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Diversity of processes for transformation of fresh fish in Northern Cameroon

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Fish as a foodstuff of high nutritional value is considerably perishable. It must be transformed in order to improve the duration of its conservation. Drying and smoking are the most popular processes to transform fish in northern Cameroon. These steps usually affect the quality of the finished products. In order to improve the quality of locally transformed fish in a handmade manner and to typify such activity, an survey was conducted in three fishing ponds in the Northern part of Cameroon with 160 fishermen and fish transformers. It appears that the technique of transforming fish in those main fishing ponds in Northern Cameroon vary at the level of preprocessing and dehydration phases of fresh fish. Smoking is done in a traditional oven followed by cleaning (4.1% in the Adamawa Region and 33.0% in the North and Far North Region) or flaking of the fish (95.9% in Adamawa and 61.1% in the North and the Far North Region). Then, come emptying (95.9% in Adamawa and 61.1% in the North and Far North), cutting into small pieces (11.1% in the Far North) or cracking (82.6% in the Adamawa Region). At the end, washing (95.9% in the Adamawa and 72.2% in the North and Far North), spinning (100%), smoking (100%) and then packaging of the fish (100%) complete the process. All these operations are conducted without equipment for protection, on uncleaned surfaces and with irregularly washed materials with clean water. The drying process is done on bare ground on top of a drying stall is a constant step in the Far North (54.9%) and North (28.6%) regions and scarce in the Adamawa region (9.3%). A particular emphasis should be laid on hygienic measures to ensure a sanitary quality of dry fish at the end of both smoking and drying processes.

Keywords: Processing, smoking, drying, Northern Cameroon, Transformation

INTRODUCTION

Fish is a popular foodstuff consumed by nearly 2/3 of the world’s population (FAO, 2012), providing a wide range of essential micronutrients including several vitamins (A, B and D), minerals (calcium, iodine, zinc, iron and selenium), proteins of high nutritional value and polyunsaturated fatty acids (omega-3) (Olapido and Bankole, 2013; Béné et al., 2016; FAO, 2017). However, due to the lack of fresh means of preservation, this highly perishable foodstuff is traditionally processed by several other technical procedures for long-term preservation (Anihouvi et al., 2005). Smoking and drying are the main processing for the population with the view of a continuous supply of fish. These two processes produce dry fish available for longer, which is transported over long distances, could be stored for months and offers a large and extensive availability. These transformations thus

contribute not only to reduce post-capture losses but also to provide food in quantity to many populations over a longer period of time (Degnon et al., 2013; Ndiaye et al., 2014).

One of the biggest weaknesses of these two fresh fish processes is the poor quality of the finished product, which remains difficult to preserve. In rural areas, traditional drying and smoking techniques do not comply with good hygienic practices, which consequently affects the sanitary quality as well as the textural and sensorial characteristics of the finished product (Hissein et al., 2018). These contaminations, which are generally carried out during processing, lead to both qualitative and quantitative depreciations following the proliferation of destructive insects or microbial agents (Ndrianaivo et al., 2016; Sameza et al., 2016; Tekou Ngunte, 2018). These impairments can lead to the total loss of product (Tamgno et al., 2020).

To preserve the microbiological and nutritional qualities of fish during processing and storage, the need to master the processing methods currently used therefore becomes an emergency. The objective of this research was to characterize fish processing in northern Cameroon in order to improve them.

MATERIALS AND METHODS

Presentation of the area of study

A research was carried out in the main fishing basins of northern Cameroon divided into three administrative regions: Adamaoua (Ngaoundere), North (Garoua), and Far North (Maroua) (Figure 1). This confined space extends between 6° and 13° North latitude and 11° and 15° East longitude (Djoufack et al., 2012). It is the confluence of several ethnolinguistic groups that include two large agro-ecological groups.

The Sudano-Sahelian zone or zone I, is between 8°36’ to 12°54’ North latitude, and 12°30’ to 15°42’ East longitude. It covers approximately the regions of the North (68090 km2) and the Far North (34263 km2), an area of 10.2 million hectares of which 0.56 million are cultivated. The climate is characterized by a monomodal rainy season of varying duration and intensity with altitude and latitude. Temperatures vary according to altitude and latitude with averages of up to 28°C in Garoua, while maximums are of the order of 40 to 45°C in April (Olivry, 1986). The area is mainly watered by Logone, Chari and Benue rivers. With the exception of Logone and Chari, which originate in more watered regions and flow to the Lake Chad basin, all the rivers in the region are characterized by non-permanent flows, hence their name mayo (Olivry, 1986). In the northern region, the Departments of Benue (Garoua and Lagdo sites) and Mayo-Rey (Tcholiré and Rey-Bouba sites) are the ones included in this research. These Divisions are mainly watered by the Bénué. In the Far North region, however, the divisions chosen are Mayo-Danay (sites of Yagoua and Tékélé) and Logone and Chari (sites of Goromo and Zina) watered mainly by the Logone (Figure 1).

The zone of the high Guinean Savannah zone or zone II is between 5°42’ to 8°36’ North latitude, and 11°24’ to 14°36’ East longitude. It essentially covers the Adamawa region which is an administrative unit of the Republic of Cameroon located between the 6th and 8th degree of north latitude and between the 11th and 15th degrees of east longitude. It has an area of 63,701 km2, with about 1,200,000 inhabitants and a density of 17 inhabitants/km². Its Sudano-Guinean climate is generally very rainy with temperatures around 20°C and rainfall exceeding 1500 mm over 7 months. The rivers of the region flow into three different basins: the Niger River Basin, the Lake Chad Basin, and the Sanaga Basin.

The Djerem, where the fishing sites of Mbakaou and Saxon have been prospected, in the district of Tibati the body of water of the Mbakaou reservoir occupies a good part of the Commune. The main rivers are the Djerem and Meng rivers with their tributaries. To these, we can add the 210 crater lakes, the most important of which are Lake Mbella Assom, Lake Maissaba, Lake Pangnéré and

Lake Pang Antenna.

The Division of Mayo-Banyo has the fishing sites of Ali-Mali and Ndoumdjandi in the district of Bankim. Its hydrographic network consists mainly of two rivers. The Mbam which runs along the entire eastern limit of the Commune and serves as a boundary with the Ngambe Tikar area, and the Mape which acts as a boundary with the Magba area.

Methodology

On the basis of a previously prepared survey sheet, an investigation was carried out from October 2019 to March 2020 among fishermen and fish processors in the chosen sites. In each of these sites, 10 fishermen and 10 processors, having at least than five years of experience, were interviewed. A total of 240 actors was investigated.

During these investigations, several questions were given to the actors. The first of these focused on the socio-professional characteristics of the actors surveyed: names, age, ethnicity, seniority in the profession, nationality of the actors,... Other questions related to treatment processes (the type of fish processed, the pre-treatments carried out for each type of fish, the water used for washing and chemicals used during processing). Answers given by the actors were noted as well as observations made on the sanitary conditions. In order to make the location map of the prospected sites, the geographical coordinates of each site were collected using a Samsung phone.

The location map of the study sites was done by using QGIS Software 3.18 version. In order to assess the degree of similarity between the different fish processes in the different regions, and to understand the existing relationships between the different variants and the type of processing, the data collected was subjected to a principal component analysis (PCA) using Xlstat software 2015.4.01.22368 version. The calculation of averages and frequencies was done by the same software.

RESULTS

Presentation of the targeted population

The survey covered two categories of people: fishermen who were mainly men (95,0%) and processors dominated by women (57.5%).

Fishermen

Fishermen are those who engage in fishing as their main occupation, whether they owned a boat or fishing gear or not. They are mainly made up of men (95%) in all the localities surveyed with the exception of the Benue basin where some women (5%) Djoukouns, Laka and Hausa have been registered. In this category of actors, dominant age (38.7%) varies between 30 and 40 years old. In each locality, the fishermen are mainly indigenous but some peoples such as Musgums (28.7%), Kotokos (17.5%), Hausa (11.2%) and Massa (7.5%) were encountered in all the prospected sites. Other fishing peoples are indigenous people from localities such as Mambila (2.5%), Tikars (2.5%), Kwandja (1.25%) in Bankim sector, as well as some foreign nationals including Nigerians (2.5%), Nigeriens (1.25%) and Malians (2.5%). The Gbayas (2.5%), Boums (2.5%), Bamouns (1.25%) and some others such as Moundang (2.5%), Tupuris (3.75%) are those encountered in the Tibati sector. In Logone and Bénué, the other fishermen encountered in addition to Musgums, Massa, Kotokos and Tupuris are the Arabs (1.25%) (from Chad and Logone and Chari), Djoukouns (3.75%), Hausa and Mbattas (5%) from Nigeria. They also practice or have had to practice the fish processing profession.

Transformers

Processors are those who smoke (in an oven) or dry (in the sun) the fish to get the dry fish. On the contrary, this category of actor is dominated by women (57.5%) who are generally the wives of fishermen or traders. The dominant age in this category is between 40 and 50 years. Smoking is also practiced by men (42.5%) who are either traders or foreigners from neighboring countries such as Nigerians and Chadians met in Mayo-Danay and Benue; Nigerians, Nigerians of Niger, Malians... present in the division of Mayo-Banyo.

Transforming processes of fresh fish

Fish pre-treatment and smoking in the Far North and North regions

The transformation processes are identical in these two regions and are divided into five stages.

Step-1: Acquisition of fresh fish

Once caught, the fresh fish are kept in the wooden or in sheet metal canoe, motorized or not and of varying dimensions depending on the fishing skill used to be convoyed to the landing site. At the landing stage, they are packaged in plastic or aluminum bowls with a capacity ranging from 5 liters to 25 liters or in bags with a capacity of 100 kg that are units of measurement. They are then transported to the processing site by transformers themselves (64%) or either using motorcycles (28.8%) or door holders (7.2%).

Step-2: Cleaning fish

The cleaning of fish concerns both the exterior and interior the fish (evisceration) and depends on the nature of the fish. Scaly fish (67.0%) such as Cyprinus carpio (Carp), Oreochromis niloticus (Tilapia), Hydrocinus sp. etc., are after flaking, emptied and washed (61.1%). Others like Heterotis niloticus (Kanga) are cut into small pieces before being washed (5.84%) or folded after washing (44.4%). Scaleless fish or Fish without scales like Clarias sp. (Catfish), Arius africanus (Machoiron) and Synodontis sp. (Kurungu) are simply cleaned on the surface with a sheet of material or a rag and folded in most cases (the anterior part turned against the posterior part) so as to form a circle (27.8%). This fold is in some cases maintained by a stick that passes from one flank to another or by the spine of the pectoral fin that holds the tail against the head. Folded species are usually Clarias sp, Heterotis sp, Cytharinus cytharinus and Arius sp.

Similarly, these fish without scales (Catfish ...) and some large scaly fish are after being cleaned cut into several pieces in the Mayo-Danay and then washed (5.3%). The washing is done in a container that is either a basin, a bucket or a bowl. The washing water is taken from a river or a pond may or not, be impregnated with insecticides (14.3%) and is used several times for several species of fish.

Step-3: Spinning fish

After washing, the fishes are spread on the drying stalls or on the fences of an empty oven so that, for about 10 to 20 minutes, the amount of water decreases considerably. This operation is very important because it makes it possible to carry out a good smoking and to prevent the fish from sticking to the racks or on top of each other. After this spin, fishes are stacked close to each other on the oven wire mesh and are ready for smoking.

Step-4: Smoking

Smoking is done in a wood-fired oven of varying shapes and dimensions depending on the sites and the quantity of fish to be processed. The wood fire is kept on high hart for about 45 minutes by combustion available as generating source of heat to cook fish. This duration may take longer depending on the nature (fatty or lean fish) and the size of the fish to be smoked. After this time, the fish is turned over so that both sides are exposed to the flame in order to obtain a homogeneity

of cooking and dehydration. Then, most of the wood is removed from the oven to reduce the flame and the embers are left causing the release of dense smoke. The fish are then covered with sheets of sheet metal that completely close the smoking furnaces. This method traps available heat and smoke and the fish continue to dehydrate and soak up the volatile compounds in the smoke.

Step-5: Packaging and storage

After smoking, the fish are left in the oven until cooling before being removed and kept in a storage tool. This tool can be a jute bag (21.5%), a traditional basket (25.1%) or a bowl (19.2%) for those who store their fish before evacuating them. For those who immediately evacuate their fish, the most used tool is cardboard (34.1%) which is recovered after the sale of the fish to be reused later.

Smoking in the Adamawa region

In the divisions of Djerem and Mayo-Banyo where all fish are smoked, the approach is different and takes place in four essential stages.

Step-1: Fish acquisition

Upon landing, processors collect fish from traditional bowls, bags or baskets and transport them as best they can to processing sites.

Step-2: Cleaning and spinning of fish

In this Region, fish species such as carp, Tilapia and captains (Lates niloticus) are scaled, cracked on each side, washed and folded (78.6%) while others such as catfish are washed simply or cleaned with a piece of cloth or washed and folded (4.1%). In Mayo-Banyo, some fish such as Hemichromis sp. or Oerochromis sp. are scaled and washed without cracking (16.3%) and others like Clarias sp. are folded without being cracked (1.02%). The washing is done with water taken either from the river (77.5%) from fishing or from a borehole (22.5%) and can be impregnated with insecticide (8.22%). The same amount of water is used several times for several species of fish. After washing, fishes are directly put in the oven (70%) or spread in the sun on straws or racks for at least 20 minutes thus allowing their spinning (30%) (Figure 2).

Step-3: Baking and smoking

After spinning, the fish are loaded into the smoking oven and then the fire is activated in the oven. This fire is kept alive in the oven for about 50 minutes variable according to the size and nature of the fish. After this time, the fish are returned to the oven to homogenize its cooking and dehydration. After reaching a level of dehydration desired by the actor, the woods are removed from the furnace and the fish are covered with sheet metal and led to a constant temperature to dehydrate and soak up the volatile matter of the smoke (Figure 2). In the division of Djerem, dehydration is not total as in the divisions of Mayo-Banyo, Benue and Mayo-Danay.

Step-4: Packing fish

After dehydration, the fish are left in the oven until they cool down. In this part of the study area the fish can be left in the oven until the next day before being stacked on top of each other either in a cardboard box (44.5%), a bag (7.8%), a traditional basket (26.6%) or a bowl (21.1%) (Figure 2).

Methods of preparing fish for drying

Drying fish is a common practice in Logone (46.7%) and Benue (33.3%) where all fish species can be smoked or dried depending on the choice of the actor and the availability of equipment. On the other hand, this practice is rare in Mayo-Banyo (6.7%) and Djerem (13.3%) and concerns small fish

that cannot fit on the fences (Souda-mouka, Gamré, etc.) as well as rotting fish that cannot be smoked.

Step-1: Cleaning and brining of fish

Small fish (Micralestes sp, Bremyvirus sp, Schilbe sp...) are washed directly either in simple water (45.0%) or water impregnated with insecticide (55.0%) or salt. Medium-sized fish (carp, catfish, captains...) are chipped and emptied (54.8%) then split and washed (54.8%) with water taken from the fishing river. This water is not regularly replaced and the work materials (containers, knife ...) are not constantly cleaned. Similarly, fish without scales of medium size are cleaned and split (45.2%). Some split fish are salted (16.1%) before being put in the sun while simply washed fish are either salted (3.2%) or spread directly in the sun (80.6%) (Figure 2).

Step-2: Drying under the sun

The fish thus prepared are spread either on the ground (15%), or on an insecticide-treated drying rack (25.9%), or on fences (13.5%), or on the roofs of houses (10%) or on locally built sheds (35.6%). These fish are turned over momentarily with the help of a wand or by the bare hand so that each side is exposed to the sun. The weather in the sun varies depending on the nature and size of the fish. It can be from three (03) days to about two weeks (Figure 2).

Step-3: Packaging and preservation of fish

After drying, the dried fish is collected by hand to be packed either in bowls (24%) or in jute bags (76%) which are stored in a hut or in a house usually treated with insecticides before being evacuated to the sales sites. These conservation tools are sometimes used several times without any prior design.

The different variants associated with a principal component analysis show the correlations between the processes of transformation and the different sites prospected as well as the differences and similarities between the different fish processes used in northern Cameroon (Figure 3). The F1 and F2 axes explain 95.8% of the total variability. Axis 1 explains 66.2% of the total variabilities observed and highlights four groups. The first group (Obs 2) consists of variables such as Cleaning-Cutting positively correlated to the axis and corresponding to the particularity of the smoking process in the Logone basin. The second group (Obs 3) which is positively correlated with the axis and reflects the particularities of the smoking process in the Benue basin. Its characteristic elements are Folding-Draining-Smoking. The third group consisting of Chipping-Emptying-Cracking-Washing is negatively correlated with the axis and reflects the particularity of the smoking process in the Adamawa region (Figure 3).

The last group of this axis (Obs 4 and 5) which is negatively correlated with the axis consists of elements such as Cleaning-Splitting-Washing-Salting and drying corresponding to the drying process in the Northern (Benue Basin) and Far North (Logone Basin) regions (Figure 3). Axis 2 explaining 29.60% of the variability highlights 2 groups. Group 1 consists of the different variants of smoking processes and the second group of variants of the drying process.

DISCUSSION

Choice of fish transformation process

The type of transformation used (smoking or drying) is adopted according to the dietary habits of the local populations, the climatic conditions of the environment under consideration and the size of the fish to be transform (Hissein et al., 2018). In the Northern and Far North regions, sun-dried fish are highly valued and are used in the feeding habits of almost all indigenous people. The

tropical climate of the Sudano-Sahelian type that prevails in those regions is very favorable to dry fish in the sun unlike that of the Sudano-Guinean type that reigns in the Adamawa region. Fish of smaller size as Alestes sp. and Micralestes sp. (Most abundant in the Benue) and Petrocephalus sp, Marcusienus sp and Schilbe sp (Most abundant in the Logone), are not being able to fit on the fence smoking racks are more abundant in the Northern and Far North regions. This would explain the fact that drying is more practised in the Northern (28.6%) and Far North (54.9%) regions.

Pre-treatment methods used for smoking

Step-1: Acquisition of fresh fish

According to Knockaert (1990), the quality of the finished product (dry fish) depends directly on the quality of the raw material (fresh fish). For Dawson et al. (1991, cited by Tidjani et al., 2013), the use of raw materials of poor microbiological quality, or even in a state of decomposition, constitutes microbiological contamination and therefore a critical step. The choose decaying fish for smoking as in the Adamawa region where all fish brought to smoking sites are smoked regardless of their condition calls into question the quality of the finished product. The presence of certain substances resulting from the degradation of fresh fish significantly reduces the lethal action of smoking on bacteria (Abochi, 2010). The sorting of fish before any processing, although it delays the work by taking more time, nevertheless has the advantage of making it possible to obtain at the end of the processing, a dry fish of good quality and suitable for preservation.

Step-2: Cleaning fish

For smoked fish, the skin is a physical barrier to insect infestation. Although important insofar as the geometry of the product particularly impacts the kinetics of the process during the transformation (Raffray, 2014), cut the fish into smaller pieces as practiced in the Logone Basin or exert openings (cracking) on the latter as in the Djerem weaken the dry fish obtained. This method directly exposes their flesh and make them vulnerable to pest attacks if storage is not being taken care of. Similarly, these fish crumble easily when they experience physical shocks.

Washing fish in contaminated water and using unsterilized equipment also have harmful consequences. According to FAO (2016), improper handling and non-compliance with basic hygiene rules by processors and producers could cause contamination and growth of pathogenic and or undesirable germs. For utensils and work equipment, Barro et al. (2013) showed that knives without being cleaned between uses promote cross-contamination by germs carried by food.

Step-3: Spinning fish

The spinning of the fish is an important step because it predisposes the fish to rapid dehydration and prevents the fish from accosting on the oven wire mesh or on one another. Despite this importance, the fish are spread for spinning on non-disinfected surfaces that can thus be contaminated during this stage. This can influence the microbiological quality of the finished product as demonstrated by some authors (Oulai et al., 2007, Hissein et al., 2019). Those authors revealed the presence of microorganisms of the genera Aspergillus, Mucor, Curvularia and Scycadium on samples of smoked fish in precarious conditions.

Step-4: Smoking

Smoking itself is the most important step in the process. It allows a uniform dehydration of the fish and gives the fish a pleasant color and smell thanks to the volatile matter of the smoke that have bacteriostatic properties. The fish thus obtained is suitable for preservation for a longer period. However, the actual smoking takes place in traditional open furnaces that consume excessive fuel and do not have a temperature control system. According to Assogba et al., 2019, high temperature influences the quantity and quality of essential amino acids during smoking compared to improved

smoking. Similarly, the wood combustion temperature also influences the production of Polycyclic Aromatic Hydrocarbons (HaP) and other volatile organic compounds known for their mutagenic and carcinogenic properties (Schnatter et al, 2005; Tarantini, 2009).

Step-5: Packaging and storage

Packing dry fish prevents them from being affected by various loss factors that can be rodents or ichthyophagous insects. However, using the same fish storage tool several times as almost all processors do allow actors to save their income by limiting expenses but this practice promotes the contamination of fish by microorganisms and especially by insect pests. As a smaller of fact, storage tools can be infested by microorganisms or insect pests that leave either eggs, larvae or even adults on them. During the next use, they infest the fish and proliferate within the stock causing quantitative and qualitative losses.

Pre-treatment methods used for drying

Step-1: Cleaning and brining of fish

For the drying of fish under the sun, opening the fish (splitting) has an advantage to accelerate the drying by promoting the migration of water to the surface. If a fish is opened, its size surface increases in comparison with its weight and thickness, thus the drying time will be faster (Hissein et al., 2018). The disadvantage of this practice lies in the fact that it exposes the flesh of the fish and makes it subject to infestations by microorganisms and insect pests. Salting of fish is also important because it promotes the dehydration and conservation of fish by limiting insect proliferation during storage (Pittia and Antonello, 2016). However, this practice has disadvantages because salty fish have a stronger tendency to reabsorb water during storage which promotes the development of mold and lipid oxidation of fish and therefore the development of degraded product traits (Ndrianaivo et al., 2016).

Step-2: Drying under the sun

Solar drying method is the simplest and most economical method for the preservation of fish, but the drying process still affects the proteinaceous quality if it is misled (Ariyawansa, 2000). In addition to the shortcomings noted with the smoking system, drying in the Logone basin is mainly done by displaying fish on the ground or on straws spread on the ground or on mats that are not regularly cleaned. To keep insect pests (Diptera and Beetles) 77.5% of transformers spray extremely dangerous insecticides directly on fish during drying. These insecticides have the advantage of protecting fish against insect pests but are nevertheless recognized as carcinogenic, endocrine disrupting and mutagenic for the most part (Pandey and Mohanty, 2015) thus impacting the health of consumers and even the environment. According to the studies carried out (Hissein et al., 2019) dried products have fairly high microbial loads due to high contamination of the raw material. Smaller fish such as “souda-mouka”, “Gamrés” are dried with many impurities (grains of sand, snail, animal and plant debris ...) thus calling into question the value of the product obtained.

Step-3: Packaging and preservation of fish

Like smoked fish, the same packaging tools are used several times without prior disinfection promoting contamination of dry fish. Before evacuation to sales sites, storing bags of fish in huts promote its rehumidification. This moisture creates an environment in fish that is conducive to the development of molds that can produce mycotoxins responsible for food poisoning in humans (CECMA, 2009).

Steps forwards

In summary, smoking and drying aim not only at extending the shelf life of fish but also to preserve

its nutritional and organoleptic quality. To achieve this, the raw material that is fresh fish must be the good microbiological quality and during pre-treatments, hygienic rules must be respected. For this, it is therefore necessary to sort the fish before any transformation, removing impurities. Already decaying fish should be dried under the sun and only fish in good condition with firm flesh should be smoked. As indicated in the main component analysis (Figure 3), scaly fish should be flaked, emptied, washed in drinking water lightly impregnated with salt or plant extracts and left in the sun for spinning on a clean surface before smoking. Similarly, fish without scales must be emptied, washed and folded before being smoked after spinning without damaging the skin. During work, washing water should be constantly replaced and work materials regularly washed and disinfected. Use a mosquito net to cover the drying stall to keep away from meat flies that are agents of contamination of fish by microbes (Brigitte et al., 2005). For packaging, use a healthy or sterilized tool.

CONCLUSION

The fish transforming processes in the three main fishing basins of the northern regions of Cameroon are very similar despite the cutting of fish into small pieces in the Logone basin and cracking on each side of the fish in the Sanaga basin that make the difference in pre-treatments. In terms of smoking itself, fish in the Djerem are not completely dehydrated during smoking as in the other departments surveyed. This can influence the duration of storage of smoked fish in this department compared to others. The use of unlicensed chemicals in processing and non-compliance with hygienic rules remain the main weakness observed in all prospected sites, thus calling into question the sanitary quality of smoked and/or dried fish.

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