



Rapid integrated assessment of food safety and nutrition related to pork consumption of regular consumers and mothers with young children in Vietnam

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ABSTRACT

Pork is the most common and widely consumed meat product in Vietnam. The study aimed to assess nutrition and food safety risks and opportunities associated with pork value chains in Vietnam. Twenty-nine focus group discussions (FGD) were conducted in Hung Yen and Nghe An provinces with 164 participants who were both regular pork consumers and mothers with young children. In each province, three districts were selected, and in each district we selected one commune. To assess the quality of pork, we took 30 swab samples of pig carcasses at slaughterhouses, 90 pork samples at slaughterhouses and markets and analysed all samples for total bacterial count (TBC), coliforms, water holding capacity and pH. The results showed that pork was the main livestock product consumed and women are responsible for buying and preparing food for daily meals. Pork was the main animal sourced food (ASF) for Vietnamese consumers, for 50–60% of ASF. There was little knowledge of zoonotic diseases. The findings suggest further studies to address consumers' concern on chemical contamination. Most market pork samples were not within the allowable range of limits standards of Vietnam for bacterial contamination: 90% of samples were above the official permissible limit for TBC and 98% did not meet standards for coliforms. Fifty percent of samples had acceptable pH but only 5% had acceptable water holding capacity. There were no significant differences in pork quality between intensifying Hung Yen and traditional Nghe An provinces, although there was a tendency for samples from Hung Yen to have better compliance. This rapid assessment revealed considerable interest and knowledge on pork nutrition and safety and found some behavioural but few quality and safety differences between traditional and intensifying systems. This indicated marketed pork is of low quality and safety, and a lack of support to consumers in making good choices.

1. Introduction

Animal source foods (ASF) are important for people as they provide essential micro and macro nutrients for human development and functioning. Regular consumption of even small amounts improves growth, physical activity and cognitive function (Neumann et al., 2003; Iannotti et al., 2017). In low and middle-income countries limited access and availability of ASF leads to malnutrition and poor health. Concern over the impacts of malnutrition have led to many programs

and policies to address them, but there has been relatively less emphasis on market-led or value chain-based approaches to improve nutrition, although these have potential to reach large numbers of people at low cost (Robinson and Yoshida, 2016).

While highly nutritious, fresh ASF are also often implicated in foodborne disease (Grace, 2015; Hoffmann et al., 2017). Under-nutrition has been a major development issue for decades, but only recently foodborne disease issues have been gaining more attention among research and NGO communities as well as policy makers. Indeed, the first

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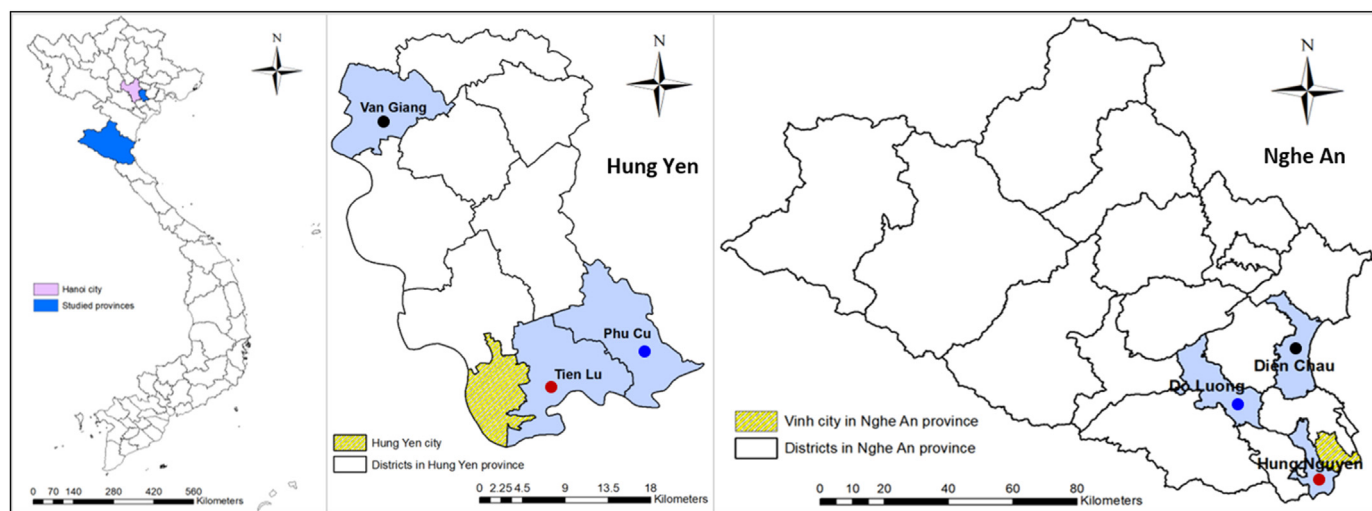


Fig. 1. Study area in selected districts in Hung Yen, and Nghe An provinces, which represented three pork value chains: peri-urban to urban (red points); rural to peri-urban (black points); and rural to rural (blue points) (For interpretation of the references to color in this figure, the reader is referred to the web version of this article).

global assessment of foodborne disease shows that the burden is comparable to HIV/AIDS, tuberculosis and malaria, causing approximately 420,000 deaths and 600 million illness cases every year (Havelaar et al., 2015). Most of the burden falls on Africa and Asia. The Western Pacific region, which includes Vietnam, is ranked as second in the world in terms of food-borne disease. In this region, at least 50,000 deaths and over 125 million people become ill due to contaminated food each year, out of the estimated 1.5 billion inhabitants, meaning that eight in every 100 people fall ill annually (Havelaar et al., 2015).

Most people in Vietnam depend on value chains for food access. Pork and pork products are the most commonly consumed ASF in Vietnam with a pig population of 30 million heads (OECD, 2017). Pork is produced mostly (80%) by smallholders with processing and selling occurring through the informal (open air and traditional type) market value chain (Lapar and Tongco, 2011). There has been a growing concern on food safety among food value chain actors in particular consumers and policy makers in Vietnam (Nguyen-Viet et al., 2017). Retailed food is often contaminated with biological and chemical hazards (Nguyen-Viet et al., 2017; Tuyet-Hanh et al., 2016). Risk assessments of food safety quantified risk of different microbial and chemical hazard in foods (Dang-Xuan et al., 2016a, 2016b; Tuyet-Hanh et al., 2016) and these suggest high levels of foodborne diseases: for example, 13% of pork consumers may suffer from foodborne, non-typhoidal salmonellosis each year.

Food consumption is influenced by beliefs around the health properties of food. Many Vietnamese follow the Chinese yin-yang (*âm-dương* in Vietnamese) theory of diet categorising food as *dương* (hot) or *âm* (cold) (Chen and Swartzman, 2001). Hot foods include red meat, alcohol and ginger; cold foods include noodles and bananas. Some foods are neutral including rice, pork or sweets. Moreover, people believe that certain animal organs such as pig heart, kidney, brain are suitable for infants and elderly people whereas other should not be given because they are un-safe or not nutritious (personal communication with co-authors). Raw pork is rarely eaten except for fermented pork (*nem chua*), and sometimes raw blood pudding (*tiết canh*). Gender also influences consumption. For example, some risky foods like *tiết canh*, mainly from pigs and poultry, are mainly eaten by men.

A recent paper described changing meat-eating behaviour in Vietnam: meat consumption has increased very rapidly since the initiation of market reforms in 1986 and the consumption should be approached at the intersection between systems of provision and everyday practices. This is driven by: (i) changes in systems of provision for meat, (ii) adding more meat to traditional meals and the import of

meat-intensive eating practices from abroad, (iii) the increasing prevalence of eating out; and (iv) the positive social connotations attached to meat as a symbol of development and progress (Hansen, 2018).

In this context, understanding the role and potential of value chains for improving or worsening nutrition and health is important. Moreover, while nutrition and safety are linked there have not been any studies in Vietnam that considered both topics in an integrated manner. Considering both can increase synergies and reduce trade-offs, for example, avoiding an increase of foodborne disease when promoting a food that is both risky and nutritious.

Our study aimed to assess nutrition and food safety risks and opportunities associated with pork value chains in Hung Yen and Nghe An provinces, Vietnam. Specific objectives were to i) understand the nutrition and food safety of pork with a focus on purchase, preparation and consumption, as well as their influencing factors, and ii) to assess the pork quality in selected settings and compare it with perceptions of pork quality of consumers.

2. Materials and methods

2.1. Study site

We conducted this study from December 2012 to May 2013 in Hung Yen and Nghe An provinces, Vietnam, representing two main patterns of pork sector development, i.e., pork systems transitioning to more intensive and traditional pork systems, respectively. Hung Yen is close to Hanoi, the capital of Vietnam, and represents a scenario of rapid, unplanned, demand driven development, driven by proximity to urban markets. Hung Yen represents a more intensifying pig system that has more medium scale pig production and Nghe An is the largest province on the north-central coast and represents a more traditional pig system with more small scale production, with different possible trajectories of development. These 2 provinces had a high pig production among the Northern and central provinces in Vietnam.

Three out of 10 districts in Hung Yen and three out of 20 districts in Nghe An were selected for detailed assessments. These districts were chosen to represent three different value chains of interest: peri-urban to urban (e.g., pork mainly produced from peri-urban areas to provide to urban areas); rural to peri-urban; and rural to rural, which show the pork flow from production to consumers. In each district, one commune was randomly selected, giving six communes in total in two provinces (Fig. 1). The choice of study areas was part of a selection strategy developed for a nine-country program seeking to upgrade nine high

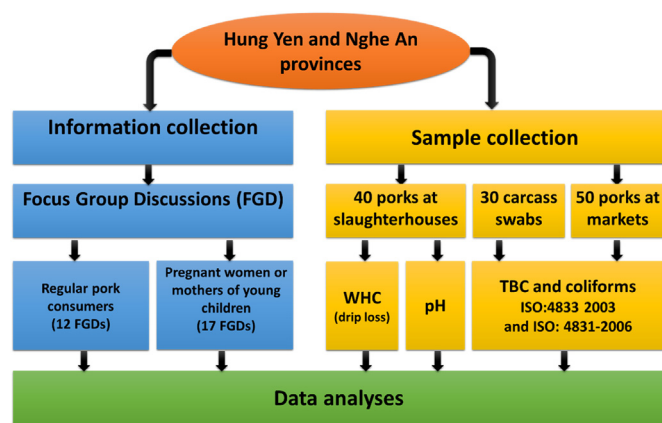


Fig. 2. Framework of the study included focus group discussion and sampling analyses.

potential animal source value chains under the CGIAR Research Program Livestock and Fish and is described in depth elsewhere (CRP Livestock and Fish, 2018).

2.2. Participant selection of FGD and process

2.2.1. Regular consumers

Based on the list of households provided by the commune authorities, different households were divided into three wealth categories: better-off, medium, and poor. In each group; the research team asked for the list of all households of the selected commune and identified participants as consumer by stratifying them by wealth (combined income and asset) followed by a random selection. This selection was done in collaboration with leaders of the commune and its women union so that we could have participants who fitted the desired criteria: representing different wealth categories (better-off; medium; and poor); occupation of women; location; and, willingness to participate (Fig. 2).

2.2.2. Pregnant women and mothers with young children

We used convenience sampling to identify consumers who were pregnant women or mother of children of five years old or younger. They were identified by the chairwoman of the commune woman union and invited to participate in the discussion.

2.2.3. Conducting FGD

Overall, 29 FGDs were conducted comprising 12 groups of regular consumers, and 17 groups of pregnant women and mothers with young children. A joint team of researchers from a public health university, an agricultural university and International Livestock Research Institute (ILRI) conducted FGDs using a participatory appraisal approach. Each FGD was facilitated by 3 project team members of which two members were the main facilitators using note-taker. The team pre-tested the FGD with 5–7 local people using a pre-tested guideline with relevant topic questions and supporting tools. A note-taker recorded answers and comments raised by participants and helped taking photos during the discussion (Fig. 2).

2.3. Data collection

The FGD covered food safety and nutrition, qualitative and semi-quantitative data on pork consumption patterns, knowledge, attitudes and practices on pork preparation and safety. A generic tool for data collection had been developed and applied in several countries (Uganda, Senegal, Ethiopia, and Egypt) but adapted for Vietnam. This included participatory epidemiology tools such as group discussions, ranking and scoring methods, Venn diagrams and seasonal calendars. These addressed a set of research questions, specifically: What is the

role of pork among animal source foods for consumers' diets? How available and accessible is pork? What are the quantity and frequency of pork purchase? Who eats pork, when and why? What are reasons not to eat pork? How nutritious and delicious is the food? How do knowledge, attitudes and practices increase or reduce the risk of pork-borne diseases?

2.4. Quality and safety tests

To assess the quality of pork, 30 swab samples of pig carcasses at slaughterhouses in Hung Yen, and 50 pork samples (30 in Hung Yen and 20 in Nghe An) at markets, and 40 pork samples at slaughterhouses (20 each in Hung Yen and Nghe An) were collected. Laboratory tests included total bacterial count (TBC, ISO 4833:2003), coliforms (ISO 4831:2006), water holding capacity (drip loss) and pH. Total bacterial count is a measure of overall bacteria; high coliforms counts are often associated with faecal contamination by people or animals and are more closely related to health risk, as many foodborne diseases are faecal-orally transmitted; pH and water holding capacity are related to stress at slaughter and storage conditions.

2.5. Data management and analysis and ethical clearance

Information from all FGD were transcribed into Excel files. They were divided in 4 main themes namely nutrition, food safety, food security, and social and cultural. Descriptive statistics was used for biological and physical quantitative data. T test or Wilcoxon test, where appropriate, were also used to compare two groups at a significance level of p -value ≤ 0.05 .

Ethical approval for this study was obtained from Institutional Review Board of the Hanoi School of Public Health (No. 148/2012/YTCC-HD3). Informed consent was obtained from all individual participants included in the study.

3. Results

3.1. Participant profile

There was a total of 164 participants. All were female, with an average age of 37 (21–68) years old. Sixty percent (99/164) was less than 40 years old. Their education level varied from no formal education to higher education. The majority (62%) were farmers, and a smaller number operated small businesses, or were housewives, teachers or workers. A total of 69 households (out of 164, 42%) had less than three members and 88 households (out of 164, 54%) had four to five members. General demographic information of the participants in the two provinces studied is showed in Table 1.

3.2. Animal source foods availability and use

ASF in the study areas comprised meat and products from pig, chicken, beef, duck, buffalo, fish, egg, shrimp, crab, eel, and snail. The ASFs mentioned most frequently were pork, chicken meat, egg and fish. In all areas, participants stated that pork was always available during the year and was easily bought from the roadside vendor to markets located around the village or commune, compared to other ASF. "We can buy pork everywhere, anytime during the day" (a 27 year old woman in Hung Yen). Main reasons mentioned by participants for the higher availability and accessibility of pork were reasonable price, "easier" to buy a small portion, easy to prepare and make different recipes, which has been daily dishes for many people. "Making dishes from pork is easy and its taste is also preferable compared to other meat" (a 36 year old woman in Hung Yen).

In rural and peri-urban areas, chicken meat and egg were available all year around, and mainly self provided with more products available on holiday or festivals from the commune or central markets. Fish,

Table 1
General demographic information from the participants in the focus group discussions.

Information	Regular consumers (n=74)	Mothers with children (n=90)	Overall (%)
Gender (Female)	74	90	164 (100)
Age			
20–30 yrs old	7	56	63 (38)
31–40 yrs old	11	25	36 (22)
41–50 yrs old	37	7	44 (27)
≥ 51 yrs old	19	2	21 (13)
Education			
No school	4	1	5 (3)
Primary or secondary school	37	31	68 (41)
High school	28	53	81 (49)
University or higher	5	5	10 (6)
Occupation			
Business	4	15	19 (12)
Farmer	54	47	101 (62)
Housewife	7	17	24 (15)
Officer	1	3	4 (2)
Teacher	5	6	11 (7)
Worker	3	2	5 (3)
Household size			
≤ 3 members	34	35	69 (42)
4–5 members	37	51	88 (54)
≥ 6 members	3	4	7 (4)
Household areas ^a			
Peri-urban to urban	25 (4)	31 (6)	56 (34)
Rural to rural	21 (4)	33 (6)	54 (33)
Rural to urban	28 (4)	26 (5)	54 (33)

^a Italic in bracket is the number of focus group discussion (FGD) conducted in the study areas.

shrimp, crab, eel were more available in the summer (rainy season-from June to September) than other periods during the year, and therefore were bought from markets or sometimes captured. Chicken or fish were available during the year for urban consumers from the markets. In addition, participants from Dien Chau and Tien Lu district in Hung Yen province, nearby the sea and the rivers, reported that they had more options to access seafood and fish. These ASF was used to replace pork

Table 2
Animal sourced foods use, availability and accessibility by consumers among the value chain of rural-rural (RR), rural- peri-urban (RP) and peri-urban-urban (PU) areas.

No	Animal sourced foods	Frequency of eating (times/month)	RR	RP	PU	Variation during the year (availability)	RR	RP	PU	Where is ASF obtained (accessibility)	RR	RP	PU
1	Pork	18–22	✓			All year around	✓	✓	✓	Vendors, village, commune markets	✓	✓	✓
2	Chicken meat	15–20		✓	✓					Local shops, supermarkets			✓
		5–10		✓	✓	All year around	✓	✓	✓	Buy from markets in commune	✓	✓	✓
3	Fish	4–8	✓			More on holidays, festivals	✓	✓		Self provided (raising)	✓	✓	
		12–18	✓			All year around	✓	✓	✓	Commune markets	✓	✓	✓
4	Egg	4–10		✓	✓	Rainy season (Jun-Sept)	✓	✓		Self catching, fishing	✓	✓	
		12–15	✓			All year around	✓	✓	✓	Self provided (raising)	✓	✓	
5	Shrimp	6–10		✓	✓	More available in winter	✓	✓		Markets round village, commune	✓	✓	✓
		8–10	✓			All year around			✓	Self catching	✓	✓	
6	Duck meat	3–6		✓	✓	Mostly in summer, rainy season	✓	✓		Markets round village, commune	✓	✓	✓
		3–4			✓	All year around			✓	Self provided (raising)	✓	✓	
7	Muscovy meat	1–2	✓	✓		Mostly in summer, rainy season	✓	✓		Commune markets			✓
		3–6	✓		✓	All year around	✓	✓	✓	Central markets	✓	✓	✓
8	Buffalo meat, beef	1–3	✓	✓		More on holidays, festivals	✓	✓		Local shops, supermarkets			
		3–4			✓	All year around			✓	Central markets	✓	✓	✓
9	Prawn, squid, tuna	1–2	✓	✓		More on holidays, festivals	✓	✓		Local shops, supermarkets			✓
		3–6	✓	✓		All year around	✓	✓	✓	Central markets			✓
10	Crab, snail, eel	1–2			✓	Mostly in summer, rainy season	✓	✓		Markets round village, commune	✓	✓	
		< 1	✓	✓	✓	Some occasions, special days	✓	✓	✓	Central markets			✓
11	Dog, cat, goat, pigeon	< 1	✓	✓	✓					Self provided (raising)	✓	✓	
		< 1	✓	✓	✓	Rice harvest (rat), rainy season (frog)	✓	✓	✓	Self caught	✓	✓	
									Markets round village, commune	✓	✓	✓	

in the meals during the week. Beef, buffalo, goat and duck meat and sea food (squid, prawn, tuna) were not always available during the year, and consumers needed to access larger or more central markets to buy these foods. These ASF were mostly used for special occasions (e.g., party or holidays) with relatively higher prices. “Chicken meat is usually sold with a whole or half carcass, thus not always affordable to buy, while beef, buffalo meat is more expensive compared to pork” (a 30 years old mother in Nghe An). Dog, cat, frog or rat meat were consumed occasionally in all study sites such as during festivity periods or eating out with friends (Table 2).

3.3. Pork purchasing, selection, and ranking of nutrition and taste

3.3.1. Pork purchasing

Most of the participants, all women, reported that they are usually in charge of purchasing, preparation of food and cooking meals for their family. Most bought pork products daily in the morning, e.g. from 6.30 a.m. to 8.00 a.m., and “it is convenient to go to the markets, because it is near”. If there was any urgent need, consumers would go to the markets in the afternoon. After purchasing, pork was quickly prepared and cooked meals on the same day. If there was any left-over fresh pork, it was kept in the fridge.

Types of pork usually bought were belly, ham, shoulder, loin, leg (18–22 times a month). Less common were pig heart, kidneys, liver, spleen, brain (1–2 times/month). Consumers believed that heart, brain, loin, hock, ham, and spare ribs were the most nutritious part of a pig. On the other hand, the most delicious were considered to be heart, stomach, loin, hock, ham, spare ribs, belly slice and spare rib roast. Other parts such as bones, nose, tail, intestines, liver were considered to be less nutritious and less delicious parts (Table 3).

3.3.2. Pork selection

This was mainly based on organoleptic characteristics: pork should be fresh, bright red, firm in appearance; when touching pork, it should be slightly sticky, elastic and soft; the meat should look clean, thick and not too wet. In the peri-urban and urban value chains, familiarity with the pork sellers and knowing the pig origin were also important criteria. But sometimes if pork did not look fresh and delicious, they did not buy.

Table 3
Pork and pork product types, purchasing frequencies, taste and nutrition ranked by participants.

Pork and pork product types	Purchasing frequency (times/month)	Price (thousand VND/kg) ^a	Nutrition ranking	Tasty ranking
Belly slices	18–22	75	Less nutritious	More delicious
Ham, shoulder	18–22	85	More nutritious	More delicious
Spare rib toast	18–22	75	More nutritious	More delicious
Loin	18–22	90	More nutritious	More delicious
Spare ribs	8–10	90	Less nutritious	More delicious
Hock (trotters)	8–10	60	More nutritious	More delicious
Intestines, spleen	1–2	40	Less nutritious	Less delicious
Stomach, tongue	1–2	60	Less nutritious	More delicious
Heart	1–2	120	More nutritious	More delicious
Liver	1	50	Less nutritious	Less delicious
Kidney	1–2	100	More nutritious	Less delicious
Brain	1–2	50	More nutritious	Less delicious
Bone	1–2	50	Less nutritious	Less delicious
Ear, nose, tail	1	60	Less nutritious	Less delicious

^a VND: Vietnamese Dong, exchange rate (20 September 2018) 1 USD = 23,307 VND.

Consumers did not select pork that had abnormal colour (too dark red or pale, yellowish fat, red spots on pig skin), looked wet or had a strange smell. “Pork meat of pigs raised from commercial farms has dark red, more lean portions, and look very nice, however, when cooking, pork release most of 50% water” (a 45 years old consumer in Hung Yen).

3.4. Pork preparation and consumption

Most respondents reported to prepare several types of dishes from pork often based on household members’ needs (e.g., young children, mother with young child, elder or adults). These include boiled, fried, steamed, stewed pork with caramel, fried with vegetables, or soup, etc. Prior to processing, raw pork was mostly washed with water, some dipped in boiled water and washed again before slicing for cooking. Some said to use separate boards and knives for raw and cooked pork; others used the same board, but before slicing cooked pork they washed the knife and cutting board with hot water. For some dishes (roasted, stew), pork was sliced and marinated with fish sauce, spices or mix with other ingredients. Depending on the member to be served (children, elder or sick person), dishes would be prepared accordingly, e.g., cooking porridge, stewing, roasting, or boil, make sausages, fried meat, spring rolls, soup, stew, boned bone. People in both provinces said that they rarely or never consumed raw pork. In terms of allocating food, the

priority for family members are, in descending order, children, the elderly, members working hard, adults and the housewife (Table 4).

3.4.1. Pork preservation

Pork was usually prepared right after purchasing, cooked and consumed the same day. When buying, some consumers asked the seller to cut the pork into small portions for them to store chilled in the fridge for daily use. Sometimes pork was washed in salted water then kept in the fridge for cooking at noon. Pork kept in the fridge was used within 1–3 days (in frozen compartment of the fridge), or within a day (in cool chamber). For households that did not have a fridge, pork was put in the bowl with an open lid, placed on the shelf, then cooked that day. Left-over food was wrapped in a plastic bag and stored in a refrigerator, however many households did not keep raw and cooked food separately in refrigerator. Some participants said that left-over food was refrigerated and reheated before eating in the next meal.

3.5. Food safety and nutrition concerns and perceptions

3.5.1. Pork safety

According to consumers’ perception, some processed pork products such as pate (*giò*), grilled chopped meat (*chả nướng*), pork ear (nem tai), roasted meat, and barbecue sold as cooked food are likely to be made

Table 4
Common pork dishes and cooking processes for dishes for children and mother of young children compared to other family members.

Family members	Dishes	Cooking process/method	Respondents’ explanation/believe
Children	Pork porridge	Chop/minced/blend pork meat and/or pork hearts, then (usually) stir-fried the meat before adding to the porridge Blend or chop leafy vegetable and root vegetable e.g. carrot, radish, potatoes; might add gac fruit oil before turning off the stove	Easy for them to swallow and to chew; Provide highly nutritious foods and vitamins for childrens’ development
	Stew pork femur/ribs bones	Clean the pork femur bones, stir it in the pot for 1 min then pour water in, add some salt, stew for another 45 min. The broth can be used for making soup or porridge Some people remove the bone marrow before using	Nutritious Nice tastenc (childrens’ favourite) Provide calcium
	Steamed pork	Pork loin can be cut into small pieces, then be marinated with some salt and fish source, and steamed in the steam cooker or in rice cooker	By steaming, all nutrients are trapped and remain inside the meat.
	Salted shredded meat (ruốc)	Pork loin were cut into cubes, boiled for 10 min, then chilled. After being chilled, shred the meat cube into pieces as thin as possible. Marinated with fish source and salt, then stir evenly, slowly until it is dry and fluffy.	Lasts very long Convenience Avoid wasting food Easy to eat (tasty)
Mother of young children (during breast feeding periods)	Soup or porridge with pork legs/dog legs stew	Stew pork/dog legs for 1–2 h Then use the broth to make porridge or soup Usually add chopped pork meat and green papaya or taro	Help produce more milk Provide more nutrients.
	Sticky rice with pork or eggs	Add sticky rice to the cooker with a certain level of water, then cook for 45 min	Help produce more milk Provide more nutrients.
Elder Adults	Most food should be chopped into small pieces and cooked for a longer time Caramelized pork stew; fried pork loin; stir-fried pork; spring rolls; chilled-stew pork pie (<i>thịt nấu đông</i>)		

Table 5
Total bacteria count (TBC) and coliforms count of pig carcass and cut pork samples.

Sample types	TBC (mean(min-max))		Coliforms (mean(min-max))	
	CFU/g, cm ²	N# sample/n (%) meet TCVN*	MPN/g, cm ²	N# sample/n (%) meet TCVN*
Pig carcass swab at SH (n = 30)	1.3 (0.03–8.5) × 10 ⁵	22/30 (73.3)	10.6 (0.05–27.5) × 10 ²	9/30 (30%)
Pork cut at market (n = 50)	10.5 (0.4–74.6) × 10 ⁵	5/50 (10.0)	128.5 (0.4–1100) × 10 ²	1/50 (2%)
Cut pork in Hung Yen (n = 30)	9.0 (0.4–32.8) × 10 ^{5 a}	4/30 (13.3)	54.1 (0.4–240) × 10 ^{2 a}	1/30 (3.3%)
Cut pork in Nghe An (n = 20)	12.7 (1.0–74.6) × 10 ^{5 a}	1/20 (5.0)	240 (1.5–1100) × 10 ^{2 a}	0/20 (0%)

CFU: colony forming unit, TCVN: Vietnamese standards, MPN: most probable number.

from unfresh or diseased pork. They heard rumors about the selling and slaughtering sick pigs at lower prices. Pork safety was also related to the type of feed, and they were concerned that the use of compound and commercial feed would lead to unsafe pork. “using complete feed and growth substance in raising pig is one of the main reasons making pork meat unsafe” (a 43 years old consumer in Nghe An). “To know the meat is not safe, or live pig was drug injected, there will be a bad smell when it was cooked” (a 39 years old consumer in Hung Yen). “Consumers, especially children, should not eat much internal organs, since they contained much cholesterol, leading to fat liver and other diseases” (a 35 years old consumer in Nghe An).

3.5.2. Cooking and nutrition

According to the mothers, stewing, or boiling pork is preferred as it preserves food nutrients. In contrast, roasting and grilling was said to reduce the nutritional quality of food. Shredding and salting was also perceived to reduce nutritional value. During cooking and processing of children's food, vegetables, potatoes are usually added to meat to provide and balance nutritional value for children's and mother's meals. Some mothers added ‘gác’ oil (a red fruit to supply more the vitamin A) when cooking rice soup for children. They mentioned that keeping in fridge and storing pork described using long time reduced taste and nutrition. Moreover, some households described using the same pots, baskets for pork and vegetables in pre-cooking preparation and processing resulting in a risk of cross-contamination.

3.5.3. Pork avoiders

This was mostly mentioned by the rural consumer group. Some thought fat, skin, pork liver, kidney and intestine should not be used to feed young children. They explained that fat was not good for the digestive system, and made children fat, or caused diarrhoea; there was concern that liver or bones marrow was toxic due to residues of chemicals. Some thought breast-feeding mothers or pregnant woman should not eat pig intestine, fat, kidney, tail, nose or ear, since it might affect the immune system, cause diarrhea and was not good for the baby's appearance.

3.5.4. Food safety governance

Consumers in Hung Yen where pig production was intensifying were

less confident in the animal quarantine service due to the low numbers of staff who were perceived as less trustful. When asking about the agencies in charge of quality testing of pork, consumers in Nghe An (where pig production was less intensifying) named commune veterinarians, local government authorities, and health agencies. However, consumers in Hung Yen did not know which agency was responsible for food safety. They selected pork meat based on their practical experiences such as colour, firmness, odour, viscosity and relationship to sellers.

3.5.5. Information source on food safety and nutrition

Participants from periurban areas said that they participated in food safety meetings, commune trainings on food selection, handling, and preparation, but consumers from urban areas did not attend food safety and nutrition courses. Most participants stated that when they heard pig disease outbreaks occurred or learned about commercial feed use, from neighbour or the media, they would try to reduce buying pork, and replace with fish or chicken.

3.6. Pork quality

The average TBC concentrations on pig carcass and pork samples were 1.3×10^5 CFU/cm² and 10.5×10^5 CFU/g, respectively. The average coliforms count on pig carcass and pork samples were 10.6×10^2 CFU/cm² and 128.5×10^2 CFU/g, respectively. While most slaughter house swabs met the Vietnamese standards for TBC, few retailer samples met standards. Most slaughterhouse swabs did not meet standards for coliform counts and while almost retailer pork was below the standards. There was no significant difference between intensifying Hung Yen and traditional Nghe An provinces for TBC ($p = 0.63$, Wilcoxon test) and coliforms ($p = 0.09$, Wilcoxon test) (Table 5).

Few samples (2/40) showed acceptable water holding capacity after 48 h of measurement. Fifty percent (50%) of samples had a range of pH from 5.5 to 6.2 after 4 h when pigs were being slaughtered. There was a significant difference of decreasing pH 4 and 7 h after slaughtering ($p < 0.01$, t -test). However, there was no significant difference in both water holding capacity ($p = 0.31$, t -test) and pH ($p = 0.62$, t -test) of pork samples between Hung Yen and Nghe An provinces (Table 6).

Table 6
Water holding capacity and pH measures of cut pork samples.

Physical measures (mean ± sd)	Overall (n = 40)	Hung Yen (n = 20)	Nghe An (n = 20)
Water holding capacity			
Weight of pork at 0 h (g)	30.5 ± 1.2	30.7 ± 1.3	30.4 ± 1.1
Weight of pork at 48 h (g)	29.3 ± 1.3	29.5 ± 1.4	29.0 ± 1.4
Loss of weight after 48 h (%)	4.10 ± 1.5	3.72 ± 1.0 ^a	4.39 ± 1.8 ^a
Sample had WHC ≤ 2.5% after 48 h ^[*]	2/40 (5%)	2/20 (10%)	0/20 (0%)
pH			
45 min	6.47 ± 0.32	6.5 ± 0.24 ^b	6.5 ± 0.33 ^b
4 h	5.99 ± 0.38	6.1 ± 0.34 ^c	5.9 ± 0.38 ^c
7 h	5.59 ± 0.29	5.6 ± 0.28 ^d	5.6 ± 0.31 ^d
pH ranges from 5.5 to 6.2 at 4 h ^[*]	20/40 (50%)	10/20 (50%)	10/20 (50%)

WHC: water holding capacity using drip loss method for 48 h storage, sd: standard deviation, [*] referred from Peter et al. (2007).

4. Discussion

4.1. Changing consumption trends

With modernisation and intensification pork consumption is becoming relatively less important and moreover more expensive foods such as beef are eaten more frequently. This pattern is consistent with the literature showing increased ASF consumption with wealth and development (Grace et al., 2018). Moreover, while the rural traditional chains show more seasonal consumption this shifts to year-round availability of urban value chains. The finding that most offal is considered “less delicious” may pre-figure the trend seen in high income countries where consumption of offal has dramatically decreased (Daniel et al., 2011). Similarly, the trend of eating risky foods such as *tiết canh* or uncooked pork has decreased significantly due to effective risk communication (Mai et al., 2008; Nghia et al., 2011; Ngo et al., 2011) and some outbreaks that caused deaths when eating *tiết canh* and uncooked pork in certain areas especially where the knowledge of zoonotic diseases is still low (Vietnamnews, 2018).

4.2. Most retailed pork is not safe

This is consistent with the literature from Vietnam which shows a high level of hazards in pork (Toan et al., 2013). There was a tendency for pork to be less safe in the more traditional chains which was contrary to our hypothesis that intensifying chains would have more contamination. However, in both systems the value chain was relatively similar in terms of production, slaughter and retail so differences may be less notable than when comparing, for example, backyard slaughter and high intensity slaughter.

4.3. Concern and competence in food safety

People were concerned over food safety and used multiple heuristics for assessing food safety and quality. However, the concerns were mainly about commercial feed, chemicals in meats, and diseased animals and not biological hazards which are likely responsible for more risk to human health (Grace, 2015; Havelaar et al., 2015; Nguyen-Viet et al., 2017). More traditional communities get more training and had more knowledge of public services, perhaps reflecting the greater role local government plays in these systems.

4.4. Risk mitigation and amplification

Food safety risk was reduced by: buying and consuming pork daily; avoiding pork considered unsafe; not eating raw pork; and storing left overs in the fridge. The main risk amplifying practices were: use of the same cutting boards for raw and cooked pork; not separating raw and cooked food; consumption of raw vegetables; and, possibly traditional preparation of pork which is kept for a long time. Washing pork is considered to be a risk mitigation measure but is not very effective (Dang-Xuan, 2018).

4.5. Nutrition is important

Consumers wish to provide nutritious meals and prioritise infants. Both modern beliefs (e.g. organ meat has high cholesterol) and traditional beliefs (eating some types of meat should be avoided by pregnant women) were seen. Pork was perceived as rich in nutrients and used to feed young children. Special care was given to pork preparation, such as cooking well or making into soup when feeding children.

An important part of this rapid integrated assessment was to identify opportunities for leveraging pork value chains for food safety and nutrition. Broadly, our study suggested that pork value chains had a high potential for improving nutrition given that pork was commonly consumed in both rural and urban settings, mainly bought from

markets, available all year round, considered nutritious and given to children. Mothers appeared to understand well the importance of pork (and other ASF) in providing nutrients for young children. There are some mis-perceptions around pork which lead to pork avoidance, which could be countered by better information.

On the other hand, the pork value chain seems to be associated with considerable health risks. The most concerning finding was the high level of bacterial contamination of pork. Unhygienic handling between slaughter house and retail drives general contamination but coliform counts are already high in the slaughterhouse and need to be controlled there. Given that consumers are both concerned about food safety yet often worried over the wrong things, improving information is an important way of driving up quality. In rural communes, it seems structures are in place to deliver this communication but to reach more modern and urban communities' innovative methods are needed perhaps involving social media. This could also address the risky practices that occur in the household.

Stress conditions during transport of pigs, lairage and at slaughter induce undesirable effects on the final quality of meat: these include meat which is pale, soft and watery (exudative) as well as meat that is dark red, firm and dry (Fischer, 2007; Stajković et al., 2017). Both of these are disliked by consumers. Improving conditions so that pigs are less stressed could then be a way of both meeting consumer demand and improving pig welfare.

Our study had some limitations. As this is a rapid assessment of food safety and nutrition, most of the information came from the FGD with selected participants who were regular consumers and young child mothers or pregnant women. It would be good to have a perspective from other stakeholders who took care of the nutrition and food safety of young children, for example from school canteens or hospital canteens. Although some attributes to safety and quality of pork were provided from sampling slaughterhouses and markets and analysis, it would be probably good to have food sampling from household to understand the safety and quality at consumption points.

5. Conclusion

Our study shows that pork is the most popular ASF in Vietnam, bought mainly from informal markets, quickly prepared and cooked. It reveals considerable interest and knowledge on pork nutrition and safety from regular consumers and mothers with young children. Pork is valued as a nutritious food and care is taken when preparing food for children. Most pork samples did not meet microbiological standards, but consumers' main concerns were related to chemical hazards and eating meat from sick pigs. This shows marketed pork is of low quality and safety and indicated lack of support of authorities to consumers in making good choices. This rapid integrated assessment of food safety and nutrition found the pork value chain in Vietnam is of high potential for improving nutrition and health and identified opportunities for influencing value chains in a more health and nutrition sensitive direction.

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Declarations of interest

None.

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