consumption locations	Effective (n)	Rate (%)
Consumers	Home	1554	48,6
	Out-of-home	846	26,4
Non-consumers		800	25
Total		3200	100

For the rest of the results, only those who consumed pork were taken into account (n= 2400).

In Côte d'Ivoire, studies on the consumption of foodstuffs are generally rare. However, they allow us to better understand the uses of these food products and the environment of consumption whether at home or in collective catering.

Emergence of Ebola virus disease (EVD) in West Africa in 2014 has led to a ban and stigmatization of this essential food source in rural zones. The prohibition of game consumption throughout the extent of Ivorian territory due to the occurrence of Ebola hemorrhagic fever has incited consumers to turn toward other sources of animal protein [8], favoring an increase in pork consumption.

The survey conducted in this study revealed that three quarters (75%) of the population surveyed in Abidjan District consume pork. This consumption in Abidjan district is higher than that of pork in Africa which was 8.9% in 1997 reported by [15]. Indeed, following the ban on game consumption, people were increasingly interested in pork consumption because of its organoleptic quality.

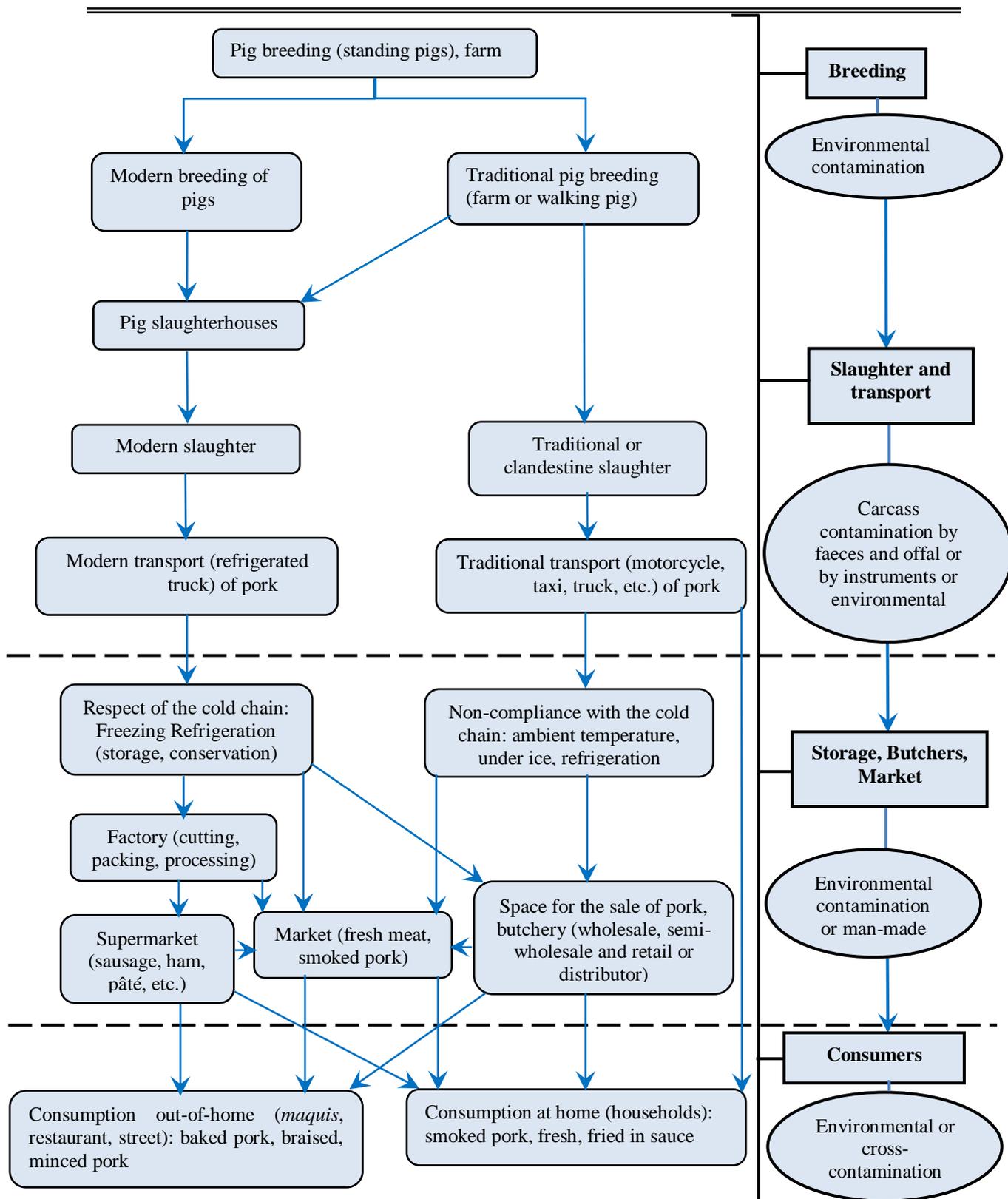


Fig.2. Pigs and pork supply chain, marketing in Côte d'Ivoire and indication of potential contamination sites

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3.3. Pork consumption frequency

Housewives typically consume pork twice (55,1%) a day, with the majority of staff consuming once (79,9%) in the day after purchasing prepared or cooked fresh pork (Figure 3). The social classes that consume the most pork are in particular housewives, traders, artisans, school pupils and students.

The statistical analysis shows that there is a significant difference between daily consumption frequencies of socio-professional categories ($p = 0,02 < 0,05$).

The preferential choice of pork among other types of meat by modest socioeconomic categories was previously mentioned by [16]. Indeed, this author has shown that households with the lowest incomes and the rural ones buy and consume more pork than other meats. In addition, he noted that pork would have strengths making it popular with consumers and giving it a place of choice in daily food [17].

Other authors have pointed out that pork enjoys a good reputation because of its affordable price, its ease of preparation, its many possibilities of accommodation due to its not too pronounced taste and its role as a component of traditional eating habits in rural areas [18, 19]. Also, pork formed part of the staple diet in many households and was held in high regard in terms of its versatility, cost effectiveness and taste.

3.4. Pork consumption at home

3.4.1. Consumption forms of pork

At home, pork was preferentially consumed in sauce in three forms (fresh, smoked and fried). Males (63,6%) and females (44,9%) have a preference for smoked pork. Females with a frequency of 29,1% consume more fresh pork compared to males (17,3%) (Figure 3).

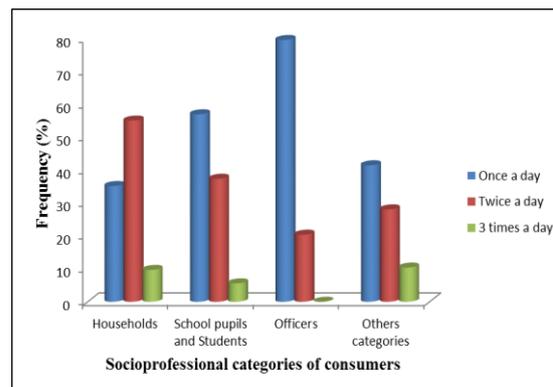


Fig. 3. Pork consumption frequency by socio-professional categories

The Chi-square test revealed a significant difference between the forms of pork consumption by both genders (Chi-square = 137858a, $p = 0,000$) (Figure 4). Consequently, the gender of the respondents influences the forms of pork consumption.

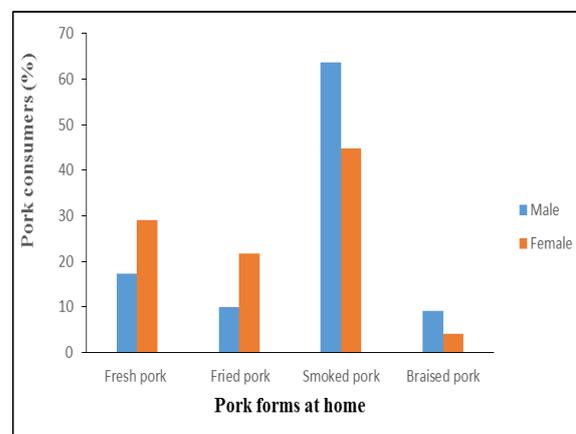


Fig. 4. Different forms of pork consumption at home

The study also reveals that at home, pork is consumed in sauce especially in three forms (fresh, smoked and fried). Males (63,6%) and females (44,9%) have a preference for smoked pork at home. Previous studies have justified this preference. According to references [20] and [21], smoking reduces the high fat content, partially masks the often unpleasant smell of fresh pork meat; which contributes to improving the nutritional

and organoleptic characteristics of the cooked product. Also, pork was consumed for several reasons, including for breakfast, lunch, dinner, snack and for emotional reasons. It was perceived to be a comfort food, also consumed to cure a hangover [22].

3.5. Pork consumption out-of-home

In general, females (31,1%) and males (23,6%) prefer to consume baked pork outside their home. In addition, other forms of pork consumption have been reported. For males, the consumption of skewer is 7,5% and consumption of offal soup by females is 7,4% (Figure 5).

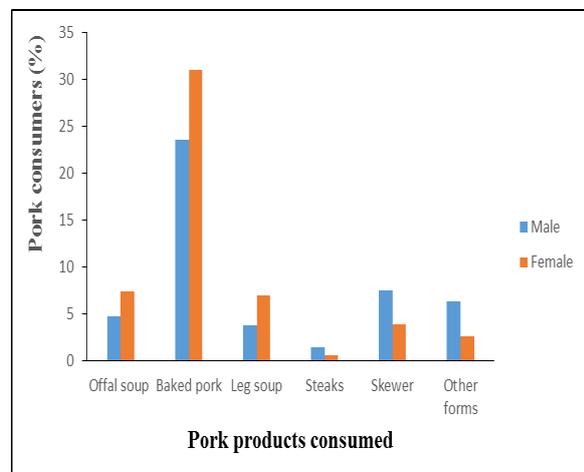


Fig. 5. Distribution of pork products consumed out-of-home

On the other hand, out-of-home, pork consumption in a baked form is most appreciated by both women and men. This consumer preference out-of-home can be explained by the greater availability and convenience of consuming meat in this form. Indeed, cooking preparation in sauce is relatively difficult, requires a variety of logistics and ingredients that are not always easy to bring together in an out-of-home environment. In addition, there is a convenience of service, consumption of the baked pork and its association with the

attiéké (grated cassava) or *allococo*, menus entering the eating habits in urban environment outside the homes and sometimes at home. In addition, the presentation of the baked meat is similar to the barbecue, which leads to a product locally called *choukouya* often consumed during the ceremonies of rejoicing (marriage, baptism, etc.) in Côte d'Ivoire. The forms of consumption encountered in N'Djamena in Chad are similar to those in Abidjan District. Indeed, grills and soups are most often consumed outside the home while sauces are consumed in the home. Meat is also used for ceremonies and friendly and family meetings [12]. Survey revealed that pork was consumed at each major eating occasion, for breakfast, lunch and dinner. Additionally, main consumption of pork takes place during feast times [22].

Growth of pathogenic bacteria can occur if the cold chain is not maintained during transport to the home. Raw meat should be packed in separate bags or containers away from other foods, particularly ready-to-eat foods, to avoid potential cross-contamination. The use of insulated bags or freezer bags is recommended during transportation. Food should be refrigerated, cooked or frozen as soon as possible following purchase.

3.6. Mean time of pork cooking

Pork is cooked mostly in the range of 31 minutes to 1 hour in both females (56%) and males (45,1%). Meanwhile, 44,7% of males cooked meat less than 30 minutes, compared to 43,8% of females (Figure 6). Data received from housewives and out-of-home salesmen revealed that they generally cook pork in sauce to avoid exposing their family and client to possible infections related to insufficient cooking. However, cross-contamination after cooking would be the main risk factor for

the transmission of disease to the consumer as reported previously by [23] and [24].

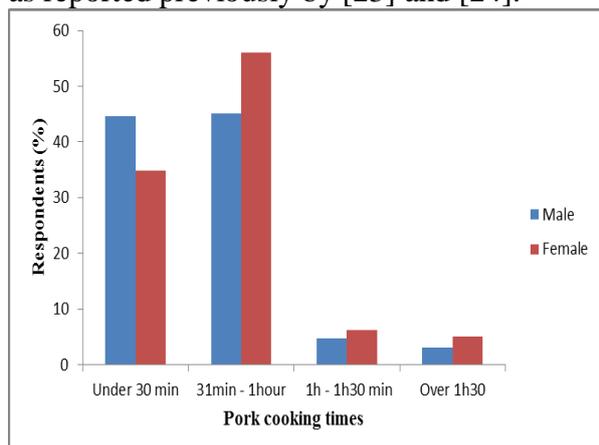


Fig. 6. Mean cooking time of pork by gender of consumers

Compliance with hygiene rules of good practice would be a prerequisite for reducing the risk of contamination of zoonosis and parasitic infestations by pork consumption. Thus, the need to inform and train the actors of the pig farms, vendors and industry on methods of packaging and preparations in breaking the chain of contamination is necessary [22].

Nevertheless, it should be recalled that in Côte d'Ivoire, food in general and especially meat are consumed frequently cooked, which a priori limits the transmission of the micro-organisms that they contain. On the other hand, these practices do not exclude a transfer of pathogenic microorganisms in the kitchen, in particular via cross contamination related to the handling of contaminated raw foods. Moreover, the evolution of the lifestyle that allows the consumption of new products cooked or raw suggests the transmission of pathogenic microorganisms. Côte d'Ivoire has been involved for decades in sanitary inspection of meat in slaughterhouses. But this inspection does not allow absolute control of the dangers for the meat consumer.

In addition, small-scale breeders set up clandestine slaughter systems for animals

intended for direct sale to consumers. All of which is a public health concern today. Meat inspection could contribute effectively to the eradication of zoonoses when associated with the presence of macroscopic clinical or lesional signs in animals and their carcasses. It does not make it possible to combat the zoonoses associated with an inapparent (asymptomatic) carriage as the case of animal yersiniosis and campylobacteriosis [4].

3.7. Symptoms after pork consumption and levels of risk to consumers

The most common symptoms were diarrhea (47,9%), abdominal pain (22,8%), fever (21,1%) and vomiting (2,5%) for males. Vomiting was more reported for females (6,8%) than males (2,5%) (Table 2).

Foodborne illness is caused as a result of the consumption of pork, or contact with, food that has been contaminated with some type of microbiological, biological, chemical or physical hazard. Pork production is affected by a variety of risk factors among which are quality of pig feed, number of subclinical carriers within a farm, conditions during transportation and lairage premises before slaughtering, slaughter line contamination by carrier animals, conditions during processing and retailing of pork products, conditions of handling pork products during catering and home-food preparation [25-28]. Thus, risk of pork contamination increases when supply chains become longer (i.e. due to poor slaughter and other post-harvest handling practices) as practiced in Abidjan District.

Consumers reported experiencing digestive problems such as diarrhea, abdominal pain, nausea, vomiting consecutive to pork consumption. These discomforts revealed consumers face in pork consumption. In

Table 5.

Symptoms after pork consumption by gender

Gender Symptoms	Male n (%)	Female n (%)
Abdominal pain	144 (22.8)	214 (20.4)
Vomiting	16 (2.5%)	71 (6.8%)
Nausea	9 (1.4%)	13 (1.2%)
Diarrhea	302 (47.9)	471 (44.8)
Fever	133 (21.1)	161 (15.3)
Abdominal pain + Diarrhea	23 (3.7%)	80 (7.6%)
Vomiting + Nausea	0	19 (1.8%)
Abdominal pain + Vomiting + Diarrhea	0	21 (2%)
Total	631	1051
Statistical analysis	Chi-square of Pearson	61.076 ^a
	<i>p</i> value	0.000

addition. studies have highlighted the failure of the street food vendor's hygiene system [29] and the risk factors for infection in humans [30]. It is found, as revealed by the investigation, that pork is also sold and consumed in the street; which exposes the consumer to a contamination whose origin may not always be an agent intrinsically transported by pork. The domestic cycle refers to the transmission pattern occurring in swine herds. Pigs can acquire infection by eating the infected flesh of other pigs or rats [31]. Consumption of undercooked pork and cross-contamination of consumer products during processing of pork products are high-risk factors [32]. Thus, the protection of public health depends on reliable rules of monitoring and reporting animal *Salmonella* infections and retailing facilities contamination, but also the undertaking of educational programs for increasing the awareness of food workers and consumers on food safety during food preparation [33-35]. The consumption of raw or undercooked pork poses a risk of infection as does the cross-contamination of ready to eat foods with bacteria from raw pork or its juices. We can use separate cooking utensils and plates for raw meat and cooked foods and always store

separately to avoid cross-contamination. Therefore, sensitize and educate farmers and other value chain actors on the control of pathogenic bacteria, parasitic and virus are needed to achieve efficient and sustainable control. Thus, good animal husbandry practices should be adhered to and pigs sourced from microbiologically reliable sources. The implementation of good biosecurity measures and good quality feed and water will ensure a healthy herd.

4. Conclusion

Pork supply and marketing circuit were revealed during this investigation. Three quarters of the people surveyed in Abidjan District consume pork. So, pork is widely consumed at home and out-of-home. The type of processing undergone by the meat affects the choice of consumers according to the place of consumption. At home, smoked pork in a sauce is more prized. Out-of-home, baked pork is appreciated by consumers. This investigation also revealed that conditions of transport, handling of pork are a risk factor. Particular attention should be paid to some people who consume pork in the form of boiled, smoked, fried and / or

undercooked. Today, in Africa, and particularly in Côte d'Ivoire, a change in eating habits and the development of fast-food restaurants are most evident in the urban population. It is therefore advisable to apply good hygiene practices in the processing, sale and pork consumption. Our results refer to insufficient hygiene management in all stages of the food chain. Educating consumers about the found risk factors presents an important action to decrease the incidence of bacterial infections. Information and sensitization of population on bacteria risk factors and preventive measures must be observed.

5. Acknowledgments

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