

Full Length Research Paper

# Preservation practices and quality perception of shrimps along the local merchandising chain in Benin

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Accepted 1 July, 2013

This study, performed through a survey, sought to investigate the quality attributes and the artisanal preservation and processing methods of fresh shrimps along the local merchandising chain in the Ouémé-Plateau and Mono Districts in the South of Benin. The survey was in the form of interviews administrated through a questionnaire and observations of shrimp's processors at work. The information gathered focused on the socio-cultural profile of actors, the types of raw materials used, the processing techniques, the quality attributes and the storage of fresh and processed shrimps as well. The data collected were analysed by means of descriptive statistics and correspondence analysis. Through the results it appeared that shrimps processing and commercialization are female activities of various socio-cultural groups including: Pédah (35%), Sahouè (9%), Xwla (20%), Aïzo (20%), Goun (16%) and Kotafon (1%). On the local markets, shrimps offer is constituted of smoked shrimps powder (40%), entire smoked shrimps (32.6%), fresh shrimps (26.6 %) and fried shrimps (0.7%). Fresh shrimp's quality is assessed through the colour, the odour and the size while the smoked ones are appreciated by the colour, the integrity, the firmness, the size and the taste.

**Key words:** Sea food, processing, smoking, frying, quality attributes, local market.

## INTRODUCTION

Fishery products are significant foodstuffs for millions people in Africa; it constitutes a major source of animal proteins, accessible to the households with low incomes, especially in the regions where the price of meat is out of the reach of an average consumer (FAO, 2004; Lem, 2005; Anonymous, 2005a). In Benin, shrimp fishing plays a significant socio-economical role, since fresh shrimps are one of the most important export products of the country (Horemans, 1998; Anonymous, 2005b). This activity occupies about 21 000 fishermen living in more than 200 villages in the south of the country, who catch wild shrimps in the brackish waters of Ahémé and

Nokoué lakes, and Lagoon of Porto-Novo (Gnimadi et al., 2006). The annual production of fresh shrimps in Benin, estimated to approximately 3000 tons, concerns mainly the Penaeidae of which *Penaeus notialis*, *Penaeus monodon*, *Penaeus duorarum* and *Penaeus kerathurus* constituted the major species (Raux, 2009). In Benin, the fishing of shrimps is a seasonal activity (from February to August). In addition, the shrimps are highly perishable food products, which can be degraded within 6 h at ambient temperature (Laghmari and El Marrakchi, 2005). Previous studies showed a fast increase in histamine content of shellfish from 36.6 to 2123.9 mg/kg after 24 h

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of storage at 25°C (Kim et al., 2009). Recent work carried out by Anacleto et al. (2011) showed that the shelf-life of halieutic processed products like crabs depends on the raw material quality. In this respect, shrimps preservation is undoubtedly a major problem with the need to constitute reserves for off seasons of fishing and to absorb fresh shrimp unsold in plenty period.

In general, the artisanal processing conditions and distribution of halieutic products in Western Africa countries are proved unsatisfactory (Essuman, 1992). It is well known that chemical compounds generated by wood combustion during smoking are transferred to the smoked products (Duedahl-Olesen et al., 2010). Moreover pathogenic microorganisms and mycotoxins which development is associated with preservation conditions were isolated from halieutic products processed in artisanal conditions and collected from markets in Nigeria (Essien et al., 2005). With the challenge of development, the developing countries must guarantee food security, by which any inhabitant can have a sufficient, healthy, balanced and acceptable food. In this respect, there is a need in Benin to improve the country practices of processing and preservation of foodstuffs in general and the products of animal origin such as shrimps in particular. The present field investigation focused on the characterization of the technical system of shrimps processing and preservation methods used along the local chain of commercialization, with the objective to gather information which allow to improve those practices in order to improve the safety of fresh and processed shrimps commercialized along the local merchandising chain, in consideration of the way these products are currently handled or treated.

Indeed, the environment in which the fresh shrimps are processed is generally unhygienic, paving the way for possible microbial contamination and production of food toxicants such as histamine. The consequence of this is quality defects, with occasional public health hazards. So, despite a lack of information on food poisoning caused by shrimps in Benin, there is a potential for sporadic amine poisoning. Thus, this study aimed to give a better understanding on the preservation and processing methods of fresh shrimps, the types of raw materials and other ingredients associated with shrimp treatment and the definition of the most important quality attributes of fresh and processed shrimps according to the actors. The current survey also investigated the specific problems related to the processing, the preservation and the storage of this product, for a further upgrading of the technologies.

## MATERIALS AND METHODS

### Choice of survey zones

A survey was carried out in the Atlantic, Mono and Ouémé Districts in the south of Benin (Figure 1). The choice of these areas is justified by the fact that shrimps fishing and processing are specific

activities of populations living along the lakes and lagoon (Nokoué and Ahémé Lakes, and Lagoon of Porto-novo) located in that places where fresh shrimps are caught. In the selected areas the field investigations were conducted at market level and in the restaurants and hotels (Table 1).

### Sampling of actors

The number of actors surveyed per locality and categories of actors in the survey zones is summarized in Table 1. Shrimps processors were randomly selected according to Dagnelie (1998) on the basis of data obtained from a preliminary census of actors of shrimps industry in Benin (Gnimadi et al., 2006). Shrimps sellers were investigated in the markets. In Cotonou municipality (Atlantic District), the markets were chosen at random whereas in Comè (Mono District) and Porto-Novo municipality (Ouémé District), all the markets were taken into account because of their limited number. In these markets, all the shrimps and by-products sellers listed were surveyed by spot. Restaurants and hotels were selected on the basis of the national directory on hotels and restaurants according to the criterion of 50 places at least. Eligible actors were selected by raking of shrimp processors, sellers and users. A total of 167 processors, 139 traders and 17 restaurants and hotels were interviewed (Table 1).

### Collection of data

A validated questionnaire was designed to collect data on shrimps processing and the preservation techniques. The survey was in the form of individual interviews or focus group discussions, and observations of processors at work. Demographic data related to gender, age, religion, marital status and academic qualification were collected. Other information collected included the quality attributes of raw and processed shrimp, the processing and preservation methods, the storage duration and the specific problems related to the methods used, the fresh shrimps and by-products.

### Data analysis

Descriptive statistics were calculated from the collected data using SAS software (version 9. 2 2003, Cary, NC: SAS Institute Inc.). Multivariate analyses were also performed on the types of shrimp and quality attributes as perceived by actors, using Statistica 7 (StatSoft, Tulsa, USA).

## RESULTS AND DISCUSSION

### Socio-cultural status of actors of the local merchandising chain of shrimp

The survey showed that the post-capture circuit of shrimps before reaching the local consumer is constituted of fresh shrimp's sellers, shrimps processors/sellers, retailers, and hotels and restaurants (Tables 2 and 3). The survey also revealed that women are the main actors in the artisanal processing and distribution of shrimps, and these activities constituted for most of them the main source of income. The majority (95%) of these women are married and 85.3% of them are married to fishermen or had a family relationship with them. The processors

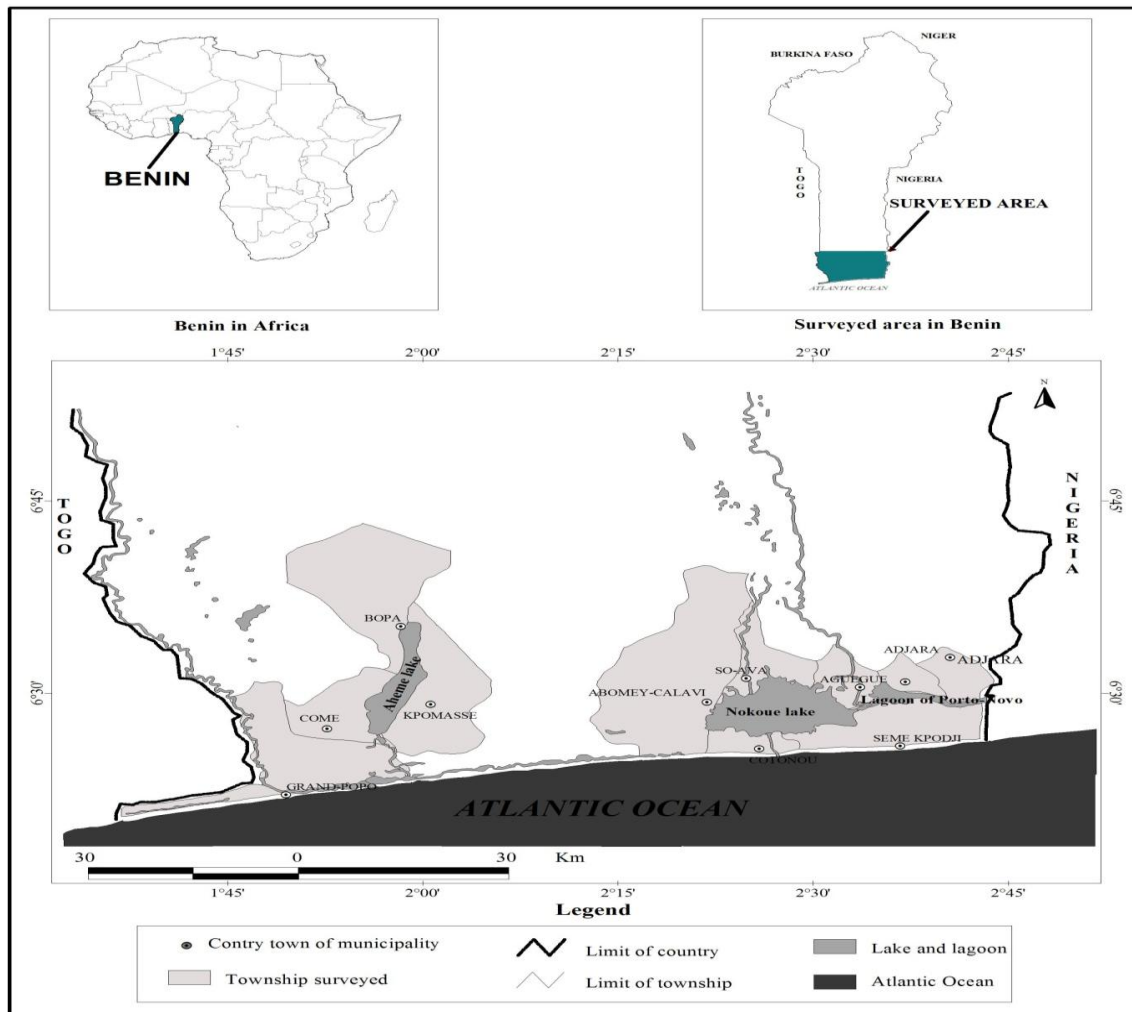


Figure 1. Surveyed zones including fishing and selling areas of shrimps.

Table 1. Number and categories of shrimps sector actors surveyed per locality in the survey zones.

Area surveyed		Number of actors surveyed			Total number of actors surveyed
Department	Township	Number of processors	Number of traders	Number of hotels and restaurants	
Atlantic-District	Abomey-Calavi	5	-	-	5
	Sô-Ava	17	-	-	17
	Cotonou	32	62	6	100
	Sèmè-kpodji	12	-	1	13
	Kpomassè	20	-	-	20
Mono-Couffo District	Bopa	14	-	2	16
	Comè	32	20	-	52
	Grand-Popo	19	-	5	24
Ouémé District	Adjarra	2	-	-	2
	Aguégué	12	-	-	12
	Porto-Novo	2	57	3	62
Total		167	139	17	323

**Table 2.** Socio-cultural characteristics of shrimps processors and sellers.

<b>Characteristics</b>	<b>Processors (%)</b>	<b>Sellers (%)</b>
<b>Age (years)</b>		
10-20	0	5
21-30	8	24
31-40	25	30
41-50	22	24
>50	45	17
<b>Gender</b>		
Female	100	100
<b>Ethnic groups</b>		
Aïzo	20	5
Goun	16	41
Xwla	20	20
Pedah	35	11
Sahouè	8	0
Kotafon	1	0
Fon	0	18
Nago	0	2
Yorouba	0	3
<b>Academic qualification</b>		
Illiterate (no school)	92	56
Primary school	7	28
Secondary school	1	16
University	0	0
<b>Marital status</b>		
Unmarried	0	5
Married	95	95
Divorcee/widow	5	0
<b>Religion</b>		
Animism	49	5
Christianism	44	87
Islam	3	4
Atheism	4	3

surveyed belonged to the socio-cultural groups of Pédah (35% of them), Sahouè (8%) and Kotafon (1%) living around the Ahémé lake, and Xwla (20%), Aïzo (20%) and Goun (16%) installed along the Nokoué lake and the lagoon of Porto-Novo (Table 2). The majority (92%) of the interviewed processors are aged from 31 to more than 50 years; among them, 44 and 49% are Christians and animists respectively. The majority of processors (92%) had no formal education; a very small number (7%) had secondary education and the remaining (1%) had only primary education (Table 2). All of them have acquired the knowledge in shrimp processing while helping a parent or a member of their husband family. Regarding

the sellers surveyed, all of them are female aged between 21 and 50 years (78%). Most of them (56 %) had no formal education, while 28 and 16% had primary education and secondary education respectively. They belonged to various socio-cultural groups including: Goun (41%), Xwla (20%), Fon (18%), Pédah (11%), Aïzo (5%), Yorouba (3%), and Nagot (2%). In contrary to processors, the majority of them (87%) are Christians. The commercial establishments users of shrimps surveyed are hotels (94%) and restaurants (6%). These establishments are mainly located in the towns: Cotonou (41%), Grand-Popo (29%), Porto-Novo (18%) and Bopa (12%) (Table 3). The employees surveyed in these

**Table 3.** Characteristics of hotels and restaurants surveyed in shrimps sector.

Characteristics	Percentage
<b>Nature</b>	
Hotels	94
Restaurant	6
<b>Localization (town)</b>	
Cotonou	41
Bopa	12
Grand-Popo	29
Porto-Novo	18
<b>Responsibility surveyed</b>	
Cook	88
Manager	12
<b>Age (years)</b>	
21-30	18
31-40	35
41-50	35
>50	12
<b>Gender</b>	
Male	82
Female	18
<b>Academic qualification</b>	
Primary school	6
Secondary school	88
University	6

establishments are cooks (88%) and managers (12%). These workers are men (82%) and women (18%) having primary education (6%), secondary education (88%) and university education (6%).

### Description of the technical system of fresh shrimp preservation

Shrimps' offer in local markets is constituted of smoked shrimps powder (40%), entire smoked shrimps (32.6%), fresh shrimps (26.6%) and fried shrimps (0.7%). Two families of shrimps are commercialized in Bénin: the *Penaeidae* fished in Nokoué and Ahémé lakes, and the lagoon of Porto-Novo, and the *Mysidaceae* caught in the sea; however, the main species of shrimps used in Benin belonged to *Penaeidae*. The reason of such situation is that the fishing of *Mysidaceae* is forbidden by the Benin ministerial order n° 518/MAEP/D-CAB/SGM/DRH/DP/SA, December 2008, related to shrimps fishing. The hotels, restaurants and households bought fresh shrimps from

sellers in the market whereas the processors and sellers purchased or received fresh shrimps from the fishermen and the wholesalers of fresh shrimp. For fresh shrimps preservation, all the restaurants and hotels surveyed usually kept fresh shrimps in a freezer while at the market level, some of the vendors (10% of vendors interviewed) preserve it in a chest filled with ice and the other (7% of respondents) maintain the fresh shrimp at ambient temperature during selling. In addition, the smoking (claimed by 72% of surveyed actors) and the frying (claimed by 4% of surveyed actors) have been identified as shrimp's preservation methods (Figure 2). Fresh shrimps kept at ambient temperature around 30°C during selling may be unsafe for consumers since fresh shrimps are very perishable raw materials.

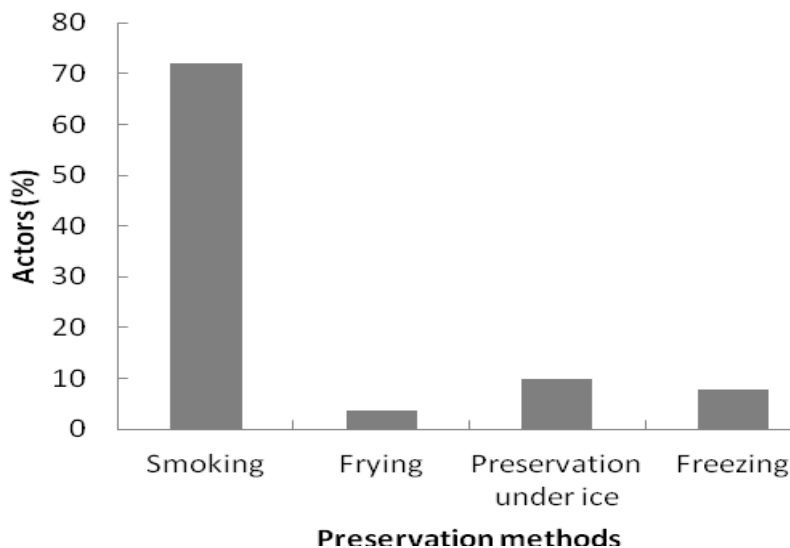
According to Adams et al. (1987), aquatic food products kept in such conditions may spoil within 12 h. The survey revealed that fresh shrimps are preserved under ice for sale during 3 to 14 days. Works by Laghmari and El Marrakchis (2005) showed that the fresh shrimps exceed quality standard beyond 72 h of preservation under ice. In addition, Anacleto et al. (2011) showed that the merchant quality and the shelf life of the halieutic processed products like crabs depend on the raw materials quality. In this respect, the sanitary quality of fresh shrimps and its by products in the local merchandising chain remains uncertain and consequently needs to be investigated. The survey also showed that the processing of shrimps in the local merchandising chain is essentially an artisanal activity. The processing sites are huts mostly located beside processor residence along the lakes and lagoon, near the fishermen landing areas. One processor transforms a rough average of 26 kg of shrimps per day during the plenty period (from March to August). The processing techniques are simple and rudimentary, equipments such as basins, baskets, metallic grid and artisanal cooker are used. The flow diagram of processing techniques used by the processors is represented in Figure 3.

### Smoking method of fresh shrimps

The processing of fresh shrimps into smoked shrimps is the result of a number of steps of unit operations after the purchase of fresh shrimps. The main steps are the sorting, the washing and the draining, the smoking, the cooling and the grinding in the case of smoked shrimps powder.

### Fresh shrimps receipt

The fresh shrimps used for processing are essentially (claimed by 76% of processors) received from fishermen. The processors do not impose any criteria during the receiving of shrimps, because of the keen competition with the wholesale fish merchants and the export



**Figure 2.** Fresh shrimps preservation methods in the local merchandise chain and categories of actors involved.

factories. For fear of being deprived of next captures, the processors are constrained to receive the entire offer from her fishing partner, whatever the shrimps are in spoilage state.

### **Sorting, washing and draining of fresh shrimps**

The fresh shrimps are then rid of undesirable objects and washed three times with well water or tap water. In order to maximize their profit, the shrimps are sorted, and the big and very fresh ones are resold to the collectors of export factories. The remaining is put in a basket for draining during 10 to 15 min.

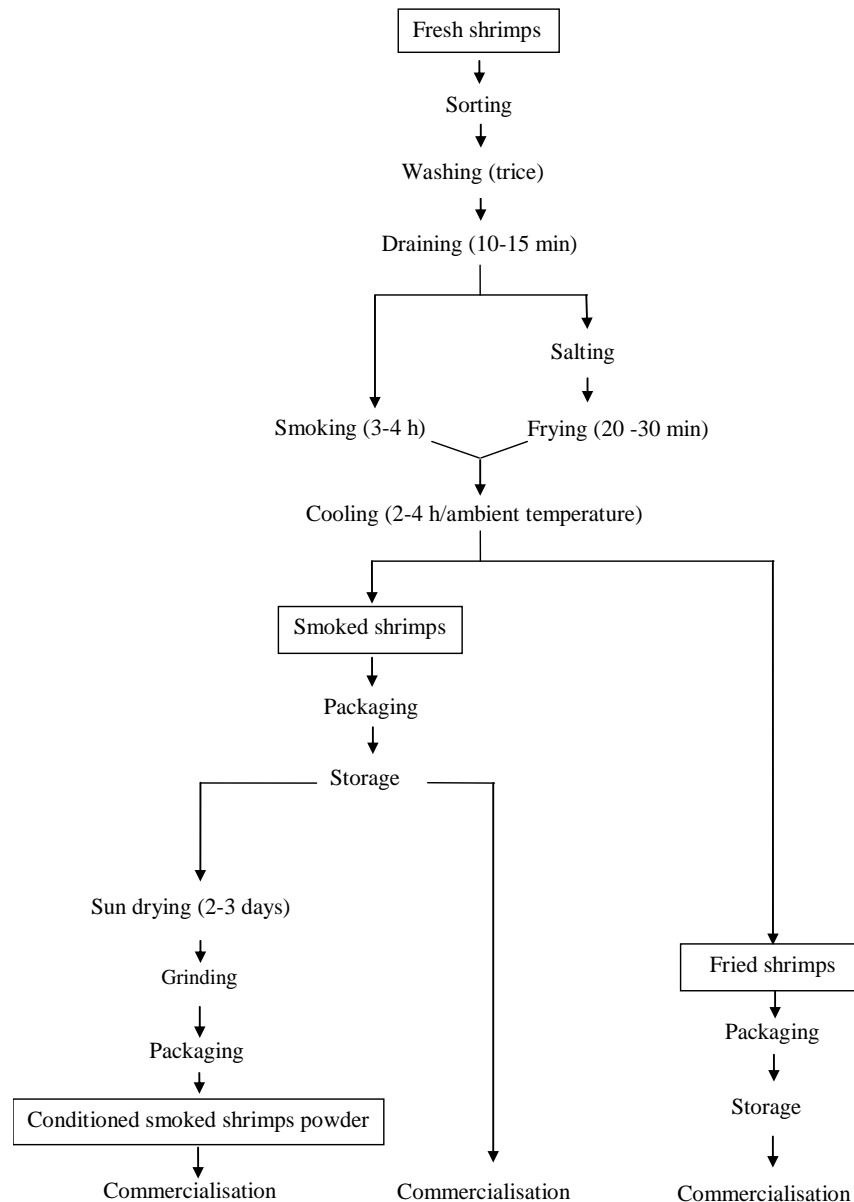
### **Smoking**

The smoking is carried out in two successive phases: The cooking phase with intense fire which confers firmness to shrimps and the drying phase with mild fire which assures dehydration of the product. During the two phases, the processors pay attention to the intensity of fire in order to avoid the burnt aspect and get the redcolor of smoked shrimps that some of them (4.40% of processors) seek to improve by using annatto tree (*Bixa orellana*) seeds powder which confers to shrimps more pronounced red color. This powder is only used in the case of smoking. The powder is generally put in water and the shrimps are immersed for about 5 min before to be smoked. The merchant quality of smoked shrimps depends on the conduct of the smoking process. In this respect, a particular attention is granted to the disposal of fresh shrimps on the smoking grid, the wood nature and

the adjustment of smoking fire level. At the beginning of smoking, fresh shrimps are thoroughly spread out over the grid of smoking. Hard woods less smoking and whose embers hold for long time are mostly used. The woods species mostly used include: Pencil tree (*Acacia auriculiformis*, used by 45% of processors surveyed), teak tree (*Tectona grown*, 11%), velvet tamarind tree (*Dialium guineense*, 10%), Australian Pine tree (*Casuarina equisetifolia*, 7%), neem tree (*Azadirachta indica*, 5%), mango tree (*Mangnifera indica*, 5%), red mangrove tree (*Rhizophora racemosa*, 5%), river redgum tree (*Eucalyptus camadulensis*, 2%), ironwood (*Prosopis africana*, 2%) and cashew tree (*Anarcadium occidentale*, 1%). In addition to these fuels, peels of cassava (*Manihot esculenta*, observed with 7% of processors surveyed) and of the coconut raid (*Coconuts nucifera*, observed with 33% of processors) are used to control the fire during the smoking. For the smoking of *mysidaceae* in particular, all the processors interviewed use wood coal to avoid the burn of shrimps because of their small size. The smoking duration is generally ranged between 3 and 4 h, after which the smoked shrimps are cooled at ambient temperature.

### **Cooling**

For cooling, the smoked shrimps are kept on the smoking grid to ambient temperature until total cooling. According to processors, the cooling stage prevents the condensation of water steam during packaging and the loss of the integrity of wetted shrimps during post smoking handling. However, during the cooling period the smoked shrimps are exposed to flies and other types of



**Figure 3.** Flow diagram of fresh shrimps processing.

insects. Such practices may lead to post processing contaminations of the end-product. After the cooling stage, the end-product may be sold as entire smoked shrimps or as powder of smoked shrimps. When the end-product is sold as whole smoked shrimps, after cooling, the shrimps are packaged in baskets and covered with cloths for storage. In the case of smoked shrimp powder, the smoked shrimps are ground after the cooling.

### **Grinding of smoked shrimps**

For grinding, the eyes of smoked shrimps are removed and the grinding is done using a mill generally available

in the markets. According to the processors, the grinding contributes to dissimulate the quality defects (colour, broken shrimps) of smoked shrimps (claimed by 8.82% of processors); thus, altered smoked shrimps are valorized through this practice. In addition, in order to increase their profit, some of processors (claimed by 12.7% of surveyed) mix fraudulently the smoked shrimps with crayfish (*Astacus*) or sardine (*Sardinella*) before the grinding. These practices put in doubt the sanitary quality of smoked shrimp's powders. For grinding, the same mill is generally used to mill different types of raw materials so there is a potential cross contamination of the shrimps powder.

Other marginal preservation techniques used by the

processors are the frying of fresh shrimps and the solar drying of smoked shrimps during storage period. For frying, the fresh shrimps are washed using well water or tap water and salted using solar salt. The salted shrimps are then fried under intense fire for about 20 to 30 min using vegetal oils. The end of frying corresponds to pink colour and firm shrimps recognized by the experience of the processors. Regarding the solar drying method, the smoked shrimps are spread over a tray at ambient temperature during 2 to 3 days before being ground. During the drying, the shrimps are exposed to the environmental conditions with risk of contamination.

### **Packaging and storage shrimps by products**

The smoked shrimps are generally packaged in baskets previously lined with cotton clothes by alternating shrimps layers with some peppers (*Capsicum annum*) (practiced by 9% of processors interviewed) and camphor (claimed by 2% of processors). Washed without particular heat treatment these wraps could bring a share of contamination to the product. According to the majority (93%) of processor, the smoked shrimps can be stored for 2.5 to 6 months. However, when the storage duration is more than 2.5 months, the smoked shrimps are briefly smoked again once a month. The fried shrimps are also stored in basket covered with paper but without any particular precaution because they are delivered within 24 h after processing. Shrimps powder is generally conditioned in recycled bottles previously cleaned and dried (claimed by 53.9% of vendors) or in plastic bags (claimed by 27.45% of vendors). The smoked shrimps powder can be stored for 4 months (claimed by 50.9% of vendors). The main spoilage problems associated with smoked shrimps and evoked by the actors are the destruction of stocks by devastating insects of the forficula and pheidole kinds (claimed by 78% processors and wholesalers interviewed), invasion by the moulds (claimed by 30.53% processors and wholesalers interviewed), rehumidification of the products (claimed by 15%), change in colour (evoked by 11.37%) and change in smell (6.58%).

### **Shrimp quality assessment of fresh shrimps and by products**

Regarding the quality assessment of fresh and processed shrimps a factorial correspondence analysis (FCA) was performed to reveal links between quality attributes of shrimps and categories of actors (fresh shrimp sellers, processors, hotels and restaurants) (Figure 4). The two axes obtained accounting for 98.26% of the total variation of which 92.53% was explained by the first axis (Axis 1) and 5.73% by the second (Axis 2) (Figure 4). Determinative criteria used to appreciate fresh shrimps

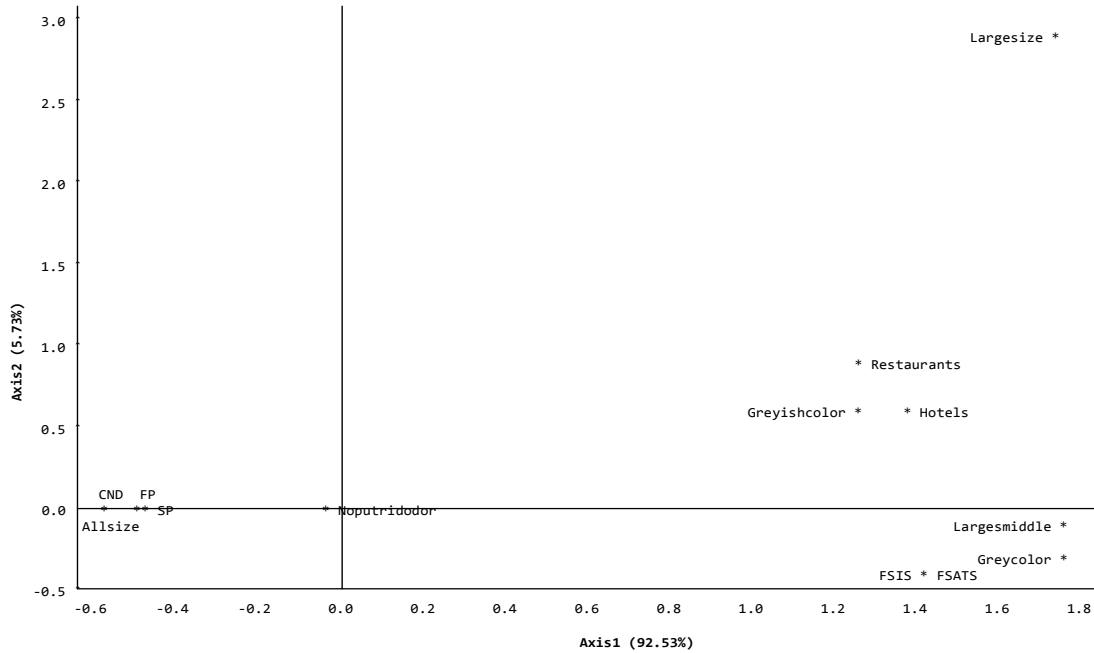
are grouped together with a type of actor. Thus, fresh shrimp's sellers, and restaurants and hotels prefer shrimps of grey colour and of middle or large size, while for the processors the colour and the size are not determinative criteria (Axis 1). Regarding axis 2, all the actors prefer shrimps of no putrid odour. Some previous studies showed that colour of shrimp's head and shrimps odour are used as sensory characteristics of spoilage fresh shrimps (Laghmari and El Marrakchi, 2005; Jaffrès et al., 2011).

For processed shrimps (fried and smoked), the FCA performed on quality criteria and actors resulted in two axes accounting for 100% of the total variation, of which 89.07% was explained by the first axis (Axis 1) and 10.93% by the second (Axis 2) (Figure 5). Regarding axis 1, smoked shrimps of dark-red colour, which are not beheaded and have not burnt aspect, are preferred. The best smoked shrimp's powder has reddish colour, with a special smoked shrimp's taste, and do not content foreign matters (Axis 1). This survey revealed that the quality of processed shrimps does not constitute in any way a problem of access to the local market. Each actor manages as he can so that his products interest the customers. However, in consideration of lack of hygiene (hygiene of raw material, hygiene of materials used for processing, hygiene of processing sites) and some bad processing practices observed along the local merchandising chain, fresh shrimps and its by products could be potential sources of microbial or other types of contamination. Consequently, in the artisanal shrimps sector where technology and standard are very low, fresh shrimps and its by products could be considered as potential vehicles for transmission of food borne diseases. In this respect, pathogenic microorganisms and thermostable toxins have been identified in smoked fish collected in the same conditions of distribution (Essien et al., 2005; Adu-gyamfi, 2006).

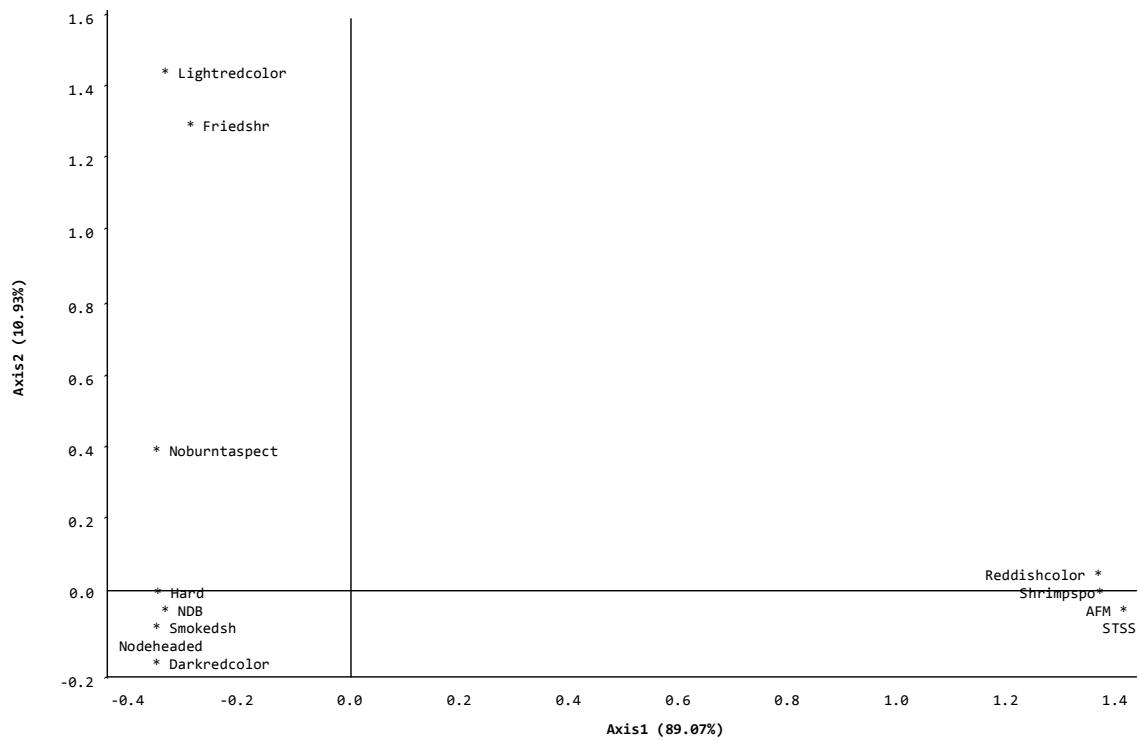
### **Conclusion**

The current study revealed that the main preservation methods of fresh shrimps in use in the survey zones are the smoking and the cooling. Consequently, shrimps offer is mainly constituted of fresh shrimps and smoked shrimps. Quality attributes of these products are based on the colour, the odour and the size, and the importance of each of them changes according to actors of the local merchandising chain. In this sector where there is no control or regulation, every actor manages as he can, so that his products interest the customers. The survey also provides comprehensive knowledge which will facilitate the improvement of artisanal handling and processing techniques of fresh shrimps in Benin. The major problems identified during the survey included the lack of hygiene and standardization of the processing techniques, the use of inadequate packaging materials





**Figure 4.** Factorial correspondence Analysis to reveal links between quality attributes of fresh shrimps and categories of actors. CND = Color is not determinative; Noputridodor = no putrid odor; Largesize = large size; Largesmiddle = Large size and middle size; Allsize = All size; FSATS = Fresh shrimps at ambient temperature sellers; FSIS = Fresh shrimps preserved under ice sellers; FP = Frying processors; S P = Smoking processors.



**Figure 5.** Factorial correspondence analysis to reveal links between determinative quality attributes and types of processed shrimps. Lightredcolor = Light red color; Darkredcolor = Dark-red color; Reddishcolor = Reddish color; Friedshr = Fried shrimps; Smokedsh = Smoked shrimps; Shrimpspo = Shrimps powder; Noburntaspect = No burt aspect; NDB = No deheaded and no burnt aspect; Nodeheaded = No deheaded; AFM = Absence of foreign matters; STSS = Spécial taste of smoked shrimps.

and the unstable nature of smoked shrimps during the storage. Future investigations need to be undertaken to characterize the fresh shrimps and its by-products commercialized in the local merchandising chain on both microbiological and physico-chemical aspects.

## ACKNOWLEDGEMENTS

Financial support for this work was received from Belgium Government through UAC 01 Project. The authors are very grateful for this support. This paper is part of the PhD work for the first author.

## REFERENCES

- Adams MR, Cooke RD, Twiddy DR (1987). Fermentation parameters involved in the production of lactic acid preserved fish-glucose substrates. *Int. J. Food Sci. Technol.* 22:105-114.
- Adu-gyamfi A (2006). Studies on microbiological quality of smoked fish in some markets in Accra, Ghana. *Ghana J. Sci.* 46:67-75.
- Anacleto P, Bárbara T, Pedro M, Pedro S, Leonor Nunes M, Marques A (2011). Shelf-life of cooked edible crab (*Cancer paragurus*) stored under refrigerated condition. *Food. Sci. Technol.* 44:1376-1382.
- Anonymous (2005a). La pêche au Bénin : atouts, contraintes et perspectives. Ministère de l'Agriculture de l'Élevage et de la Pêche, Direction des Pêches, Cotonou, Bénin, juillet 2005, P. 6.
- Anonymous (2005b). Produit intérieur brut du Bénin: composantes et emplois. Rapport annuel INSAE/DSEE/SCN, P. 40.
- Dagnelie P (1998). *Statistiques théoriques et appliquées*, Tome. 2:559.
- Duedahl-Olesen LJH, Christensen JH, Højgard A, Granby K, Timm-Heinrich M (2010). Influence of smoking parameters on the concentration of polycyclic aromatic hydrocarbons (PAHs) in Danish smoked fish. *Food Addit. Contam.* 9:1294-1305.
- Jaffrès E, Lalanne V, Macé S, Cornet J, Cardinal M, Sérot T, Dousset X, Joffraud JJ (2011). Sensory characteristics of spoilage and volatile compounds associated with bacteria isolated from cooked and peeled tropical shrimps using SPME-GC-MS analysis. *Int. J. Food Microbiol.* 147:195-202.
- Essien JP, Ekpo MA, Brooks AA (2005). Mycotoxigenic and proteolytic potential of moulds associated with smoked shark fish (*Chlamydoselachus anguincus*). *J. Appl. Sci. Environ.* 3:53-57.
- Essuman KM (1992). Fermented fish in Africa: a study on processing, marketing and consumption. FAO Fisheries Technical Rome. 329:80.
- FAO (2004). Mainstreaming fisheries into national development and poverty reduction strategies: current situation and opportunities, by A. Thorpe. FAO Fisheries Circular Rome. P. 997.
- Gnimadi A, Gbaguidi A, Kakpo GL, Gnimadi CC, Latifou L, Salifou LL, Sohoul ZL, Tossou CE (2006). Base de données sur les activités de pêche dans les lagunes du Bénin (lac Ahémé, lac Nokoué et lagune de Porto-Novo). Résultats du recensement. Programme pour des Moyens d'Existence Durable dans la Pêche (PMEDP), rapport de mission, 2:397.
- Horemans B (1998). The state of artisanal fisheries in West Africa in 1997. Program for the integrated development of artisanal fisheries in West Africa, Cotonou- Benin, IDAF / WP/122:44.
- Kim M, Mah J, Hwang H (2009). Biogenic amine formation and bacterial contribution in fish, squid and shellfish. *Food Chem.* 116:87-95.
- Laghmari H, El Marrakchi A (2005). Appréciation organoleptique et physico-chimique de la crevette rose *Parapenaeus longirostris* (Lucas, 1846) conservée sous glace et à température ambiante. *Revue Méd. Vét.* 4: 221-226.
- Lem A (2005). Aquaculture-world trends, opportunities for developing countries, technical and financial constraints. UNCTAD/FAO, Geneva. P. 48.
- Raux J (2009). Diagnostic de la filière crevette au Bénin. Développement du secteur privé au Bénin et l'identification d'un projet de compétitivité et de croissance sous le 10ème FED, rapport de consultation, CE/FINEUROPE, P. 50.