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HEALTH RISK ASSESSMENT OF SKIPJACK TUNA (*Katsuwonus pelamis*) FROM ARTISANAL FISHERIES IN ABIDJAN

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ABSTRACT

Tuna from small-scale fishing is an important part of the fisheries resources consumed in Côte d'Ivoire. However, its sanitary quality remains questionable due to the lack of control and the precarious conditions of its production. The aim of this study is to characterise the tuna produced by artisanal fishing and to assess the health risks incurred by consumers of this foodstuff. This is precisely Listao tuna (*Katsuwonus pelamis*). To do this, an analysis of the physico-chemical and microbiological characteristics was carried out and the health risks were determined. The results show that most of the parameters investigated are within the tolerable range. Thus the high histamine level remains below the tolerable threshold (100 ppm / 100 g). Mercury, a metal that is dangerous to human health and considered to be the major chemical risk for fish consumers, was detected in very low concentrations in the samples analysed (<1 mg/kg). Although they are considered as trace metals in food, the concentrations of cadmium and arsenic are very high compared to mercury. Microorganisms indicative of poor hygiene practices such as Aerobic Mesophilic Germs (AMG) were found in all samples at concentrations above the reference value (FM > 5.10^6). Anaerobic sulphite reducing microorganisms (ASR) were found in the samples but at acceptable concentrations. The pathogenic germ *Escherichia coli* was found in all samples at concentrations above the reference value (F>100). The other pathogens *Vibrio paraemolyticus*, *Salmonella typhi* and *Staphylococcus aureus* were not detected in any of the samples analysed. The unsatisfactory tuna samples consisted of 55% smoked tuna and 54% fresh tuna. However, the eating habits of Ivorians, who very often eat cooked tuna, make it possible to eliminate these dangers and reduce the health risks. In view of the results obtained, the tuna produced in Abidjan from artisanal fishing can be considered safe for its consumers. It can therefore contribute effectively to the food security of the population.

KEYWORD: Tuna - Artisanal - Evaluation - Health risks – Abidjan.

1. INTRODUCTION

Tuna is an important source of protein **(Conan, 2022).**[1] It is widely consumed in Côte d'Ivoire especially in urban, school and university settings (**Anoman et *al.*, 2018).**[2]

The local market is supplied in two main ways. These are tuna from industrial residues known as 'false tuna', which is considered to be of inferior quality, and tuna from artisanal fishing. Tuna is sold in the main artisanal fishing landing points in Abidjan and the interior of Côte d'Ivoire (**N'da *et al.*, 2007; FAO, 2014; RTI, 2021).**[3,4,5]

Despite the growing interest of the Ivorian population in this foodstuff, certain factors such as fishing and production conditions as well as eating habits may entail risks for the consumer of artisanal tuna in Abidjan.

Indeed, the post-harvest management process of tuna reception, preservation and sale has significant effects on its marketability and hygienic quality. Under such environmental conditions, many micro-organisms, such as histaminogenic bacteria proliferate. These cause the decarboxylation of histidine leading to the production of histamine, a toxic agent for humans **(Kouakou et *al.*, 2013).**[6]

Moreover, tuna is a large fish which, through bio-accumulation, can store large quantities of heavy metals which are harmful to the health of the consumer (**Adingra and Kouassi, 2011; ANSES, 2012; Conan, 2022).**[7,8,1]

The sanitary characteristics of "fake tuna" are confirmed during controls carried out by canneries, which leads to its rejection. On the other hand, artisanal tuna is hardly ever checked, so that little data on its sanitary quality is available in Côte d'Ivoire.

The objective of this study is to determine the sanitary quality of artisanal tuna in Abidjan and to evaluate the health risks to which consumers of this foodstuff are exposed. Listao tuna (*Katsuwonus pelamis*) was used for the microbiological and physico-chemical analyses. It is the third most caught fish in the world after anchovy and Alaskan hake. Among the tuna species, it is the most fished in the world and in Côte d'Ivoire **(Ethic Océan, 2022).**[9] It accounts for around 50% of world catches. Moreover, its relatively low weight (1 to 20 kg) for a maximum length of 1 m, compared to other species, facilitates its transfer to the analysis sites.

2. MATERIALS AND METHODS

2.1 Materials

The study material consisted of Skipjack tuna (***katwonus pelamis***) from three artisanal fishing landing sites in Abidjan. The technical laboratory equipment consists mainly of an X-ray fluorescence spectrometer and an HPLC apparatus.

2.2 Methods

2.2.1 Sampling sites and sampling

The tuna comes from three artisanal fishing landing sites in Abidjan. These are the Abobo Doumé site, the Vridi site and the Zimbabwe site. On each site, 3 fishmongers were identified. The sites were chosen for their ease of access but above all because of the intense tuna production and marketing activity that takes place there **(FAO, 2008).**[10] At each fish processor, 10 tuna from the same batch were selected, 5 of which were to be analysed in the fresh state and the other 5 in the smoked state. A total of 90 tuna were analysed at the three sites. Histamine analysis was only performed on fresh tuna, with 9 tuna per sample**.**

2.2.2 Collection, Transfer and Processing of samples before analysis

The samples were taken from the muscles in the pectoral area (tail), the dorsal part and the head of the tuna**.** The fish is taken from the fishmongers who are the intermediaries between the fishermen and the sellers. The fishmongers take the fish from the holds of the pirogues. In these spaces, the fish is kept on ice. It is caught the night before and transported to the sales sites early in the morning. At the fishmongers', it is kept in non-functional refrigerators under ice with added salt. The fish is displayed in batches. Once the price has been agreed, the fish is retrieved with a scalpel and placed in a cooler under ice and transported to the analysis site.

2.2.3 Microbiological analyses

The microbiological parameters investigated are germs that are indicators of good hygiene practices and pathogens of major public health importance and frequently encountered in seafood products **(WHO, 2013).**[11] These include aerobic mesophilic germs (AMG), anaerobic sulphites (ASR), salmonella, *Vibrio parahemolyticus*, *Staphylococus aureus* and *Echerichia coli*. GAMs were tested according to the recommendation of **NF EN ISO 4833**[12] on PCA medium. The plates were placed in an oven at 30ºC for 72 hours. The reading was done by taking into account all visible colonies with a diameter of 0.5 mm after dilutions from 10 to 10^{-5}. The method recommended by the **AFNOR NF V08013** standard[13] was used to test for Salmonella. During the reading, only black colonies and transparent colonies were retained. They were identified on the leminor rack. The **ISO 6887**[14] standard for the detection of fishery products was used for the detection of *Vibrio para hemolyticus*. It is isolated on TCBS medium. Only blue-green colonies of 3 to 5 mm in diameter were counted. The search for *sulphite-reducing anaerobes was* carried out according to the **AFNOR NF V08-061** standard.[15] Inoculation was done in Petri dishes. Only colonies surrounded by a black halo were counted. The membrane filtration method was used to detect and quantify E. coli **(CEAEQ, 2015).**[16] **ISO** Standard **6888 (2021)**[17] which specifies a horizontal method for the enumeration and investigation of staphylococci was used to investigate *staphylococcus aureus.*

The interpretation of the results of the microbiological parameters was based on the microbiological criteria for foodstuffs set by the European Union Commission **(EC, 2007).**[18] A three-class sampling plan was used to assess the quality of the analytical results.

2.2.4 Physical and chemical analyses

The heavy metals searched for are lead, cadmium, arsenic and especially mercury because of its potentially high concentrations in large fish, including tuna. The search for mercury is explained by its high toxicity and the health risk it poses for tuna consumers, particularly pregnant women. The other elements searched for are sodium chloride (NaCl) and histamine because of their involvement respectively in arterial hypertension and histamine poisoning in tuna consumers **(Dalgaard *et al*, 2008; Durette *et al*, 2018**).[19,20] Heavy metals and sodium chloride were determined using the X-ray fluorescence spectrometry (XRF) method, which allows the determination of chemical elements in the sample, according to the detection limit of the instrument. The high performance liquid chromatography wavelength fluorescence method was used for the determination of histamine.

The interpretation of the results for heavy metals was based on the criteria set by the Codex Alimentarius Commission **(CAC, 2019).**[21] Histamine results were interpreted according to the microbiological criteria for foods set by the European Union Commission **(EC, 2007).**[18] Sodium chloride values were interpreted

according to the average values of the ciqual tables **(ANSES, 2021).**[22] A three-class sampling plan was used to assess the quality of the analytical results.

2.2.5 Health risk assessment

The health risks were assessed in four steps according to the Codex Alimentarius Commission (CAC) method for biosafety risk assessments **(FAO/WHO, 2007).**[23] It takes into account the physical, chemical and microbiological risks associated with the consumption of artisanal tuna**.**

The health risks associated with tuna consumption were mainly determined from information collected on the effect of tuna consumption on consumers **(Table 1).** Literature searches on tuna were also used to assess these health risks.

The criticality of the risk was determined by multiplying its frequency (probability of occurrence) and its severity. Thus, risks with a score of less than or equal to 2 are considered low and symbolised by a green colour (green zone). Risks with a score between 3 and 5 are considered high and symbolised by the colour orange. Finally, risks with a score between 6 and 9 are considered very high and symbolised by the colour red **(Table 2).**

2.2.6 Statistical analysis of the data

The statistical analysis consisted of an ANOVA test comparing the resulting means of each microbiological and physico-chemical parameter at a 5% significance level (**Beaume, 2015).**[24]

Table 1: Survey data on consumption of artisanal tuna in abidjan.

Type of tuna consumed	Frequency of consumption	Effect of consumption on the body
Fresh red tuna ; Smoked red tuna ; Fresh Listao tuna ; Smoked skipjack tuna ; Fresh yellowfin tuna ; Smoked yellowfin tuna ; Fresh Patudo Tuna ; Smoked Patudo Tuna ; Fresh tuna ; Smoked Albacore Tuna	1 time / Day; 2 times / Day 1 time / week ; 2 times a week; 1 time / 2 weeks ; 1 time / month	Headache; Vomiting; Diarrhoea; Digestive disorders; Palpitations; Swelling of the face or lips; Itching of the skin or throat

Table 2: Health risk assessment criteria for artisanal tuna in abidjan.

Probability / Frequency	Gravity	Risk score R *(Criticality)	Level of the Risk	Risk response
Rare: 1	Low: 1	R < 3	**Low risk**	No action
Occasional: 2	Average: 2	3≤ R < 6	**High risk**	To be treated as a second priority
Very Common (common): 3	Strong: 3	6≤ R ≤ 9	**Very high risk**	To be treated as a priority

**** Risk criticality (R)**: Probability x Severity*

3. RESULTS

3.1 Physico-chemical and microbiological quality

3.1.1 Physical and Chemical quality

The analyses showed the presence of lead and mercury in the samples at low concentrations in the smoked tuna (Pb < 0.3 mg/kg) and in all samples (Hg < 0.1 mg/kg) respectively. Fresh tuna contained lead concentrations slightly above the reference value (Pb = 1 mg/kg). The concentrations of cadmium and arsenic are very high compared to mercury and lead. The mercury concentration of the samples is 17 times lower than that of cadmium and 4 times lower than that of arsenic **(Table 4).**

The presence of salt (NaCl) and histamine was detected in the samples in high proportions respectively at 23.89 mg / 100g and 31.68 ppm / 100 g in fresh tuna. Salt is also high in smoked tuna (NaCl = 22.80 mg / 100 g). Nevertheless, the proportions of sodium chloride and histamine are lower than the reference values (**Table 3)**.

3.1.2 Microbiological quality

The values of GAM (FM > 5.10^6 cfu / g) and E. Coli (FM > 100 cfu / g) are high in both fresh and smoked tuna. They are higher than the reference values which makes the samples unsatisfactory for these two parameters.

The fresh tuna samples do not contain RSA, unlike the smoked samples, which do contain RSA but in an acceptable proportion (FM ≤ 20 cfu/g).

The other pathogenic micro-organisms *Salmonella typhi*, *Vibrio para emolyticus* and *Staphylococcus aureus* were absent in the samples analysed **(Table 5)**.

In addition, a comparison between smoked and fresh tuna shows that the samples of Smoked tuna samples contain more of the desired microorganisms (55%) than fresh tuna samples (45%) **(Figure 1).**

3.2 Health risk assessment

The most important risks to be addressed as a priority are related to chemical hazards. These are histamine, salt, heavy metals, especially mercury and polycyclic aromatic hydrocarbons (PAHs). These hazards cause risks such as high blood pressure (salt), foetal abnormalities in pregnant women (mercury), cancer (PAHs) and itching, palpitations, skin rashes (histamine).

The risks from microbiological hazards are just as important as the risks from chemical hazards. However, most of the hazards that cause them are eliminated by salt and cooking. They should be treated as a second priority.

The risks associated with physical hazards are tolerable so that no provisions need to be made to control them. Consumers should be made aware of the need to sort and clean fish thoroughly before consumption **(Table 6)**.

Table 3: Histamine and Sodium chloride content of tuna samples analysed.

Features	Type of tuna	Average value observed	Reference values	Assessment
Histamine	Fresh tuna	31.68 ppm	≤ 100 ppm	Quality Satisfactory
	Smoked tuna	-	-	-
Salt (Nacl)	Fresh tuna	0,03 mg/100g	≤ 0.093mg /100g	Quality Satisfactory
	Smoked tuna	0,04 mg/100 g		Quality Satisfactory

Table 4: Heavy metal content of tuna samples.

Sought-after parameters	Types of tuna	Average concentration (mg/kg)	Reference values (mg/kg)	Appreciation
Mercury (Hg)	Fresh tuna	< 1	≤ 1.2 mg/ kg	Satisfactory quality
	Smoked tuna	< 1		Satisfactory quality
Lead (Pb)	Fresh tuna	1	≤ 0.3 mg/kg	Unsatisfactory quality
	Smoked tuna	0,1		Satisfactory quality
Cadmium	Fresh tuna	23,8	≤ 1 mg / kg	Unsatisfactory quality
	Smoked tuna	17,4		Unsatisfactory quality
Arsenic	Fresh tuna	4,2	≤ 0.1 mg/ kg	Unsatisfactory quality
	Smoked tuna	4,5		Unsatisfactory quality

Table 5: Microbiological characteristics of the tuna samples analysed.

Types of microorganisms Characteristics	Type of tuna	Average observed load (CFU/g)	Reference values (CFU/g)	Appreciation
Mesophilic aerobic germs (MAG)	Fees	$11,39\ 10^6$	*FM ≥ 5.10^6	Unsatisfactory
	Smoked	$39,78\ 10^6$		Unsatisfactory
Anaerobes Sulfito Reducing	Fees	0	F ≤ 2	Satisfactory
	Smoked	15	2 < F ≤ 20	Acceptable
Escherichia coli	Fees	300	F > 100	Unsatisfactory
	Smoked	1069		Unsatisfactory
Vibrio para emolyticus	Smoked	0	F ≤ 10^6	Satisfactory
	Fees	0		Satisfactory
Salmonella typhi	Fees	0	Absence in 25 g	Satisfactory
	Smoked	0		Satisfactory
Staphylococcus aureus	Fees	0	F ≤ 10^2	Satisfactory
	Smoked	0		Satisfactory

** FM: Microbial flora*

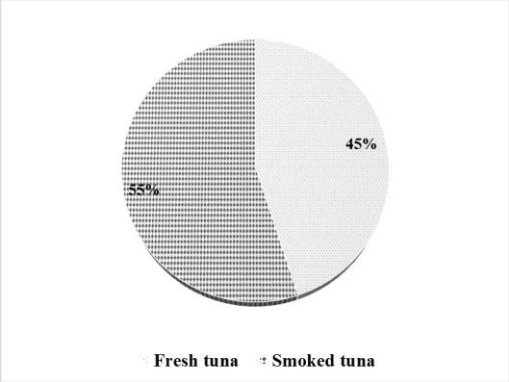

Figure 1: Microbial load distribution in fresh Tuna and In smoked tuna.

Table 6: Estimated health risks associated with the consumption of artisanal tuna from Abidjan.

Hazard category	Hazard identification	Characterisation of exposure to the hazard	Criticality of risk			Estimate
			Probability	Gravity (G)	Score (R)	Conclusion
Physical hazards	Sand, pebbles, wood debris, plastic debris, pieces of metal ...	- Teeth breakage - Throat impediment - Injuries	1	2	**2**	Low risk
Chemical hazards	Salt (Nacl) Mercury Histamine Polycyclic aromatic hydrocarbons (PAH)	High blood pressure - Anomaly on the fetus - Itching, palpitations, skin rashes... - Effect of PAHs in women smokers	3	2	**6**	Very high risk (Treat as a priority)
Microbiological hazards	*Salmonella* *Vibrio parahemolyticus* *Staphylococus aureus* *Escherichia coli*	Effects of M.O. on the consumer	2	2	**4**	High risk (Treat as second priority)

DISCUSSION

Microbiological and physico-chemical analyses showed the presence of different hazards in tuna from artisanal fisheries in Abidjan. Aerobic mesophilic germs (AMG), E. Coli and anaerobic sulphite-reducing bacteria (SRB) are the most frequent microorganisms in the samples. Their presence is an indicator of faecal contamination of tuna samples **(WHO, 2013).**[11] The presence of RSA also reflects poor hygiene practices of the staff in charge of handling tuna at landing, during storage and all the conditions of inappropriate post-harvest production. It also reflects the poverty and precariousness in which artisanal tuna is produced **(Kablan, 2019).**[25] The presence of E coli was detected in all samples except for those of fresh tuna from Abobo Doumé and smoked tuna from Vridi. This presence is more of a health risk for fishermen, fishmongers and sellers than for consumers of tuna **(WHO, 2013**).[11] The fact that smoked tuna has a higher concentration of pathogenic microorganisms than fresh tuna could be due to the more pronounced handling of the tuna during the smoking process, unlike fresh tuna. This result is corroborated by a study on the sanitary quality of fishery products in the artisanal fishing port of Cotonou. The results of this study showed that fish are mainly contaminated by germs after they are caught (**Wantofio et *al*, 2022).**[26] Although present in the samples, the micro-organisms do not represent major hazards for the Ivorian consumer as the tuna is usually cooked before consumption (**Anoman *et al.*, 2018).**[2] Most microorganisms are destroyed during cooking.

In the Abidjan region, household wastewater and industrial waste are discharged into drainage or sewage systems. This practice is likely to introduce toxic chemicals such as heavy metals, notably mercury, into artisanal tuna. This is considered dangerous for the

foetus in pregnant women **(Monnet, 2020; ANSES, 2012).**[27, 8]

The results show low concentrations of mercury and lead in the samples and high concentrations of cadmium and arsenic. The cadmium concentration is 17 times higher than the reference value and the arsenic concentration is 42 times higher than the reference value. Heavy metals are generally considered as trace metals in food. However, the concentrations of cadmium and arsenic determined in artisanal tuna from Abidjan may raise concerns for its consumers. Increased and recurrent consumption of tuna could lead to the tolerable weekly intake for cadmium and arsenic being exceeded, which are 2.5 ug/ kg body weight and 0.3 ug/kg body weight respectively **(CEAEQ, 2015).**[16]

Histamine levels in the tuna samples were very high. Some values reached 76 ppm. However, they are below the threshold value of 100 ppm/100g. However, histamine levels remain high in relation to those of industrial tuna from Abidjan, which average between 1 and 20 ppm depending on the stage of processing **(Ogoumon 2012; Kablan et *al*, 2019).**[28,25] These high values can be explained by the conservation time in the holds of the pirogues, which can last from a few hours to several days before landing at the fishmongers. In addition, the storage conditions at the fishmongers', processors' and sellers' premises are factors in the proliferation of Hist aminogenic bacteria **(Podeur 2014; Dalgaard *et al*, 2008; ANSES, 2022).**[29,20,30]

Sodium chloride (salt) is mainly used for the preservation of tuna. It migrates into the fish flesh during preservation. The salt content is respectively (0.03 mg / 100g) for fresh tuna and (0.04 mg / 100g) for smoked tuna. These values are lower than those of fish products that have undergone processing and are intended for the same target populations as the Abidjan artisanal tuna. These are respectively the salt concentration of adjuevan and guedj which are respectively (10.5 g/100 g; 9.6 g/100 g) **(Kouakou *et al.*, 2013; Fall *et al.*, 2017).**[6, 31] By comparing the salt content and the risk of arterial hypertension, Abidjan artisanal tuna appears to be less dangerous than other fish products consumed in Côte d'Ivoire and in the West African sub-region, notably *adjuevan* and *guedj*.

The consumer survey showed that the chemical risks were the highest. Most consumers complained of symptoms due to the presence of histamine in tuna. These results corroborate with those of the ANSES which state that histamine poisoning is the leading cause of food poisoning related to fish consumption worldwide (**ANSES, 2022).**[30]

Despite the unsanitary storage and sales conditions at most production sites, physical risks are not encountered by consumers. This is due to the gutting and cleaning of fish before delivery to customers.

CONCLUSION

The analyses carried out on the artisanal tuna produced in Abidjan showed that the levels of anti-nutrients sought were below the tolerable threshold for some and above for others. The levels of *Mesophilic Aerobic Germs* (MAG), *Escherichia coli*, cadmium and arsenic exceed the tolerable threshold. Furthermore, the risk assessment showed that the most frequent risks are chemical and microbiological. While cooking the tuna before consumption is a means of reducing the microbiological risk, measures must be taken to deal with the chemical risk.

Recommendations and Perspectives

In view of the results of the analyses, it would be advisable to limit or space out the consumption of tuna so as not to exceed the tolerable weekly intake (TWI) of heavy metals, particularly cadmium and arsenic. This study is particularly important as it will serve as a basis for consumers to ensure the sanitary quality of the tuna they consume.

In addition, further studies should be conducted to measure the medium and long-term effect of chemical hazards on the health of consumers of tuna from the Abidjan artisanal fishery.

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