

**ASSESSMENT OF THE EFFECTS OF THE SMOKE GENERATION PROCESSES AND OF
SMOKING PARAMETERS ON THE ORGANOLEPTIC PERCEPTION, THE LEVELS OF THE
MOST ODORANT COMPOUNDS AND PAH CONTENT OF SMOKED SALMON FILLETS**

***/ÉVALUATION DES EFFETS DU PROCESSUS DE GÉNÉRATION DE LA FUMÉE ET DES
PARAMÈTRES DE FUMAGE SUR LA PERCEPTION ORGANOLEPTIQUE, LES NIVEAUX DES
COMPOSÉS PLUS ODORANTS ET LA TENEUR EN HAP DES FILETS DE SAUMON FUMÉ***

by/par

Thierry Sérot¹, Régis Baron, Mireille Cardinal, Clément Cataneo, Camille Knockaert,
Bruno Le Bizec, Carole Prost, Fabrice Monteau and Vincent Varlet

Abstract

Salmon fillets were smoked by using four different smoke generation processes pyrolysis: by smouldering, with thermostatic plates or friction and liquid smoke vaporization. Different smoking times (1, 2 or 3 hours) and smokehouse temperatures (22 °C and 32 °C) were applied. The effects of these parameters on smoked salmon flavour, odour and odorant compounds and PAH content were evaluated. Smoked salmon fillets were submitted to sensory analysis and the concentration of odorant volatile compounds were investigated by gas chromatography coupled to mass spectrometry and olfactometry (GC-MS/O/FID). Liquid smoke atomization smoking process led to products described by “cold smoke” and “vegetal” odour and flavour attributes; a PLS 2 regression shown that these odour and flavour could be related to several phenolic compounds such as syringol or p-cresol and lipid oxidation products, and pyridine derivatives, respectively. The other smoked salmons were characterized by “salmon-like” attributes for a short time and low temperature of smoking and “wood fire smoke” flavour attributes when smoking parameters increase. This organoleptique evolution could be related to the increase of the deposition of phenolic and furannic compounds with increases of smoking parameters (time of smoke exposure and smokehouse temperature).

The results show a significant correlation between the smoking process parameters, and the presence of PAHs. Smouldering is the smoke generation process that leads to smoked fish with the highest TEQs. The difference is caused by the higher levels of low molecular-weight PAHs than in fish smoked by other techniques. However, the contents are always under the legal threshold concerning benzo(a)pyrene (5 µg.kg⁻¹). Smoked fish obtained by liquid smoke vaporization presented the lowest level of PAHs but benzo(a)pyrene concentration is nevertheless important.

Key words: *Fish smoking process, Smoke generation, Smoked salmon, Organoleptic properties, GC/olfactometry, Odor-active compounds, PAH, GC/MS/MS*

Résumé

Des filets de saumon ont été fumés en utilisant quatre procédés de génération de fumée: la pyrolysis du bois par autocombustion, friction ou à l'aide de plaques thermostatées, et par atomisation de fumée liquide. Différentes durées de fumage (1, 2 ou 3 heures) et de températures du fumoir (22 °C et 32 °C) ont été utilisées. L'effet de tous ces paramètres sur la flaveur et l'odeur, la teneur en composés odorants et en HAP a été évaluée. Les filets de saumon fumé ont été soumis à une analyse sensorielle et leur concentration en composés volatils odorant a été étudiée à l'aide d'une technique de chromatographie en phase gazeuse/olfactométrie (GC-MS/O/FID). Le fumage par atomisation de fumée liquide conduit à des produits décrits par des notes de «fumée froide» et «végétale». Une régression PLS2 (Partial Least Squares) a permis de montré que ces odeurs étaient dues à plusieurs composés phénoliques tels que le syringol ou le p-crésol et à des produits d'oxydation des lipides et des dérivés de pyridine respectivement. Les autres saumons fumés ont été caractérisés par les descripteurs «saumon» pour un temps court et une température de fumage basse et «fumée feu de bois» lorsque les valeurs des paramètres de fumage augmentaient. Cette évolution pourrait être liée à l'augmentation des dépôts de composés phénoliques et des composés furannic lors de l'augmentation des paramètres (temps d'exposition de la fumée et fumoir température). Les résultats montrent également une corrélation significative

¹ École nationale d'ingénieurs des techniques des industries agricoles et alimentaires (ENITIAA), rue de la Géraudière, BP 82225, 44322 Nantes, Cedex 3, France. thierry.serot@enitiaa-nantes.fr

entre les modes de fumage, et la présence de HAP. L'autocombustion est le processus de génération de fumée qui conduit à des poissons fumés présentant la TEQ la plus élevée. La différence pourrait être causée par des niveaux plus élevés de HAP de faible poids moléculaire que dans les poissons fumés par d'autres techniques.

Toutefois, la teneur est toujours sous le seuil légal concernant le benzo (a) pyrène (5 µg.kg⁻¹). Les poissons fumés obtenus après atomisation de fumée liquide présentent le niveau le plus bas de HAP, mais la concentration en benzo(a)pyrène est néanmoins similaire aux autres procédés.

Mots Clés: *Procédé de fumage du poisson, Génération de fumée, Saumon fumé, Propriétés organoleptiques, Chromatographie en phase gazeuse/olfactometrie, Composés odorants, HAP, CG/SM/SM*

1. INTRODUCTION

The smoking of fish is a traditional process whose objective is the preservation of the product. The preservation effect is generally attributed to the anti oxydant and antimicrobial properties of phenolic compounds. This process is also responsible for significant modifications of the organoleptic properties of fishmeal (Kjallstrand and Petersson, 2001).

The control of the organoleptic characteristics can be of real interest to processors who want to adapt their products to consumers demand. Previous works have shown that the method of smoke generation and the smoking process used (Cardinal *et al.*, 1997) have a considerable influence on the sensory characteristics of smoked fish, particularly on smoke flavour perception (Cardinal *et al.*, 2006). However, these works did not allow to establish a relationship between sensory properties and chemical composition of smoked fish, particularly composition of odorant compounds provided by smoke.

There are also strong pressures on chemical safety for smoked products from the EU institutions. Thus the Codex Alimentarius Commission on contaminants in food, at its 29th session from 16 to 20 April 2007 established a reflection on reducing levels of Polycyclic Aromatic Hydrocarbons (PAHs) in food dried and smoked. In addition, the EU Regulation 1881/2006 requires a formal setting new stricter rule on the content of PAH in smoked products.

The presence of PAHs, especially benzo[a]pyrene, in smoked fish has previously been reported (Simko *et al.*, 2002) but little information is available concerning the influence of the smoking processes. Some studies compare modern and traditional smokehouses (Karl and Leinemann 1996; Karl 1997) but, to our knowledge, there is no comparative study of modern industrial smoking processes for fish with respect to the 20 PAHs suspected to be carcinogens (European Commission, 2005b). Moreover, to reduce PAH levels in smoked fish, a liquid smoke atomization process has been developed in recent decades. No comparative studies of liquid smoke with traditional smoking techniques, applying wood pyrolysis, are available.

The decision of the Codex Alimentarius Commission is very important for the activity of the smoked fish industry because it will lead to the questioning of certain practices and the necessity of an absolute control of processes to produce smoked fish presenting both excellent organoleptic and all guarantees in terms of food safety.

There is, therefore, on the part of industry players a strong demand for information on the parameters of generation of smoke compounds and on the mechanisms of their deposition on the flesh and their development over conservation.

The aim of the works carried out in our laboratory and in collaboration with IFREMER and ENV Nantes was to elucidate, by using GC-MS/O, the main odorant compounds in smoked salmon flesh (Varlet *et al.*, 2006, 2007a). Then we assess the impact of parameters of smoking process (type of generator, temperature of the smokehouse, duration of smoking) on the nature and content of odorant volatile compounds and PAH in smoked fish fillets.

We also try, by means of Partial Least Square regression, to explain the data of sensory analysis performed on smoked salmon with data of GC-MS/O.

2. MATERIAL AND METHODS

Fish processing

Salmon (*Salmo salar*) (3~4 kg) were filleted, trimmed and put on grids in a cold chamber at + 2 °C for 2 hours. All the fillets were about 1 kg. They were hand-salted with refined salt (Salins du Midi, France) and left for 3 hours at + 12 °C before being rinsed with water (15 °C) and stored at + 2 °C for 18 hours until smoking.

Before smoking, a drying step was carried out by putting the fillets in the smokehouse at 18 °C during 15 min in order to standardize the internal temperature at 8 °C for all the samples. After smoking the fillets were stored during less than one week (5 days) at + 2 °C prior to be frozen at -80 °C until sensory analysis.

Smoking equipment and procedures

The smokehouse consists in a separate chamber from the wood smoke generators. It was a HMI Thirode (PC90 Model) device (Thirode, France), 1500 × 1300 × 2250 mm with a capacity of 380 kg, mounted on a trolley with 28 grids on which the fillets were deposited. The air/smoke circulation was horizontal. Salmon fillets were exposed to the smoke for 1, 2 and 3 hours at a temperature of 22 and 32 °C. The exhaust valve opening was 1/3 and closed for liquid smoke and the relative hygrometry was sat at 60%. For each process, except liquid smoke, the smoke was introduced in the smokehouse with a flow rate of 90 m³/h.

Smouldering parameters

A generator (Thirode, France) produced smoke by pyrolysis (between 400 and 450 °C) of beech sawdust using the smouldering method. The pyrolysis was maintained thanks to an air intake producing a continuous flow around the heated ring by a fan. The sawdust fell on the heated ring by gravity from a hopper. Introduction of sawdust was programmed every six minutes. The sawdust moisture was close to 20%.

Thermostated plates parameters

A generator 720 × 1120 × 1730 mm (Thirode, France) produced smoke by pyrolysis (500 °C) of beech chips. A system spreads the chips on thermostatic. The smoke was pulsed by a ventilator in order to obtain the same flow rate of smoke in the smokehouse than smouldering and friction.

Friction parameters

A generator type FR 1002 (Muvero, The Netherlands) produced smoke by friction (380 °C) by pressing a beech log (8 × 8 × 100 cm) against a rotating friction wheel during 10 seconds and every 30 seconds. The beech log is pressed pneumatically by means of a wood gripper with a pressure of 3.5 bars.

Liquid smoke atomization parameters

Liquid smoke was purchased from a smoke flavouring manufacturer (France). It is a purified condensate of beech smoke. Liquid smoke is atomized by pressurized air in the smokehouse at ambient temperature with a vaporization device (Lutetia, France). Liquid smoke was injected in the smokehouse for 2 minutes every 3 minutes. The hygrometry of the smokehouse was sat at 70%.

Isolation of volatiles compounds

Volatile compounds from 50 grams of smoked salmon were extracted by SDE (Simultaneous Steam Distillation – Solvent Extraction with a Likens-Nickerson apparatus). The distillation-extraction was continued for 3 hours. The extract was concentrated to 5 ml by evaporating the solvent thanks to a Kuderna Danish apparatus and to 500 µL under a gentle cold stream of nitrogen.

GC-O-MS analysis

The volatiles compounds were detected and identified according to the methods described by Varlet *et al.*, (2006).

Sensory evaluations

A descriptive test with conventional profiling (Stone *et al.*, 1998) was carried out to evaluate the sensory characteristics of smoked salmon fillets. Samples were scored by twenty panellists belonging to the IFREMER staff and trained on sensory descriptors for smoked salmon. The panellists were asked to evaluate the intensity of odour and flavour descriptors on a continuous scale displayed on the computer screen, from “0” (low intensity) to “10” (high intensity). The descriptors, “wood fire smoke”, “cold smoke”, “butter”, “vegetal”, “salmon-like” and “herring-like” odours were chosen according to their efficiency to differentiate fish sample characteristics.

Extraction and analysis of PAH

Extraction, washing and analysis by GC/MS/MS of PAH were carried out according to method described by Varlet *et al.* (2007c).

Statistical treatments

All the statistical analyses (Analysis of variance (ANOVA)) were performed with STATGRAPHICS Plus 5.1 software (Statistical Graphics Corp., Herndon, USA).

3. RESULTS AND DISCUSSION

Effect of smoke generation processes and smoking parameters on sensorial properties of smoked salmon

The ANOVA performed on sensory attributes identified two groups, one constituted by fillets smoked by external smoke generators (thermostatic plates, friction and smouldering) and the other constituted by salmons treated by liquid smoke. The results of a Fischer's Least Significant Difference (LSD) procedure shows that there is no significant difference at 5% between the intensities of odour attributes for all samples smoked by thermostatic plates, smouldering and friction wood smoke generators (Table 1).

The same test performed on flavour attributes shows that the products smoked by thermostatic plates, smouldering and friction have obtained significantly different marks for the attributes global flavour and butter flavour.

Products treated with liquid smoke were characterized by high scores for the sensory attributes “cold smoke” and “vegetal” whereas salmons smoked by smouldering, friction or thermostatic plates exhibit a “wood fire smoke” and “salmon-like” odour and flavour. The products smoked by friction have been characterized by the highest scores for “butter” sensory attribute.

The results of multi-way ANOVA highlighted an increase of “global”, “wood fire smoke” and “cold smoke” odour and flavour and also of “herring-like” flavour when time of smoking increases (Table 1) while the increase of smokehouse temperature leads to an increase of “global” odour and flavour, of “wood fire smoke”, “cold smoke” and “herring-like” odours of smoked salmon. However a negative effect of these parameters has been found on “butter” odour and “vegetal” flavour.

When liquid smoke was used the “vegetal” odour was more significantly perceived by the assessors when products are smoked at 22 °C than at 32 °C.

The increase of “smoky” sensory attributes intensity (cold smoke, global odour, wood fire smoke) with the increase of the time to smoke exposure could be explained by a greater deposition of the smoke aroma compounds (Chan *et al.*, 1975). The increase of “smoky” odour and flavour intensity could be responsible for the decrease of “butter” and “vegetal” flavour and odour perception by masking this note.

Table 1. Representation of the effects and interactions on scores of each attribute given by the 20 panellists produced by smoking processes, time and temperature parameters

Attribute *	Process **	Time	Temperature	Process-Time	Process - Temperature	Time - Temperature
oglo	+	LS ^a , TP ^b , F ^b , S ^b	+	□	+	□
owf	+	TP ^a , F ^a , S ^a , LS ^b	+	□	+	□
ocs	+	LS ^a , TP ^b , F ^b , S ^b	+	□	+	□
obut	+	F ^a , TP ^b , S ^b , LS ^c	-	+	□	-
oveg	+	LS ^a , TP ^b , F ^b , S ^b	-	-	-	+
osalm	+	TP ^a , F ^a , S ^a , LS ^b	-	-	-	+
oher	-	-	-	+	□	-
fglo	+	LS ^a , TP ^{a,b} , F ^{b,c} , S ^c	+	□	+	□
fwf	+	TP ^a , F ^a , S ^a , LS ^b	+	□	-	-
fcs	+	LS ^a , TP ^b , F ^b , S ^b	+	□	-	-
fbut	+	F ^a , TP ^{a,b} , S ^{b,c} , LS ^c	-	-	-	-
fveg	+	LS ^a , TP ^b , F ^b , S ^b	-	+	□	-
fsalm	+	TP ^a , F ^a , S ^a , LS ^b	-	-	-	-
fher	-	-	+	□	-	-

+: Significant effect of the considered factor or interaction at a risk of 5 %.

-: No effect of the considered factor or interaction at a risk of 5 %.

□: Increase of scores with the increase of the parameters of the factor considered.

□: Decrease of scores with the increase of the parameters of the factor considered.

*: Global odour (oglo), wood fire smoke odour (owf), cold smoke odour (ocs), butter odour (obut), vegetal odour (oveg), salmon-like odour (osalm), herring-like odour (oher), global flavour (fglo), wood fire smoke flavour (fwf), cold smoke flavour (fcs), butter flavour (fbut), vegetal flavour (fveg), salmon-like flavour (fsalm), herring-like flavour (fher).

**: Process followed by the same letter on a same line is not significantly different. The processes are ranked from the process where the compound concentration is the strongest to the lowest. TP Thermostated Plates, LS: Liquid Smoke, F: Friction, S: Smouldering.

Effect of smoke generation processes and smoking parameters on odorant compounds content of smoked salmon

Eighty-eight odorant areas were detected by at least four judges in smoked fish extract by GC-O and 74 were identified by GC/MS. But for this study a volatile compound was considered as a potent odorant if it was detected by at least six judges. According to the criteria chosen, 18 odour-active compounds have been found in the aromatic extract of salmon smoked by smouldering, 26 in the aromatic extract of salmon smoked by thermostatic plates and 25 and 27 aromatic compounds have been found in “friction” and “liquid smoke” extracts, respectively. Odorant compounds were mainly represented by phenolic and furannic compounds (Table 2).

The results of ANOVA (Table 2) show significant differences concerning the contents of the furannic compounds (furfural (1), furfuryl alcohol (3), 5-methylfurfural (8)), and enolones derivatives (2-methyl-2-cyclopenten-1-one (6), 2-hydroxyl-3-methyl-2-cyclopenten-1-one (10), 2,3-dimethyl-2-cyclopenten-1-one (11)) between fishes processed by thermostatic plates and the by the other techniques. The concentrations of phenolic compounds (phenol (9), o-cresol (12), guaiacol (14), guaiacol derivatives (20, 24, 27, 30) and isoeugenol isomers (32, 33) are also significantly higher in salmons smoked by this technique. Friction and smouldering lead to products with close odour-active compounds contents except for 2-acetyl furan (7), 2,4-hexadienal (5), 4-vinylguaiacol (27) and 4-allylsyringol (35) higher concentration in salmon smoked by friction.

These results confirm previous works carried out in our laboratory (Serot *et al.*, 2004; Cardinal *et al.*, 2006; Varlet *et al.*, 2007) and can be explained by the high wood pyrolysis temperature used for the thermostatic plates process (close to 500 °C vs 380 °C for friction and 450 °C for smouldering). High quantities of aroma compounds are generated at high pyrolysis temperatures. Conversely, lower concentrations of phenolic, furannic and enolones compounds can be observed with the decrease of wood pyrolysis temperature as it is noticeable for smouldering.

Products treated by liquid smoke show the highest concentrations 2-hydroxyl-3-ethyl-2-cyclopenten-1-one (17), syringol (28), p-cresol (13). It can be also noted that some odorant volatile compounds are found only in salmon treated by liquid smoke atomization such as pyridine derivatives (4-methylpyridine (2) and 2,6-dimethylpyridine (4)).

Table 2. Representation of effects and interaction on the concentrations of the odorant volatile compounds produced by smoking processes, time and temperature parameters

Number code	Compounds	Odour in smoked salmon	Process *	Time	Temperature	Process-Time	Process-Temperature	Time-Temperature
1	furfural	smoke, green	+ TP ^a , F ^b , S ^c , LS ^d	+ □	+ □	+ □	+ □	+
2	4-methylpyridine	green, milk	+ LS ^a , F ^b , TP ^b , S ^b	+ □	-	+ □	+ □	-
3	furfuryl alcohol	cooked/soup, chemical	+ TP ^a , F ^b , S ^b , LS ^c	+ □	+ □	+ □	+ □	+
4	2,6-dimethylpyridine	roasty, green, milk	+ LS ^a , F ^b , TP ^b , S ^b	-	-	-	-	-
5	2,4-hexadienal	cooked vegetable, fatty	+ F ^a , TP ^b , S ^c , LS ^d	+ □	+ □	-	+ □	-
6	2-methyl-2-cyclopenten-1-one	cooked potato, green	+ TP ^a , F ^b , S ^c , LS ^c	+ □	+ □	+ □	+ □	-
7	2-acetyl furan	cooked vegetable, potato	+ F ^a , TP ^b , S ^c , LS ^c	+ □	+ □	+ □	+ □	+
8	5-methylfurfural	cooked, earthy, green	+ TP ^a , F ^b , S ^c , LS ^c	+ □	+ □	+ □	+ □	+
9	phenol	marine, metallic, chemical, mushroom	+ TP ^a , LS ^b , S ^b , F ^c	+ □	+ □	-	+ □	+
10	2-hydroxy-3-methyl-2-cyclopenten-1-one	cooked, spicy	+ TP ^a , LS ^b , F ^c , S ^d	+ □	+ □	-	-	-
11	2,3-dimethyl-2-cyclopenten-1-one	spicy, wood fire, roasty	+ TP ^a , F ^b , S ^b , LS ^b	+ □	+ □	-	+ □	-
12	o-cresol	chemical, spicy, burnt, Burnt, animal, spicy	+ TP ^a , LS ^b , F ^b , S ^b + LS ^a , TP ^b , F ^c , S ^c	+ □	+ □	-	+ □	+
13	p-cresol	smoked, vanilla, ink	+ TP ^a , F ^b , S ^c , LS ^c	+ □	+ □	-	+ □	+
14	guaiacol	chemical, burnt, spicy/woody	+ TP ^a , S ^b , F ^c , LS ^c	+ □	+ □	-	+ □	+
15	2,6-dimethylphenol	cooked, green, spicy	+ TP ^a , S ^b , F ^b , LS ^b	+ □	+ □	-	+ □	+
16	2,3,4-trimethylcyclopenten-1-one	solvent, medicinal	+ LS ^a , F ^b , TP ^b , S ^b	+ □	+ □	-	+ □	+
17	3-ethyl-1,2-hydroxy-2-cyclopenten-1-one	ashes, green	+ TP ^a , LS ^b , F ^b , S ^b	+ □	+ □	-	+ □	-
18	1,2-dimethoxybenzene	cucumber, violet, spicy, smoked	+ TP ^a , LS ^b , S ^b , F ^c	+ □	+ □	-	+ □	-
19	2,4 and 2,5-dimethylphenol / (E)-2-nonenal	candy, spicy, smoked	+ TP ^a , LS ^b , S ^b , F ^b	+ □	+ □	-	+ □	-
20	4-methylguaiacol	cooked vegetable, fatty, green	+ TP ^a , F ^a , S ^b , LS ^b	+ □	+ □	-	+ □	-
21	2,3-dimethoxytoluene	burnt, green, chemical	+ TP ^a , F ^b , LS ^b , S ^b	+ □	+ □	-	+ □	-
22	(E)-2-decenal	spicy, green, milk	+ TP ^a , F ^a , LS ^a , S ^b	-	-	-	-	-
23	(E)-2-decenal	green, smoke, vanilla, clove	+ TP ^a , F ^b , LS ^b , S ^b	+ □	+ □	-	+ □	-
24	4-ethylguaiacol	sawdust, rotten, burnt	+ TP ^a , F ^c , LS ^b , S ^b	+ □	+ □	-	+ □	+
25	indanone	oily, green, fatty	+ TP ^a , S ^b , F ^c , LS ^d	+ □	+ □	-	+ □	-
26	(E,E)-2,4-decadienal	smoke, green, spicy	+ F ^a , LS ^b , S ^c , TP ^c	+ □	+ □	-	+ □	-
27	4-vinylguaiacol	burnt rubber, spicy	+ LS ^a , F ^b , TP ^b , S ^b	+ □	+ □	-	+ □	-
28	syringol	spicy, smoke, clove	+ F ^a , TP ^{a,b} , LS ^{b,c} , S ^d	+ □	+ □	-	+ □	+
29	eugenol	green, spicy, vanilla	+ TP ^a , LS ^b , F ^{b,c} , S ^c	+ □	+ □	-	+ □	-
30	4-propylguaiacol	cooked, earthy	+ TP ^a , F ^b , LS ^b , S ^b	+ □	+ □	-	+ □	-
31	1,2,3-trimethoxy-5-methylbenzene	burnt rubber, spicy	+ TP ^a , F ^a , LS ^b , S ^b	+ □	+ □	-	+ □	+
32	(Z)-isoeugenol	clove, green, roasty	+ TP ^a , F ^a , LS ^b , S ^b	+ □	+ □	-	+ □	+
33	(E)-isoeugenol	spicy, woody	+ LS ^a , F ^b , TP ^b , S ^b	+ □	+ □	-	+ □	+
34	2,3,5-trimethoxytoluene	smoke, rotten	+ F ^a , LS ^{a,b} , S ^b , TP ^b	+ □	+ □	-	+ □	-
35	4-allylsyringol	animal, roasty, chemical	+ LS ^a , F ^b , TP ^b , S ^c	+ □	+ □	-	+ □	-
36	8-heptadecene							-

+ : Significant effect of the considered factor or interaction at a risk of 5%.

- : No effect of the considered factor or interaction at a risk of 5%.

□ : Increase of concentration with the increase of the parameters of the factor considered.

* : Processes followed by the same letter in a same line are not significantly different. The processes are ranked from the process where the compound concentration is the strongest to the lowest.

A multi-way ANOVA (Table 3) indicated that time and temperature had significant effects on the deposition of odorant compounds in fish fillets ($p < 0.05$).

The increase of odorant compound contents related to the increase of smokehouse temperature could be due to higher fluidity of the lipid phase of fish flesh when temperature increased (Sérot *et al.*, 2004). A high temperature could also prevent condensation of water vapour on the surface of fish fillets resulting in a washing out of deposited smoke compounds (Chan 1975). These results could be related to the sensory data, as the notes for "smoky" attributes are higher when products are smoked at 32 °C related to the increase of deposition of wood smoke components.

Effect of smoke generation processes and smoking parameters on PAH content of smoked salmon

We can note that whatever the settings of the parameters, all smoking processes lead to higher levels of low molecular-weight PAHs than those of high molecular-weight (Figure 1). The concentrations of PAH from fluorene to fluoranthene varied between 1 and 5 µg kg⁻¹. Regarding the four processes, it should be noted that 5-methylchrysene, indeno [1, 2, 3-c,d]pyrene, dibenz[a,h]anthracene and all the dibenzopyrenes were not found in samples, whatever the time of smoke exposure or smokehouse temperature. These PAHs are considered much more toxic than low molecular-weight PAHs, such as fluorene.

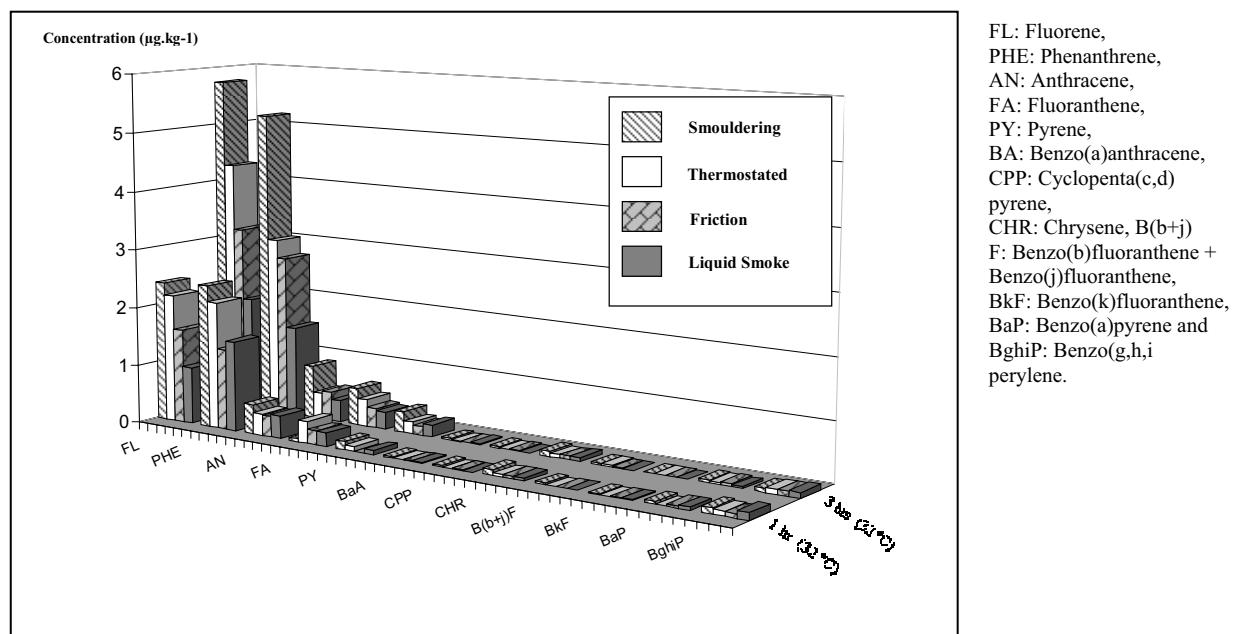


Figure 1. Distribution of PAHs contents according to the smoking process for one or three hours of smoking time at 32 °C

Since PAHs do not have the same level of toxicity, a TEF (toxic equivalent factor), expressed in comparison to benzo[a]pyrene, was defined for each PAH (Table 3). The concentration of each PAH is multiplied by its corresponding TEF and then added to obtain a single value illustrating the toxicity of the foodstuff studied. This value corresponds to the TEQ (toxic equivalent quantity) (AFSSA, 2003). The TEQ approach was chosen to express the total PAH contamination of a smoked or unsmoked product.

FL: Fluorene,
PHE: Phenanthrene,
AN: Anthracene,
FA: Fluoranthene,
PY: Pyrene,
BA: Benzo(a)anthracene,
CPP: Cyclopenta(c,d)
pyrene,
CHR: Chrysene, B(b+j)
F: Benzo(b)fluoranthene +
Benzo(j)fluoranthene,
BkF: Benzo(k)fluoranthene,
BaP: Benzo(a)pyrene and
BghiP: Benzo(g,h,i)
perylene.

Table 3. Toxic equivalent factor for the studied PAHs

List of PAHs	TEF (INERIS)	TEF (Larsen <i>et al.</i> , 1998)
Fluorene	0.001	0.05
Phenanthrene	0.001	0.0005
Anthracene	0.01	0.0005
Fluoranthene	0.001	0.05
Pyrene	0.001	0.001
Benzo(a)anthracene	0.1	0.005
Cyclopenta(c,d)pyrene	0.1	0.02
Chrysene	0.01	0.03
5-methyl-chrysene		
Benzo(b)fluoranthene	0.01	0.1
Benzo(j)fluoranthene		0.05
Benzo(k)fluoranthene	0.01	0.05
Benzo(a)pyrene	1	1
Benzo(g,h,i)perylene	0.01	0.02
Indeno (1,2,3-cd)pyrene	0.1	0.1
Dibenzo(a,h)anthracene	1	1.1
Dibenzo(a,l)pyrene		1
Dibenzo(a,e)pyrene		0.2
Dibenzo(a,h)pyrene		1
Dibenzo(a,i)pyrene		0.1

TEF of 5-methylchrysene was only assessed for an aerial contamination and set at 1 (Collins *et al.*, 1998)

The ANOVA performed on data, shows significant differences of the PAH concentrations according to the smoking process. Smouldering gave the highest and liquid smoke the lowest concentrations of low molecular-weight PAHs. Friction and thermostatic plates lead to intermediary and similar levels of contamination, especially for fluoranthene and pyrene (from 0.10 to 0.40 µg kg⁻¹) or phenanthrene. Whereas the content of the PAH with a higher molecular weigh (Benzo[a]pyrene, Benzo[g,h,i]perylene) is the highest when friction process is used and no significant difference is observed for the other processes.

Fisher's least significant difference (LSD) procedure performed on TEQ data calculation allows a comparison between two groups (Figure 2). The first group consists in fish smoked by using friction and smouldering processes and whose fillets present a high TEQ value. The second group consists in fish smoked by using thermostatic plated and liquid smoke atomization; in the latter case the fillets presented TEQ value significantly weaker.

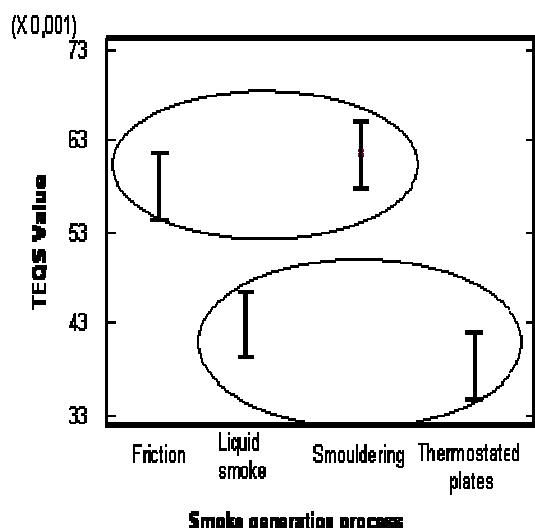


Figure 2. Comparison of TEQ value means according to the smoke generation process, 95% Least Significant Difference was plotted

It is important to note that when smoke comes from wood pyrolysis the maximum residue limit of 5 $\mu\text{g}.\text{kg}^{-1}$ of benzo(a)pyrene fixed by the European Commission for smoked seafood products is never reached.

The statistical analysis of data shows that the effect of time and temperature of smoking depends on the molecular weight of PAH. The effect of temperature smoking was highlighted only for the most lightweight compounds, i.e. Fluorene, Phenanthrene, Anthracene (Figure 3) The effects of smoking times concern also the low molecular weight compounds like Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene and Benz[a]anthracene.

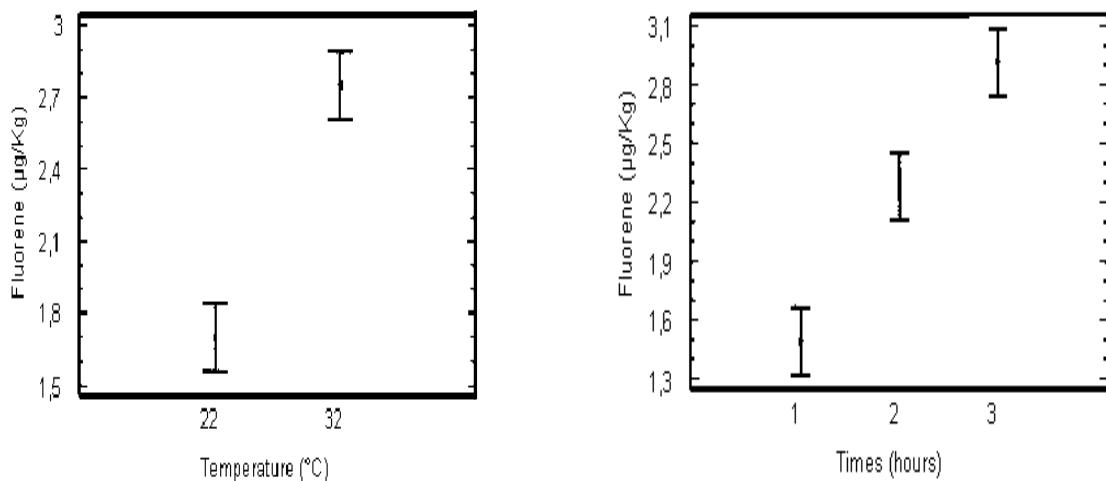


Figure 3. Comparison of fluorine content in smoked salmon according to time and temperature values: 95% Least Significant Difference was plotted

Furthermore, a multiway ANOVA shows a strong interaction between times of smoking and smoke generation process. Indeed, when smoking times increase the PAH content is significantly more important during the production of smoke by smouldering than by other processes.

4. CONCLUSIONS

This study shows the complexity of the composition of smoke compounds deposited on fish fillets during smoking.

We have shown, through olfactometric methods, the importance of smoking process parameters on the odorant compound contents. Furthermore for the first time we were able to establish a statistical relationship between the odorant volatile compounds content, the parameters of smoking and organoleptic perception of the flavour of smoked salmon. The results of this study confirm the importance of phenolic and furanic compounds in smoked salmon aroma, particularly for “wood fire smoke” odour and flavour in products smoked by thermostatic plates, friction or smouldering. Syringol and cresols seem to be implied in the “cold smoke” sensory attributes of the products treated by liquid smoke.

The development of an efficient analytical method has allowed to characterize and quantify the PAH present in smoked fish. The content of PAH is related to smoke generation process and smoking parameters. Nevertheless the PAH quantities are always below the European legal limit for smoked fish. The highest concentration of benzo(a)pyrene is found after three hours of smoke exposure and reaches 0.04 $\mu\text{g}.\text{kg}^{-1}$, still clearly below 5 $\mu\text{g}.\text{kg}^{-1}$.

It can be noted that there is no correlation between volatile compounds content and PAH content. Indeed, the thermostatic plates’ process leads to high contents in odorant compounds and allows to obtain smoked products with a low TEQ, while we have a reverse situation for friction and smouldering processes.

However, to obtain additional information, further trials are necessary, including not only the effect of the parameters of the smoke generation (kind of wood, wood moisture, temperature air quantity) but also the impacts of the composition of fish fillets, particularly lipid and water contents.

5. RECOMMENDATIONS

Our work shows that traditional industrial smoking processes give smoked fish with some organoleptic characteristics and that a high perception of smoke flavour can be related to high time and temperature of smoking. So the organoleptic quality of smoked fish can be easily adapted to consumer's demands. However, when lightly smoked fish is produced, some safety problems can occur.

The use of liquid smoke atomization can produce smoked fish with organoleptic characteristics significantly different from traditional industrial processes. However, our trials were carried out with one kind of liquid smoke. Studies actually performed in our laboratories with other kinds of liquid smoke tend to demonstrate that it could be possible to obtain, by liquid smoke atomization, smoked fish with organoleptic properties very close to those of fish smoked with traditional processes.

The formation of PAH during smoking and drying is dependent on a number of variables, including:

- Kind of wood;
- Wood moisture;
- Smoking method (smoking or drying - direct or indirect);
- The distance between the food and the heat source (not really shown);
- Processing time;
- Temperature during processing;
- Smoke generation mode; and
- Cleanliness and maintenance of equipment.

Many authors reported that the use of the soft wood species (resinous wood) results in increased levels of benzo[a]pyrene compared to the use of hard wood. Maga, 1988, proposed to use hard woods instead of soft woods to reduce the PAH content. However, limited research has been conducted showing some discrepancies. (Guillén *et al.*, 2000).

Direct smoking is the traditional type of smoking process where the smoke is produced in the same chamber in which the food is processed; indirect smoking uses smoke generators, with the smoke being produced in a separate chamber and possibly cleaned in various ways before being fed into the smoking chamber. Direct smoking requires less equipment than indirect smoking but can result in higher levels of PAH in the product. Previous studies show that when direct smoking process was used PAH contents could be 10 times higher than PAH contents when indirect smoking process was used.

In our study we used three indirect smoking processes and we can observe that the PAH content was always lower than the European legal limit.

Recent trials performed in our laboratory seem to show that the use of wet wood could decrease the PAH contents, so we can propose that PAH content of smoked can be minimized by:

- Use of hard wood rather than soft wood to generate smoke;
- Use wood that is not too dry;
- Using indirect smoking process whenever possible instead of direct smoking;
- Control of smoke generation temperature should include assessment of the resulting PAH content in the smoke;
- Filter or cool the smoke between generator and smokehouse; and
- In the case of facilities with a certain production capacity, the use of liquid smoke atomization could be an alternative. This process allows both the organoleptic quality control and production process with a low rate of PAH. It also helps to eliminate fire hazards.

Reduction of time and temperature of smoking did not seem defining parameters for PAH contamination especially as their decrease could provide an inadequate microbial food safety.

6. REFERENCES

AFSSA. 2003. Avis de l'AFSSA relatif à une demande d'avis sur l'évaluation des risques présentés par le benzo[a]pyrene B[a]P et par d'autres hydrocarbures aromatiques polycycliques (HAP), présents dans diverses denrées ou dans certaines huiles végétales, ainsi que sur les niveaux de concentration en HAP dans les denrées au-delà desquels des problèmes de santé risquent de se poser. Agence Française de Sécurité Sanitaire des Aliments. Saisine n°2000-SA-0005.

Anonymous. 2004. European consumer preferences for smoked salmon. Collective report from European project - QLK1-2000-01575, specific RTD programme "Quality of Life and Management of Living Resources"– EUROSALMON – Nantes: Adriant.

Cardinal, M., Berdagué, J.L., Dinel, V., Knockaert, C. & Vallet, J.L. 1997. Effect of various smoking techniques on the nature of volatile compounds and on the sensory characteristics of salmon meat. *Sci. Alim.*, 17, 679–696.

Cardinal, M., Cornet, J., Sérot, T. & Baron, R. 2006. Effects of the smoking process on odour characteristics of smoked herring (*Cuplea harengus*) and relationships with phenolic compound content. *Food Chemistry*, 96, 137–146.

Chan, W.S. & Toledo, R.T. 1975. Effect of smokehouse temperature humidity and air flow on smoke penetration into fish muscle. *J. Food Sci.*, 1975, 40, 240–243.

Collins, J.F., Brown, J.P., Alexeef, G.V. & Salmon, A.G. 1998. Potency equivalency factors for some polycyclic aromatic hydrocarbons and polycyclic aromatic hydrocarbons derivatives. *Regulatory Toxicology and Pharmacology* 28(1):45–54.

De Boer, J. & Law, R.J. 2003. Development in the use of chromatographic techniques in marine laboratories for the determination of halogenated contaminants and polycyclic aromatic hydrocarbons. *Journal of Chromatography A* 1000:223–251.

European Commission. 2005b. Official Journal of the European Union, L 34:43–45.

Guillén, M.D. & Manzanos, M.J. 2002. Study of the volatile composition of an aqueous oak smoke preparation. *Food Chem.*, 79, 283–292.

Guillén, M.D., Sopelana, P. & Partearroyo, M.A. 2000a. Determination of polycyclic aromatic hydrocarbons in commercial liquid smoke flavorings of different compositions by gas chromatography-mass spectrometry. *Journal of Agriculture and Food Chemistry* 48:126–131.

Guillén, M.D., Sopelana, P. & Partearroyo, M.A. 2000b. Polycyclic aromatic hydrocarbons in liquid smoke flavorings obtained from different types of wood. Effect of storage in polyethylene flasks on their concentrations. *Journal of Agriculture and Food Chemistry* 48:5083–5087.

INERIS, Doornaert, B., Pichard, A. & Gillet, C. 2003. Hydrocarbures aromatiques polycycliques (HAPs). Evaluation de la relation dose-réponse pour des effets cancérogènes: Approche substance par substance (facteurs d'équivalence toxique – FET) et approche par mélanges. Evaluation de la relation dose-réponse pour des effets non cancérogènes: Valeurs Toxicologiques de Référence (VTR). INERIS-DRC-03-47026-ETSC-BDo-N°03DR177.

Järvenpää, E., Huopalahti, R. & Tapanainen, P. 1996. Use of supercritical fluid extraction-high performance chromatography in the determination of polynuclear aromatic hydrocarbons from smoked and broiled fish. *Journal of Liquid Chromatography and Related Technologies* 19(9):1473–1482.

Karl, H. 1997. Influence of the smoking technology on the quality of smoked fish regarding undesirable compounds. In: *Seafood from Producer to Consumer, Integrated Approach to Quality*. Luten JB, editor. Amsterdam: Elsevier Science Publishing. pp. 633–639.

Karl, H. & Leinemann, M. 1996. Determination of PAH in smoked fishery products from different smoking kilns. *Zeitschrift fur Lebensmittel Unterschung und Forschung*, 202:459–464.

Kjhallstrand, J. & Petersson, G. 2001. Phenolic antioxidants in wood smoke. *The Science of the Total Environment*, 27, 69–75.

Monteau, F., Sarcher, L., Varlet, V., Maume, D., André, F. & Le Bizec, B. 2005. Compared mass spectrometry approaches for PAH determination in food. Work presented at the Dioxin 2005 / ISPAC 20 congress, Toronto, Canada.

Sérot, T., Baron, R., Knockaert, C. & Vallet, J.L. 2004. Effect of smoking processes on the contents of 10 major phenolic compounds in smoked fillets of herring (*Cuplea harengus*). *Food Chem.*, 85, 111–120.

Šimko, P. 2002. Determination of polycyclic aromatic hydrocarbons in smoked meat products and smoke flavouring food additives. *Journal of Chromatography B* 770:3–18.

Šimko, P. 2005. Factors affecting elimination of polycyclic aromatic hydrocarbons from smoked meat foods and liquid smoke flavorings. *Molecular Nutrition and Food Research* 49:637–647.

Stone, H. & Sidel J. 1998. Quantitative descriptive analysis: Developments, applications and the future. *Food Technology*, 52: 48–52, 1998.

Varlet, V., Knockaert, C., Prost, C. & Sérot, T. 2006. Comparison of odour-active volatile compounds of fresh and smoked salmon. *Journal of Agricultural and Food Chemistry*, 54(9), 3391–3401.

Varlet, V., Prost, C. & Sérot, T. 2007. New procedure for the study of odour representativeness of aromatic extracts from smoked salmon. *Food Chem.*, 100(2), 820–829.

Varlet, V., Sérot, T. & Prost, C. 2007a. New procedure for the study of odour representativeness of aromatic extracts from smoked salmon. *Food Chemistry*, 100, 820–829.

Varlet, V., Sérot, T., Cardinal, M., Knockaert, C. & Prost, C. 2007b. Olfactometric determination of the potent odour-active compounds in salmon muscle (*Salmo salar*) by using four smoke generation techniques. *Journal of Agricultural and Food Chemistry*, 55, 4518–4525.

Varlet, V., Serot, T., Monteau, F., Le Bizec, B. & Prost, C. 2007c. Determination of PAH profiles by GC-MS/MS in salmon muscle processed according to four different smoking techniques. *Food Additives and Contaminants*, Volume 24, Issue 7 July 2007, 744–757.

Wang, G, Lee, A.S., Lewis, M., Kamath, B. & Archer, R.K. 1999. Accelerated solvent extraction and gas chromatography/mass spectrometry for determination of polycyclic aromatic hydrocarbons in smoked food samples. *Journal of Agriculture and Food Chemistry* 47:10626–1066.

COMMERCIAL FISH SPECIES IDENTIFICATION WITH ISOELECTRIC FOCUSING: APPLICATION TO BREADED FISH PRODUCTS

/IDENTIFICATION DES ESPÈCES COMMERCIALES AVEC LA FOCALISATION ISOÉLECTRIQUE: APPLICATION AUX PRODUITS DE LA PÊCHE/

by/par

V. Tepedino, L. Ababouch, M. Ferri¹ and A. Berrini

Abstract

The globalization of fish and fishery products markets combined with the increase of consumer demand lead to a huge variety of non-endemic fish species in the marketplace. This might raise concerns about the inability of fish inspectors to distinguish fish species with similar morphological characteristics, particularly when they are processed and sold as fillets or slices in the country of origin, and to detect fish substitution, a practice where high value species are mislabeled and/or substituted in whole or in part with low value, species or products with potential toxins.

Several biochemical methods have been developed in order to identify fish species. The isoelectric focusing (IEF) of the water soluble sarcoplasmic proteins proved to be suitable, fast and reliable. A project funded by the Italian Agricultural Ministry aimed at identifying fish species with IEF has recently been concluded. The results demonstrated the suitability of the method in identifying most of the commercial fish species. The database developed contains the patterns of more than 250 fish species, and the software is able to compare the IEF patterns and identify unknown species.

In the present paper we show the application of the IEF method to semicooked products in order to demonstrate the usefulness of the method also in the identification of species used in breaded fish products (breaded fish fingers and fillets). The importance and advantages of using the IEF technique in the African fish industry exporting to Europe in the context of self-control and certification program are also highlighted.

Key words: *Isoelectric focusing (IEF), Breaded fish products, Commercial fraud, Traceability*

Résumé

La globalisation des marchés de poisson et produits de la pêche combinée à la demande croissante du consommateur conduit à une grande variété d'espèces non endémiques de poisson sur le marché de poisson. La conséquence directe est l'incapacité pour les inspecteurs du poisson de distinguer les espèces de poisson ayant des traits morphologiques similaires, en particulier quand elles sont transformées et vendues comme filets ou tranches dans le pays d'origine. Une identification correcte du poisson est fondamentale pour éviter une substitution frauduleuse.

Plusieurs méthodes biochimiques ont été développées dans le but d'identifier les espèces de poisson. La focalisation isoélectrique (IEF) sur les protéines sarcoplasmiques hydrosolubles a montré sa pertinence, sa rapidité et sa fiabilité. Un projet financé par le Ministère italien de l'agriculture visant à identifier les espèces de poisson avec IEF a été récemment accompli. Les résultats ont démontré la pertinence de la méthode dans l'identification de la plupart des espèces commerciales de poisson. La base de données contient les modèles de plus de 250 espèces de poisson, et le logiciel est capable de comparer les modèles IEF et identifier des espèces inconnues.

Dans le document présent nous avons appliqué la méthode IEF aux produits semi-cuits pour démontrer l'utilité de la méthode également dans l'identification des espèces utilisées dans les produits de poisson pané (bâtonnets et filets de poisson pané).

Mots clés: *Focalisation isoélectrique (IEF), Produits de pêches panés, Fraude commerciale, Traçabilité*

¹ Ministry of Health, Veterinary Service – ASL Pescara, Strada 387 da denominare 5, 65154 Pescara, Italy. gbnltf@tin.it/info@aquatilia.it

1. INTRODUCTION

Consumers, and particularly children, like breaded fish products due to the enriched flavour, lack of bones and easiness to prepare. For their manufacture different fish species belonging to Order of Gadiformes and Pleuronectiformes are used. In the marketplace these products are labelled as breaded cod fish fingers, breaded cod medallions and breaded plaice fillets. The fish species declared on the label and mostly used for the manufacture of cod fish fingers and cod medallion are the Argentine hake (*Merluccius hubbsi*) and the shallow water Cape hake (*Merluccius capensis*), while for the plaice fillets the species commonly used is the plaice (*Pleuronectes platessa*).

Current EU legislation does not require a compulsory indication on the label of the scientific or common denomination of the species used in the processed fish products. According to traceability and transparency requirements specified in the White Book and subsequent EU Regulations, consumers must be provided with all information regarding ingredients and species used in the manufacturing of any food products, including fish products.

In order to check if processed food products are properly labeled and to identify fraudulent use it is necessary to employ an analytic laboratory method for the identification of species.

The Isoelectric focusing (IEF) on polyacrylamide gels of the sarcoplasmic proteins proved to be particularly effective for the identification of species on fresh and frozen fish products (Lundstrom, 1979; Rehbein, 1990; Tepedino, 2001). In processed and thermal treated products, proteins can be denatured and might lose their own characteristics. This often leads to an IEF pattern altered compared to the standard, and therefore not identifiable. However, most breaded products (fish fingers, medallions and fillets) are quickly pre-fried in oil and such heat treatment does not seem to alter the proteins.

2. OBJECTIVES

The purpose of this research was to use the IEF technique to identify fish species used to prepare breaded cod fish fingers, and breaded plaice fillets. A preliminary market investigation was carried out in Milan (Italy) with the purchase of fifteen packages of processed and quick frozen fish products of different brands with the selling denomination of “Breaded Cod fish fingers”, “Breaded Cod medallions” and “Breaded Plaice fillets”.

3. METHODOLOGY

Frozen breaded fish fingers, medallions and fillets were cut in the central part in order to sample the muscular tissue. Special care was used to avoid sampling the breaded parts. 0.2–0.5 g of tissue were collected using a scalpel, and suspended in H₂O to obtain a concentration of 1 g/ml. The protein extraction was carried out as previously described (Berrini, 2005; Tepedino, 2004; Tepedino, 2003).

The extracted proteins were analyzed with the IEF technique described earlier. Briefly, 30 µg of extracted proteins were loaded on a gel for IEF (GelBond PAG pH 3.5–9.5, GE Healthcare). The separation was performed at 10 °C, applying constantly 30W, with a maximum voltage of 1500V. The run time was 90 min. At the end of the run, the gel was fixed on TCA, acetylsalicylic acid for 60 min and stained with Coomassie Brilliant blue. The gel image was acquired using a scanner with a resolution of 300 points/cm and inserted into the data-base to perform the pattern analysis (Gel Compar II, AppliedMath, Saint-Martens, Belgium).

4. RESULTS

The IEF patterns obtained from breaded products were perfectly identifiable in comparison with the standard patterns obtained from the fresh products. This confirms that the quick pre-fry does not alter sarcoplasmic proteins of the inner part of breaded fish.

Figure 1 shows an example of the standard patterns of Argentine hake (*Merluccius hubbsi*), Cape hake (*Merluccius capensis*), plaice (*Pleuronectes platessa*) and dab (*Limanda limanda*) and the patterns obtained from breaded fish fingers and fillets. The patterns from unknown breaded samples are perfectly comparable with the patterns from standard species. This allows a certain identification of the species used in the preparations. Table 1 reports the results obtained from the 15 products analysed.

As far as cod-based products are concerned, the species identified were the Argentine hake (*Merluccius hubbsi*) (n. 5), the Alaska pollack (*Theragra chalcogramma*) (n. 2), the Cape hake (*Merluccius capensis*) (n. 2) and the blue whiting (*Micromesistius poutassou*) (n. 1). The results showed that for the manufacture of breaded products, different fish species with diverse commercial value and quality are commonly used. In fact, the generic term “cod” includes different species belonging to either the Gadidae family or Merluccidae family. Since the indication on the label of the scientific denomination of fish species used in processed fish products is not compulsory, the majority of the analysed samples complied with current legislation. The only products not complying with the legislation were those containing Alaska pollack and Blue whiting, that cannot be labelled with the generic term “cod”.

Regarding the samples of breaded plaice fillets, only 1 out of 5 was manufactured using the species *Pleuronectes platessa*, while the others were made with the Dab (*Limanda limanda*). It has to be noted that for all these commercial products the species reported on the label was *Pleuronectes platessa*. This is an illegal labelling.

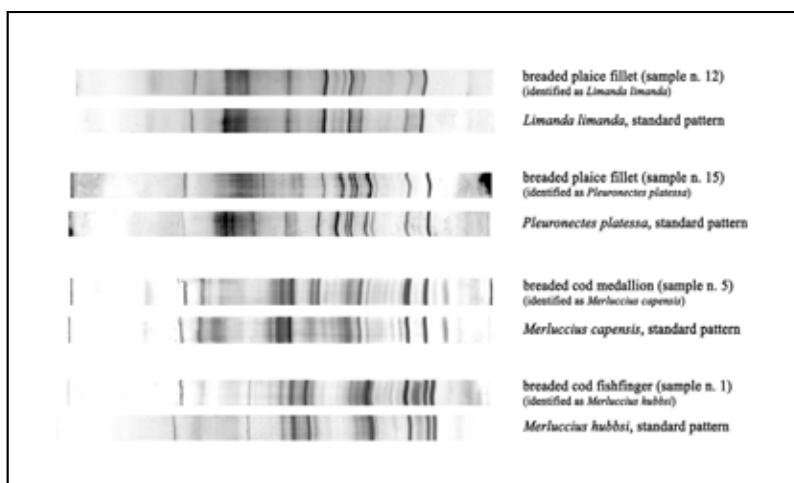


Figure 1. Standard patterns of some fish species and the patterns of breaded fish fingers and fillets

Table 1. Market research

Sample n.	Selling denomination of the product	Fish species indicated on the label (where present)	Fish species actually used and detected with IEF
1	Breaded cod fishfingers	<i>Merluccius hubbsi</i>	<i>Merluccius hubbsi</i>
2	Breaded cod fishfingers	<i>Merluccius hubbsi</i>	<i>Merluccius hubbsi</i>
3	Breaded cod fishfingers	<i>Merluccius hubbsi</i>	<i>Merluccius hubbsi</i>
4	Breaded cod medallions		<i>Theragra chalcogramma</i>
5	Breaded cod medallions		<i>Merluccius capensis</i>
6	Breaded cod medallions		<i>Theragra chalcogramma</i>
7	Cod slices in crunchy breading		<i>Merluccius capensis</i>
8	Cod slices in crunchy breading		<i>Micromesistius poutassou</i>
9	Cod slices in crunchy breading		<i>Merluccius hubbsi</i>
10	Cod slices in crunchy breading		<i>Merluccius hubbsi</i>
11	Breaded plaice fillets	<i>Pleuronectes platessa</i>	<i>Limanda limanda</i>
12	Breaded plaice fillets	<i>Pleuronectes platessa</i>	<i>Limanda limanda</i>
13	Breaded plaice fillets	<i>Pleuronectes platessa</i>	<i>Limanda limanda</i>
14	Breaded plaice fillets	<i>Pleuronectes platessa</i>	<i>Limanda limanda</i>
15	Breaded plaice fillets	<i>Pleuronectes platessa</i>	<i>Pleuronectes platessa</i>

5. CONCLUSIONS

Electrophoretic methods are widely employed in investigations of food products. IEF is a particularly well known technique used for species identification in fish products, even in those partially processed (breaded preparations). The correct fish identification is fundamental to avoid fraudulent substitution as in the case of Plaice fraud described above, and is a challenge faced by consumers and regulators. The direct advantages of using the IEF technique are to:

- help the inspectors identify fish products that, due to processing, are not easily identified macroscopically, and also detect species substitution that could result in potential adverse health consequences or could be a source of economic fraud; and
- provide consumers with true information about the product and its origin. This is particularly true nowadays with a growing appreciation of these “ready to cook” products by consumers, which requires a proper label indication of fish species used and their origin.

6. SPECIAL RECOMMENDATION FOR DEVELOPING COUNTRIES

Protein IEF, which is the most popular official method for fish species identification in the United States of America, can be of great interest to developing countries, in particular the African region where, in the last decade, artisanal and industrial processing plants increased their export to the European market of fish products mostly in the form of fillets. Species commonly used for fillets production belong to *Merluccius capensis* (Cape hake), *Solea senegalensis* (Senegalese soley), *Pseudupeneus prayensis* (West African goatfish), *Lates niloticus* (Nile perch) and *Zenopsis conchifer* (Slevery John Dory). These fillets are used in the European post-processing industry to manufacture breaded fish fingers, breaded fish medallions and other products.

The economy of IEF (which with around US\$15/IEF pattern is cheaper than DNA method), its practicability (no need for sophisticated laboratory and expertise) and rapidity (results obtained in less than 2 days), make this technique a practical and friendly method to use for developing countries affected by economic and laboratory infrastructure constraints. The African fish industry in the context of self-control programs, might apply IEF techniques as pre-verification tests by randomly checking batches of fillets and other fish products destined for export and, consequently, certify what is declared on the label. In Italy the IEF is being positively evaluated as a potential official method and this will help mutual verification between exporter and importer.

IEF techniques will definitely allow the African fish industry to comply with transparency and traceability requirements specified under EU legislation, add value to their products and offer better guarantees to European and worldwide consumers, providing them with correct information on the origin of, and species utilized in, processed fish products.

Ultimately the technical cooperation and information exchange between countries will pave the way for transferring this technology and make it available to African research institutions involved in fish quality and safety.

7. REFERENCES

Berrini, A., Tepedino, V., Borromeo, V. & Secchi, C. (2005) *J. AOAC Int.* 88, 670–672.
Lundstrom, R.C. 1979. *J. Assoc. Off. Anal. Chem.* 62, 624–629.
Rehbein, H. 1990 *Z. Lebensm. Unter. Forsch.* 191, 1–10.
Tepedino, V., Berrini, A., Borromeo, V., Gaggioli, D., Cantoni, C., Manzoni, P. & Secchi, C. 2001 *J. AOAC Int.* 84, 1600–1607.
Tepedino, V., Raimondi-Evalli, S., Berrini, A., Borromeo, V., Secchi, C. & Manzoni, P. 2003. *Eurofishmarket* 1, 10–13.
Tepedino, V., Raimondi-Evalli, S., Berrini, A., Borromeo, V., Secchi, C. & Manzoni, P. 2004. *Eurofishmarket* 2, 16–26.

ÉTUDE COMPARATIVE DE LA QUALITÉ BACTÉRIologIQUE DE L'EAU UTILISÉE DANS LES INDUSTRIES DE LA PÊCHE AU SÉNÉGAL EN FONCTION DU TRAITEMENT APPLIQUÉ

[COMPARATIVE STUDY OF THE BACTERIOLOGICAL QUALITY OF WATER USED IN FISHING INDUSTRIES IN SENEGAL ACCORDING TO THE TREATMENT APPLIED]

by/par

K.S.B. Sylla¹, B. Musabyemariya and M.G. Seydi

Résumé

Au Sénégal, les traitements les plus utilisés sont la chloration, l'ozonation et le traitement par les rayons ultra-violets. Cette étude menée au niveau de 5 usines de transformation des produits de la pêche (A, B, C, D et E) a pour objectif d'apprécier l'efficacité des traitements appliqués sur l'eau du réseau public (eau potable) mais également sur l'eau de mer. Elle a consisté en des analyses bactériologiques (500 échantillons) de l'eau et de la glace utilisées dans ces unités.

Des résultats il ressort que, 77,3% des échantillons d'eau et de glace de l'ensemble des usines sont satisfaisants avant traitement et 91,2% le sont après application des différents traitements.

L'analyse de l'effet des traitements appliqués a montré que:

Au niveau de l'usine A (utilisant l'ozone)

Absence d'efficacité en ce qui concerne les coliformes fécaux, thermotolérants et les ASR. Pour les streptocoques et la flore aérobie l'ozone a permis une réduction respectivement de 25% et 15% de la contamination initiale.

Au niveau des usines B et C (utilisant le chlore)

Le chlore a permis la diminution respectivement de 15% et 7% de la contamination par les coliformes fécaux et les staphylocoques. Pour les autres germes, une conformité totale est obtenue après traitement.

Au niveau de l'usine D (utilisant les UV)

Le traitement aux rayons ultraviolets a conduit à l'élimination respectivement de 15% et 35% de la flore totale et des coliformes totaux. Par contre pour les ASR et les streptocoques, l'effet est plus faible car les pourcentages obtenus sont de 5%.

Au niveau de l'usine E (utilisant le chlore + les UV)

Le traitement combiné a entraîné une élimination de toutes les contaminations observées avant.

Il découle de cette étude que l'eau traitée aux rayons ultra violet et au chlore est moins contaminée. En effet, d'après les statistiques du bureau de contrôle des produits de la pêche, les usines utilisant les autres méthodes de traitement ont connu plus d'alertes communautaires (UE).

Mots clés: Eau, Glace, Bactériologie, Industrie de pêche

Abstract

In Senegal, the most used water purification treatments are by chlorination, ozone or UV rays. The aim of this study, which was carried out in five fish processing factories in Dakar (A, B, C, D and E), was to understand the effectiveness of treatments applied to water in the public network (drinking water) and also to sea water. 500 water and ice samples from these factories were collected for bacteriological analysis.

Results showed that 77.3% of the water and ice samples from all the factories were satisfactory before treatment and 91.2% after the various treatments had been applied.

¹ École inter-États des sciences et médecine vétérinaires (EISMV), Laboratoire HIDAOA, Université de Dakar, BP 5077, Dakar, Senegal.
khsylla@refer.sn

The analysis of the effects of the treatments applied showed that:

In factory A (using ozone)

Absence of effectiveness regarding the faecal coliforms and sulfite-reducing anaerobic bacteria (SRAB). For streptococci and aerobic flora, ozone allowed a reduction of 25% and 15%, respectively, of the initial counts.

In factory B and C (using chlorine)

Chlorine allowed a reduction of 15% and 7%, respectively, of contamination by faecal coliforms and staphylococci. For other germs, a total compliance with microbiological criteria was obtained after treatment.

In factory D (using UV rays)

UV ray treatment led to the elimination of 15% and 35%, respectively, of the total aerobic flora and coliforms. However, for SRAB and streptococci, the effect was weaker as the obtained results were 5%.

In factory E (using chlorine + UV rays)

The combined treatment resulted in the elimination of all the previous contamination.

This work showed that the water treated using UV rays and chlorine is less contaminated. Indeed, according to the statistics of the control office of fishery products, the factories using the other methods of treatment have had more EC alerts.

Keywords: Water, Ice, Bacteriology, Fish industry

1. INTRODUCTION

L'eau est pratiquement le seul moyen utilisé dans les industries alimentaires pour laver les locaux, les installations et les denrées; notamment dans les établissements de transformation des produits de la mer (J.C. Minla'a *et al.*, 2001).

A cet effet, elle intervient dans le transport, les opérations de prétraitement des poissons, dans la fabrication de glace et dans les autres opérations de filetage, de marinade, de congélation et de mise en conserve. Son usage est donc incontournable.

Cependant l'eau peut constituer un vecteur potentiel de germes pathogènes (salmonelles, vibron cholérique, etc.) mais aussi des germes d'altération (*Pseudomonas*), ou de contamination fécale (coliformes fécaux). Ainsi des analyses bactériologiques sont effectuées régulièrement sur l'eau afin de déterminer leur niveau de potabilité. La qualité de l'eau utilisée diffère énormément d'un endroit à l'autre, de même que la méthode de traitement.

Pour prévenir les conséquences néfastes d'une contamination de l'eau chez les consommateurs et sur la qualité du produit, les industries des produits de la pêche doivent mettre en place des moyens efficaces de traitement de l'eau, afin de respecter les normes de qualité requises par l'Union européenne pour les produits à l'exportation.

L'objectif de ce travail est de vérifier par sondage, l'efficacité des systèmes de traitement de l'eau utilisée dans cinq usines de traitement des produits de la pêche situés à Dakar. Il présente les résultats d'analyses officielles réalisées au laboratoire d'HIDAOA de l'école vétérinaire de Dakar, pour le compte de la direction des pêches maritimes.

2. MATÉRIEL ET MÉTHODES

Matériel

Milieu de l'étude

Cette étude a été réalisée au niveau de cinq unités de transformation des produits de la pêche (usines de filetage-réfrigération-congélation) qui détiennent tous un agrément pour l'exportation de leurs produits élaborés au niveau de l'Union européenne. Les noms de ces entreprises ont été mis sous anonymat sur demande de l'autorité

compétente chargée du contrôle et de l'inspection. Les lettres de l'alphabet A, B, C, D et E ont été utilisés à cet effet.

Matériel de prélèvement

- Glacières;
- Flacons en verre pyrex de 500 ml;
- Bouchons stériles;
- Papier collant pour identifier les flacons;
- Carboglaces; et
- Petit chalumeau (camping gaz).

Matériel de laboratoire

Il est constitué par l'ensemble des éléments utilisés dans un laboratoire d'analyse bactériologique des produits alimentaires, il s'agit:

- des milieux de culture et des réactifs;
- d'une balance de précision pour la pesée;
- de la verrerie: tubes à essai, erlenmeyer, flacons, boîte de Pétri, pipettes, étaleur;
- du matériel de stérilisation;
- des bains-marie pour la régénération des milieux; et
- du matériel d'incubation.

Méthodes

Prélèvement

- Les flacons utilisés sont des flacons de 500 ml en verre, lavés, séchés et stérilisés au four Pasteur pendant 45 minutes à 180 °C;
- Les prélèvements sont effectués au robinet. Avant de procéder au prélèvement le robinet est stérilisé avec une flamme pendant 2 minutes;
- Après l'ouverture du robinet, l'eau coule librement pendant quelques minutes avant que le remplissage des flacons ne soit fait;
- Une fois le flacon rempli le goulot est flambé avant de fermer avec le bouchon, ensuite le flacon est placé dans une glacière.

Échantillonnage

Au niveau de chaque usine et durant 3 mois (de janvier à mars 2007), 100 échantillons ont été prélevés en raison de 50 échantillons avant traitement et 50 autres après application du traitement en fonction des méthodes suivantes:

- l'usine A, utilisant l'ozonisation de l'eau;
- l'usine B et C, utilisant la chloration de l'eau;
- l'usine D, utilisant le traitement par les rayons UV; et
- l'usine E, utilisant la combinaison UV + chloration.

Germes recherchés

Les groupes de germes recherchés et les méthodes utilisées sont consignés dans le Tableau 1.

Tableau 1. Germes recherchés et normes utilisées

Germes recherchés	Normes utilisées (AFNOR)
Germes aérobies viables à 37 °C et 22 °C	NF EN ISO 6222
Coliformes totaux	NFT 90-413
Coliformes thermotolérants (<i>E. Coli</i>)	NF EN ISO 9308-1
Anaérobies sulfito-réducteurs (<i>Clostridium perfringens</i>)	NF EN ISO 26461-2
Entérocoques intestinaux (streptocoques)	NF EN ISO 7899-2
Staphylocoques pathogènes	NFT 90-421

L'interprétation des résultats a été faite selon les critères microbiologiques établis par la réglementation européenne en vigueur dans le domaine.

3. RÉSULTATS ET DISCUSSION

Résultats

Les flores totales à 37 °C, 22 °C et les anaérobies sulfito-réducteurs ont donné des résultats chiffrés (germes/ml).

Pour les coliformes totaux, coliformes thermotolérants, les staphylocoques, les streptocoques fécaux, les résultats sont qualitatifs c'est-à-dire indiqués par des signes: positif pour présence de germes et négatif pour absence de germes.

Niveau de contamination par la flore aérobie à 37 °C et 22 °C

Tableau 2. Niveau de contamination de l'eau par la flore aérobie mésophile totale

Usine de pêche	Niveau de conformité des échantillons en pourcentage	
	Avant traitement de l'eau	Après traitement de l'eau
A	80%	95%
B	79%	100%
C	80%	100%
D	80%	95%
E	80%	100%

Niveau de contamination par les anaérobies sulfito-réducteurs (ASR)

Tableau 3. Niveau de contamination de l'eau par les ASR

Usine de pêche	Niveau de conformité des échantillons en pourcentage	
	Avant traitement de l'eau	Après traitement de l'eau
A	20%	25%
B	92%	100%
C	90%	100%
D	91%	95%
E	90%	100%

Niveau de contamination par les coliformes totaux

Tableau 4. Niveau de contamination de l'eau par les coliformes totaux

Usine de pêche	Niveau de conformité des échantillons en pourcentage	
	Avant traitement de l'eau	Après traitement de l'eau
A	Présence dans 90%	Présence dans 85%
B	Présence dans 40%	Absence dans 100%
C	Présence dans 35%	Présence dans 5%
D	Présence dans 39%	Présence dans 4%
E	Présence dans 38%	Absence dans 100%

Niveau de contamination par les coliformes thermotolérants

Tableau 5. Niveau de contamination de l'eau par les coliformes thermotolérants

Usine de pêche	Niveau de conformité des échantillons en pourcentage	
	Avant traitement de l'eau	Après traitement de l'eau
A	Présence dans 39%	Présence dans 30%
B	Présence dans 21%	Absence dans 100%
C	Présence dans 25%	Présence dans 10%
D	Présence dans 6%	Absence dans 100%
E	Présence dans 5%	Absence dans 100%

Niveau de contamination par les streptocoques fécaux

Tableau 6. Niveau de contamination de l'eau par les entérocoques

Usine de pêche	Niveau de conformité des échantillons en pourcentage	
	Avant traitement de l'eau	Après traitement de l'eau
A	Présence dans 35%	Présence dans 10%
B	Absence dans 100%	Absence dans 100%
C	Absence dans 100%	Absence dans 100%
D	Présence dans 20%	Présence dans 15%
E	Présence dans 25%	Absence dans 100%

Niveau de contamination par les staphylocoques

Il a été observé l'absence de ces germes dans tous les échantillons des usines B, D et E. S'agissant des usines A et C, une contamination de 10% des échantillons a été constaté avant traitement de l'eau. Les résultats après application des traitements montrent une baisse de la contamination jusqu'à 3% des échantillons.

Discussion

Pour la flore aérobie à 37 °C, la moyenne trouvée est de 155,85 germes/ml d'eau; elle est de 503,5 germes/ml pour la flore à 22 °C. Selon Galzy (1981), une eau présentant moins de 1000 bactéries/ml est pure. Toutefois, les normes de références de la CEE autorisent respectivement des taux inférieurs à 20 germes/ml pour la flore à 37 °C et 100 germes/ml pour la flore à 22 °C. L'interprétation de nos résultats selon ces normes, montre que 20% et 2% des échantillons sont non satisfaisants respectivement avant et après traitement de l'eau. Ces non conformités sont liées d'une part à une pollution importante de la nappe phréatique et d'autre part, à une insuffisance dans le processus de traitement de l'eau pour les entreprises utilisant l'ozone et les UV seuls.

S'agissant des ASR, il ne doit pas exister plus d'une spore de bactéries anaérobies sulfito-réductrices dans 20 ml d'eau, selon les critères microbiologiques. Cette étude a révélé que 16% des échantillons provenant des usines sont non-conformes pour ce groupe de germes. Il convient de préciser que, la présence d'ASR a été observée uniquement dans les échantillons d'eau de mer traitée à l'ozone provenant de l'usine A. En effet, plusieurs travaux (Huss, 2004 and Nigel, 2002) ont montré la présence de ces germes dans le milieu aquatique; ce qui témoigne d'une contamination fécale.

En ce qui concerne les coliformes totaux et thermotolérants, la réglementation stipule que 95% des échantillons ne doivent pas contenir de coliformes totaux dans 100 ml d'eau. Elle exige également l'absence de coliformes thermotolérants dans 100 ml d'eau. Nos résultats ont révélé que 10% des échantillons étaient non satisfaisants. Cette présence de coliformes pourrait être due essentiellement à la contamination de la glace par le personnel d'une part, et d'autre part, aux instruments et le matériel de prélèvement ou de conservation.

Pour les streptocoques fécaux, la réglementation exige aussi l'absence de germes dans 100 ml d'eau. Nos résultats ont montré un niveau de contamination moins important que pour les coliformes fécaux ce qui explique leur résistance beaucoup moins importante dans le milieu extérieur.

Enfin, il a été observé l'absence de staphylocoques présumés pathogènes dans tous les échantillons des usines B, D et E. Pour les deux autres entreprises le traitement mis en place a permis de réduire la contamination initiale de 7%.

Globalement, il ressort de cette étude que:

- l'ozonation utilisée par l'usine A, a donné une non conformité pour tous les germes;
- la chloration utilisée par les usines B et C, a donné une non conformité pour les coliformes totaux;
- le traitement aux rayons ultraviolets utilisés par l'usine D, a donné une non conformité surtout pour les coliformes et les streptocoques; et
- le traitement combiné aux rayons ultraviolets et au chlore utilisé par l'usine E, a permis d'avoir une conformité pour tous les germes.

Suite à ces résultats, l'autorité compétente a pris des mesures à l'encontre de ces entreprises de pêche:

Usine A: fermeture de la ligne utilisant l'eau de mer traitée (crevettes et seiches) + remplacement par la chloration du système de traitement à l'ozone qui s'avère inefficace;

Usines B et C: renforcement des contrôles microbiologiques + suivi des durées de stockage de l'eau et de la glace;

Usine D: diminution des débits importants d'eau dans les canalisations pour augmenter l'efficacité des rayons UV + contrôles microbiologiques renforcés.

4. CONCLUSIONS

L'eau utilisée pour la transformation des produits de la pêche est l'un des points de contrôle critique les plus importants. En effet, cette étude a montré qu'il peut exister des différences de contamination avant traitement de l'eau d'une usine à une autre. Cependant, les traitements appliqués ont permis une réduction de la charge microbienne pour l'ensemble des germes recherchés. Mais, il faut noter que les résultats ont montré également, une diminution de la contamination plus importante pour la méthode de traitement combiné alliant les UV et le chlore. Ce traitement épuratif présente l'avantage d'être moins coûteux que l'ozonation en termes d'investissement, c'est pourquoi nous recommandons aux industriels du secteur l'installation de lampes UV au niveau des canalisations d'eau. En effet, la plupart des usines utilisent déjà la méthode de chloration de l'eau.

5. BIBLIOGRAPHIE RESTREINTE

AFNOR (Association Française de Normalisation). 1996. Microbiologie alimentaire: Méthodes horizontales, tome 1. Paris, AFNOR, 663 pp.

Huss, H. 2004. Assessment and management of food safety and quality. In FAO/Document technique sur les pêches, (444), 230 pp.

Minla'a, J.C., Ndao, D. & Seydi, M.G. 2001. Etude du niveau de mise en place du système HACCP dans les entreprises des produits halieutiques au Sénégal. Journ. Microb. Hyg. Ali., 2001, 13 (36), 14–23.

Nigel, F. L. 2002. Analyses microbiologiques des aliments et de l'eau: guide pour l'assurance qualité. Editions Cordon Breach, Institut PASTEUR de Lille, 186 pp.

THE INFLUENCE OF DAGAA-BASED POULTRY FEED QUALITY ON CHICKEN EGG PRODUCTION WITHIN LAKE VICTORIA BASIN

[L'INFLUENCE DE LA QUALITÉ DE L'ALIMENT À BASE DE VOLAILLE À BASE DE DAGAA SUR LA PRODUCTION D'ŒUFS DANS LE BASSIN DU LAC VICTORIA]

by/par

Margaret Masette¹

Abstract

A preliminary study to assess the influence of dagaa quality on the egg production was conducted in three selected districts within the Lake Victoria basin where post-harvest losses in dagaa fishery are known to vary between 25% and 90%. Besides, most dagaa products are socially stigmatized for various reasons. Dagaa intended for animal feed production is haphazardly handled and processed which results in unacceptable quality. However, the effects of this malpractice on the ultimate users/consumers have not been established. Between March and July 2008, an assessment to link dagaa quality and egg production was conducted. Fifteen randomly selected poultry farmers were interviewed; physical as well as chemical tests were conducted to evaluate the quality of dagaa. For one month, two flocks of laying chicken were fed on two different qualities of dagaa-based feeds. Results indicated that the principal constraint among poultry farmers was the quality of dagaa which was exacerbated by adulteration with extraneous materials which included livestock dung, plant materials, stones and sand/soil. The level of adulteration affected mixing ratios and egg production. The ash content of low quality feed was four times higher than in pure dagaa (control sample) and the protein content was 2–5 times less. Chicken fed on high quality feed laid twice as many eggs as the flock fed on low quality feed. Consequently, incidences of egg breakage were more frequent in flocks feeding on low quality than high quality feed; hence the need to improve dagaa handling and processing, curbing adulteration malpractices and regularizing pricing patterns. Implementation of the suggested mitigation measures will reduce post-harvest losses and increase dagaa for human consumption.

Key words: *Dagaa quality, Feed, Egg production, Uganda*

Résumé

Afin d'évaluer l'influence de la qualité du dagaa dans la production d'œufs, une étude préliminaire a été conduite dans trois districts sélectionnés dans le bassin du lac Victoria où les pertes post-capture dans la pêcherie du dagaa sont connues pour varier entre 25-90%. De plus la plupart des produits de dagaa sont socialement stigmatisés pour plusieurs raisons. Le dagaa destiné à la production d'aliment pour animaux est mal manipulé et traité, par conséquent de qualité inacceptable. Cependant, les effets de cette mauvaise manipulation sur les utilisateurs/consommateurs finaux n'ont pas été établis. Entre mars et juillet 2008, une évaluation a été conduite pour élucider le lien entre la qualité de dagaa et la production d'œufs. Quinze aviculteurs sélectionnés au hasard ont été interviewés; des tests physiques et chimiques ont été conduits pour évaluer la qualité du dagaa. Pendant un mois, deux batteries de poules pondeuses ont été nourries avec des aliments à base de dagaa de deux différentes qualités. Les résultats indiquent que la principale contrainte parmi les aviculteurs était la qualité de dagaa, qui était exacerbée par l'altération avec des substances étrangères y inclus les excréments de bétail, des matières végétales, cailloux et sable/terre. Le niveau d'altération a affecté les taux de mélange et la production d'œufs. La teneur en cendre dans l'aliment de basse qualité était quatre fois plus élevée que dans le dagaa pur (échantillon de contrôle) tandis que la teneur en protéines était 2-5 fois moins. Les poules nourries à l'aliment de haute qualité pondaient deux fois plus que la batterie de poules nourrie à l'aliment de faible qualité. Par conséquent, les incidences de brisure des œufs étaient plus fréquentes dans les poules nourries à l'aliment de basse qualité que de haute qualité; d'où le besoin d'améliorer la manutention et transformation de dagaa, en réduisant les mauvaises pratiques et en régularisant le paramètre de fixation de prix. La mise en œuvre de ces mesures atténuantes proposées réduiraient les pertes post-capture et augmenteraient le dagaa pour consommation humaine.

Mots clés: *Qualité du dagaa, Alimentation pour animaux, Production d'œufs, Ouganda*

¹ Food Biosciences Research Centre (FBRC), National Agricultural Research Laboratories (NARL), PO Box 7852, Kampala, Uganda. margasette@utlonline.co.ug

1. INTRODUCTION

Dagaa (*Rastrineobola argentea*) is a silvery sardine-like fish with an average length and weight of 5 cm and 15 g, respectively. With the declining Nile perch (*Lates niloticus*) and Nile tilapia (*Oreochromis niloticus*) catches, dagaa has been the mainstay for Uganda's 3.5% per annum increasing human populations as well as regional markets. In addition, it is an important protein and mineral source in the formulation of animal feed. Although the recent total catches in Lake Victoria seem to be decreasing, the value has tended to stabilize at about US\$ one million mark (Figure 1) which is a significant contribution to the national economy.

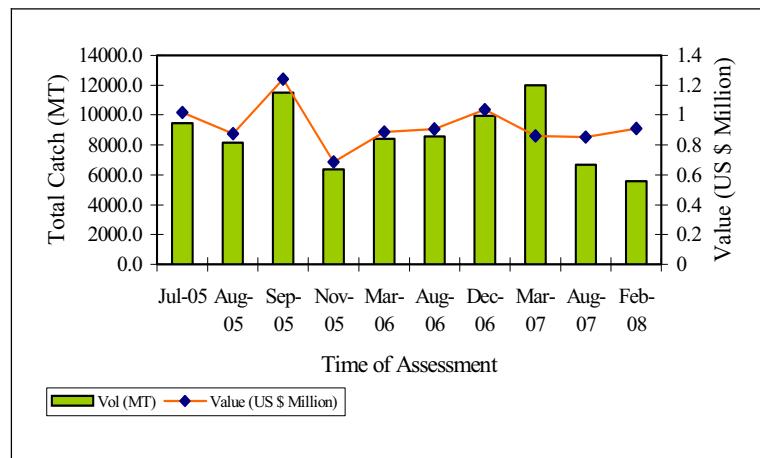


Figure 1. The status of Lake Victoria dagaa fishery, Uganda

(Source: *Catch Assessment Survey Report by Muhoozi L. – Researcher based at National Fisheries Resources Research Institute (NaFiRRI)*)

Despite the declining catches, the post-harvest losses are fairly high. Using a load tracking method, a recent loss-assessment study at three landing sites around Lake Victoria (Uganda) estimated a 40% loss. According to the Department of Fisheries Resources (DFR), 80% of all dagaa caught in Ugandan waters is usually processed for animal feed and only 20% is marketed for human consumption. Essentially, the underlying criterion for division of the market space is the quality status of dagaa. During the rainy season, the losses may be as high as 90% and because of insufficient drying the quality deteriorates further which often relegates dagaa to animal feed production. Several contributory factors to high post-harvest losses in the dagaa fishery have been identified. They include poor handling and processing practices, birds (egrets), pigs, weather dependent preservation method (Okoche, 2008; Masette, 2005). With the declining per capita fish consumption from 13 kg in 1980 to the present 6 kg in Uganda, human health and economic development have been definitely affected but the impact(s) are as yet uncertain. Masette (2005) suggested low-cost preservation methods to reduce losses and thereby reversing the 80:20 marketing matrix. However, regardless of the marketing options, there is a need to ensure acceptable quality as an approach to demystify the social stigma attached to dagaa.

Currently, the major concern among dagaa end-users is the unacceptable quality. From field observations, several major factors that influence dagaa quality have been identified. Masette, (2005) observed that the fishing regimes, poor handling practices from fishing ground to processing sites and insufficient drying lowered dagaa quality through spoilage. In addition, the traditional way of sun-drying dagaa on rocks or bare ground exposes it to a myriad of potential contaminants, namely: sand, soil and livestock dung. Despite the high risk of contamination and adulteration, most processors dealing with dagaa for animal feed have resisted adoption of improved methods. The resistance is linked to the pricing pattern as noted by Masette and Atyang (2007). Apparently, dagaa processed for animal feed production was sold by weight as opposed to dagaa sold for human consumption that was sold by volume. As such, drying on bare ground is advantageous to the processor as adulterous materials increase weight of the final product. The careless attitude observed among dagaa dealers during the drying process and subsequent handling is a calculated strategy to prop up the malpractice. It is not uncommon to see processors walking over dagaa whilst drying or flocks of birds pecking. According to many of them this is “a way they compensate for the loss” by including sand or other extraneous materials. The pricing pattern also appears to be an impetus for unscrupulous dealers to deliberately add shovels of sand/gravel, soil or other extraneous materials into sacks of dagaa for monetary gain. The malpractice has inadvertently led to the social stigmatization of dagaa among middle and upper class potential consumers in Uganda. As such, dagaa is usually associated with low income earners who, by virtue of their limited economic outlay, rarely demand high quality products. On the contrary, the market in South Sudan and Democratic Republic of Congo (DRC) is so

insatiable and lucrative that dagaa of questionable quality is marketed expensively, probably to the middle class. It can therefore be inferred that because the consumers in these neighbouring countries do not demand high quality dagaa products, they inadvertently promote the adulteration of dagaa products in Uganda.

The quality of dagaa not only influences consumption patterns but also plays a significant role in other sectors of the economy. For instance, in the poultry sector, the quality of dagaa is known to influence the performance of laying chickens. Recently, one poultry farmer observed that when he changed from animal feed dagaa to the high quality dagaa intended for human consumption, the number of eggs increased by 40% per day (Wanda, pers. comm.). Another farmer also noted that the mixing ratio (maize bran: milled dagaa) increased by a factor of 3 when poor quality dagaa feed was used, compared to high quality dagaa meant for human consumption (Dhatemwa, pers. comm.). Since dagaa for human consumption was three times more expensive than dagaa meant for animal feed production, he had resorted to sieving out sand from the latter before milling. A dairy farmer also recorded a drop in the milk yield when she changed from high quality dagaa pellets to highly adulterated version (Okiror, pers. comm.). It is evident that in the three cases, the quality of dagaa was the probable variable. The level of adulteration as well as pricing patterns highly compromised the quality of dagaa. The poor quality dagaa invariably affects the performance of the respective animal enterprise. However, despite the rampant malpractice in the dagaa fishery, many livestock farmers are not aware of the link between low egg/milk production and the quality of dagaa-based feed. Admittedly, there are many factors that could influence egg production, i.e. breed, feed and age (Larbier and Leclerco, 1994; Austic and Nesheim, 1990), but the link between dagaa quality and egg production requires urgent verification.

Overall objective

To identify factors affecting optimal utilization of dagaa.

Specific objectives

- To objectively establish the effect of mishandling and adulteration of dagaa on egg production;
- To assess the level of adulteration in dagaa-based poultry feed; and
- To determine selected chemical constituents of poultry feeds on the local market.

2. MATERIALS AND METHOD

Materials

Dagaa-based poultry feed for layers, flock of Golden Comet breed, structured questionnaire, weighing balance, relevant laboratory equipment and chemicals.

Methods

The baseline information on poultry sector in the three selected districts of Kampala, Wakiso and Jinja within Lake Victoria Basin (Uganda) was collected using a structured questionnaire which was designed with the help of a veterinary officer in charge of poultry sector based at the headquarters of the Ministry of Agriculture, Animal industry and Fisheries (MAAIF). It was then administered to 15 randomly selected poultry farmers engaged in egg production enterprises. Their responses were coded and analyzed using Excel package. The level of adulteration was assessed by identifying non-dagaa materials in ten batches (1 kg each) of dagaa intended for poultry feed production and their occurrence tallied. Five samples of low quality layers mash were purchased in duplicates from the market, one high quality sample was purchased from a reputable local dealer (A) and the control sample (pure milled dagaa) processed at FBRC laboratories. The six duplicate samples were subjected to chemical analyses for selected chemical constituents, namely proteins, ash and minerals (calcium and phosphorus) using standard AOAC methods. To determine the effect of dagaa-based feed quality on egg production, two different laying flocks (Golden Comet) were fed different types of feed with varying quality attributes in the dagaa component. The feed (A) was processed from high quality dagaa while the local feed (B) had doubtful quality owing to its high level of adulteration. The number of eggs laid daily was recorded for a period of one month and subjected to Levene's Test for Equality of Variances.

3. RESULTS AND DISCUSSION

The quality of dagaa varies with the intended use and market outlet. Whereas dagaa intended for human consumption exhibits high quality attributes and particularly lustre, colour and limited percentage of grit, dagaa

intended for animal feed production is highly adulterated, dull in colour and therefore low in quality. As such, the level of adulteration determines the respective product cost and it could be the driving force behind the malpractices in the dagaa fishery especially for that intended for animal feed production.

The linkage between dagaa quality and egg production in three districts - Uganda

The linkage between dagaa quality and egg production was deduced from the responses of poultry farmers in the three selected districts. Although, the location of nests had a bearing on the percentage of broken eggs, the latter was probably indicative of calcium deficiency associated with low quality dagaa-based feed (Figure 2). Only 40% of the respondents realized the linkage and correspondingly added an average of 12% dagaa to other ingredients in the mixing formula to improve chicken performance.

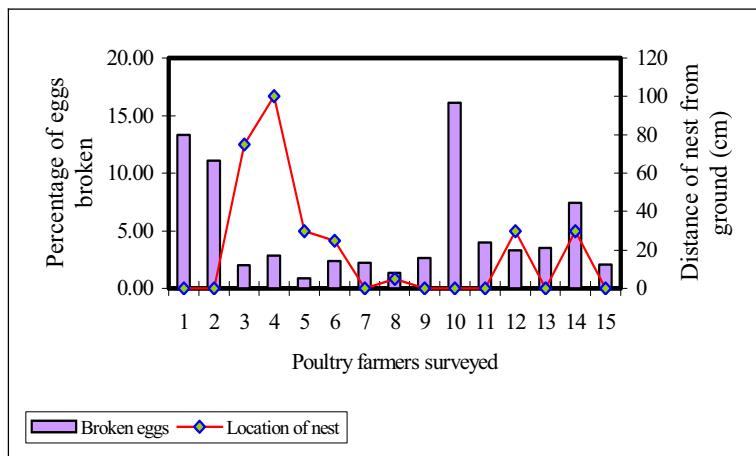


Figure 2. The relationship between location of nests and rate of egg breakage

Farmers 1, 2 and 10 in Figure 2 had the highest percentage of broken eggs per day which was attributed to the location of nests, soft shells (33.3%) and other factors (66.7%) which included mishandling by workers, oversized/missized and trampling under feet by the birds themselves. To reduce egg breakage, most farmers picked eggs 4 times a day on average. However, the breakage could also have been due to deficiencies in dietary calcium and phosphorus (Haumirtel, 1990; Sohail and Roland, 2002) which could have been adequately supplied by high quality dagaa-based feeds.

The effect of selected poultry feed on egg production

There are many factors that influence egg production for example breed, type of feed, feeding regimes and age (Larbier and Leclerc, 1994; Austic and Nesheim, 1990) but the present study focused on the type of feed. Two flocks of laying hens belonging to Golden Comet breed that were fed on different types of feed adequately demonstrated the assertion. The flock fed on feed (B) purchased locally had a significantly low laying performance than their counterparts fed on feed (A) ($P < 0.05$, $F = 5.840$ according to Levene's Test for Equality of Variances). The trend of egg production in the flock fed on feed (B) seemed to decrease with time while the flock that was fed on feed (A) seemed to increase (Figure 3).

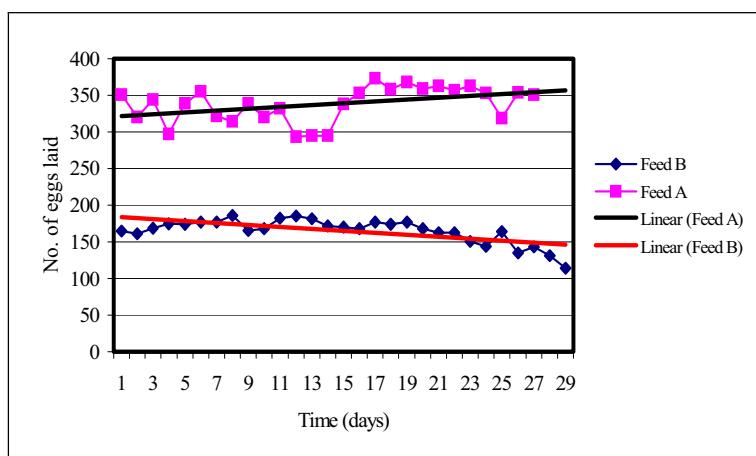


Figure 3. The effect of poultry feed on egg production of Golden Comet breed

As already mentioned, most local feeds seem to have high ratios of maize bran in their formulation to compensate for low quality dagaa which seem to have played a critical role in the performance of laying eggs observed in Figure 3.

Adulteration with extraneous materials

Within the Lake Victoria Basin, dagaa is mostly sun-dried on bare ground where it is exposed to all sorts of extraneous materials including livestock dung, soil, sand, stones and plant materials (barks, twigs and leaves). The magnitude of contamination varies with the type of drying surface and the presence of domestic animals at the landing site/processing site. Usually, dagaa intended for animal feed is not sorted for quality hence the presence of various extraneous materials in dagaa samples found on the local market (Figure 4).

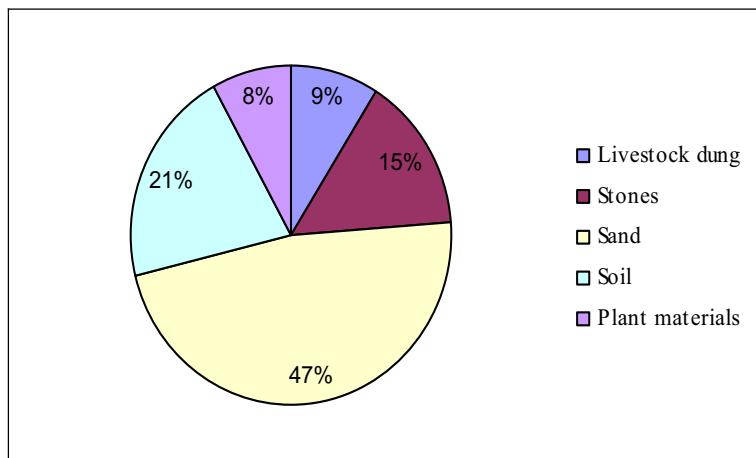


Figure 4. Extraneous materials found in dagaa intended for livestock feed manufacture

At the feed milling plant, there have been unsubstantiated reports that dagaa traders deliberately add sawdust to milled products to increase volume and weight. The malpractice undoubtedly creates a nutritional imbalance in the final feed which subsequently interferes with mixing ratios. During the present survey, it was evident that sand ($\approx 50\%$) represented a substantial component in dagaa intended for livestock feed production (Figure 4). According to previous studies (Masette and Atyang, 2006; Masette, 2005) dagaa intended for animal feed was sold per unit weight as opposed to sales of dagaa for human consumption that was sold per unit volume. This scenario allows dagaa traders to deliberately add sand and soil into dagaa sacks to increase weight. This malpractice undoubtedly earns them abnormal profits at the expense of end-users.

Chemical constituents of poultry feed on the local market

Like other livestock, chickens require basic chemical nutrients (proteins, fats and minerals) in sufficient quantities to maintain life, promote growth and health. Invariably, the type of feed consumed determines the amounts and quality of the respective chemical constituents. In the present study, the low quality feeds (1–5) showed high levels of ash and comparatively low protein content (Figure 5).

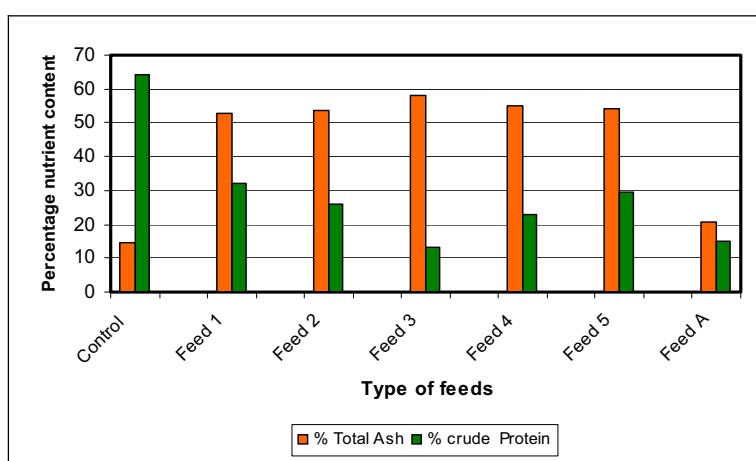


Figure 5. Ash and protein content of sample (B) and sample (A) poultry feed in Kampala

The ash content of 15% in the control sample was almost four (4) times and 1.4 times the ash content of the low quality feeds' average and sample (A), respectively. The high ash content in Feeds 1–5 may be attributed to the malpractice (Figure 4) and to the inclusion of mollusc shells in most poultry feed formulations in Uganda. The comparatively high protein content in Feeds 1, 2, 4 and 5 (Figure 5) may be due to the addition of large quantities of maize bran of which, according to the animal feed analyst, the Ugandan variety contains 10.5% protein on average (Katongole; pers. comm.). Although all the feeds investigated (with the exception of Feed 3), meet the protein requirement of 16–17% for laying hens (Ensminger, 1992), it is probable that the protein in low quality feeds was from plant source (maize bran) which invariably has a low biological value (Potter and Hotchkiss, 1995). Probably, it was this type of plant protein which partly contributed to low average egg production of 165 eggs per day (Figure 3). According to Larbier and Leclerc (1994), dietary regimes containing lower protein levels around 15% do not seem to influence subsequent laying performance provided lysine and sulphur amino acids are supplemented. Arguably, dagaa has more of these amino supplements than plant based protein sources (Huss, 1994, Potter and Hotchkiss, 1995), hence use of less dagaa and more maize bran in feed formulations undermines egg production regardless of the breed.

Although sample (A) feed had comparatively less protein content than Feeds 1, 2, 4 and 5 (Figure 5), it was consistent with the 16–17% requirement for laying hens (Ensminger, 1992). Probably, the low protein ash ratio in the feed had an effect on performance of laying hens in that the higher the ratio, the lower the performance but this assertion can only be proved by subsequent studies. Evidently the sample (A) feed was a better quality than low quality feeds which contributed to high egg production in Figure 3.

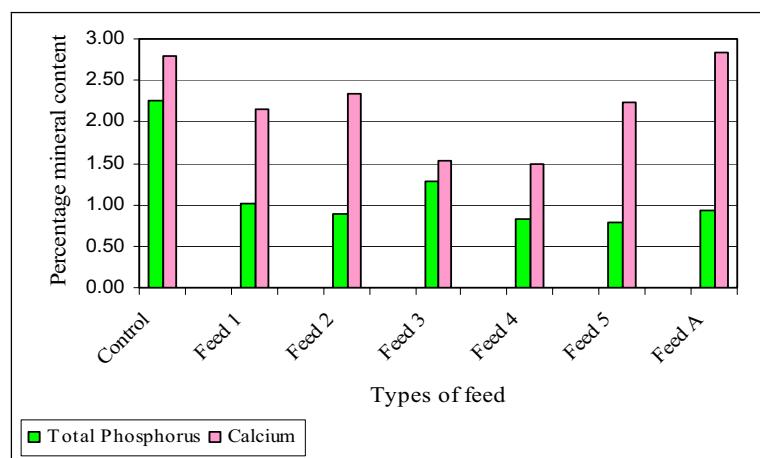


Figure 6. Phosphorus and calcium content of sample (A) and (B) poultry feed in Kampala

Phosphorus is an essential nutrient for laying hens because of its role in eggshell formation and metabolism (Said *et al.*, 1984; Roland, 1990) while calcium is an important dietary requirement for maximum egg shell thickness (Zollitsch *et al.*, 1996) when layers are fed on only 3.25 for 100 gram intake. Dagaa and mollusc shells are included in Ugandan poultry feed formulations to provide the necessary calcium and phosphorus for purposes of minimizing incidences of egg breakage. The level of egg breakage observed during the survey (Figure 3) was partly attributed to soft or lack of egg shells which was presumably indicative of Ca and P deficiency. According to Austic and Nesheim (1990) a laying hen requires 3.7% calcium and 0.4% phosphorus. Based on this requirement all feeds available on the local market (Figure 6) were deficient with regard to calcium but had adequate amounts of phosphorus. Since the control was significantly lower than the required calcium amounts, the extension workers normally urge farmers to supplement their feeds with mollusc shells (Aisu, pers. comm.). Probably, the optimum performance of a laying hen is only achievable by varying quantities and mixing ratios of relevant minerals which was beyond the scope of this study. Indeed, Haumirtel (1990) concluded that the minimum phosphorus requirement for the laying hen was 360 mg P/hen/day when the calcium concentration was restricted to 25 g/kg. However, to achieve the highest egg production and lowest mortality, 7.0 to 8.0 g/kg or 880–1020 mg P/hen/day were needed. Generally, well handled and processed dagaa can bridge the calcium deficiency in poultry feeds to enhance egg performance.

4. CONCLUSIONS

Although there are a myriad of factors that influence egg production, the preliminary results of this study indicated that the quality of dagaa had a significant influence on the egg production in Golden Comet breed in that when low quality or highly adulterated dagaa sample (A) was used in the formulation of feed, the egg

production was low and egg breakage was high due to inadequate protein and calcium. The level of adulteration seemed to interfere with mixing ratios and causes nutritional imbalance as minerals (calcium and phosphorus) content decreases in the final product. Supplementing low quality dagaa with other ingredients is an expensive alternative regardless of the end use. The pricing patterns in the dagaa fishery seemed to encourage adulteration and careless attitude among processors which in turn contribute to high post-harvest losses in the sector. Improvement of handling and processing of dagaa will reduce these losses, lift the social stigma and channel substantial quantities of dagaa for human consumption.

5. RECOMMENDATIONS

- Regardless of the intended use, dagaa should be appropriately handled to reduce post-harvest fish losses, and ensure quality and food security.
- Value-added and user friendly products should be developed from dagaa to increase the percentage of fish for human consumption.
- Comprehensive study should be conducted to provide consolidated data for better pricing pattern and other regulatory tools within the Lake Victoria Basin.
- Policy makers should institute bylaws to mitigate the malpractices and standardize measurement tools in dagaa fishery.
- Further sensitization of all stakeholders involved in handling, processing and marketing of dagaa with back-up from further researchable aspects in the fishery.

Acknowledgement

I am greatly indebted to Eng. Alfonse Candia, poultry farmer, who provided study inputs and recorded the relevant data for the duration of the study on his farm.

6. REFERENCES

Austic, R.E. & Neshem, M.C. 1990. Poultry Production. 13th Edition. Publish. Lea and Febiger USA. Pg 218.

DFR. 2002. Department of Fisheries Resources under Ministry of Agriculture, Animal Industry and Fisheries, Uganda. Annual report.

Ensminger, M.E. 1992. Poultry Science 3rd Edition. Published by Interstae Publishers.

Hartel, H. 1990. Evaluation of the dietary interaction of calcium and phosphorus in the high producing laying hen . Pub. British Poultry Science. Vol. 31. Issue 3. pg 473–494.

Huss, H.H. 1995. Quality and changes in fresh fish, FAO fisheries Technical Paper 348, 198 pages, FAO, Rome. Italy.

Larbier, M. & Leclerco, B. 1994. Nutrition and feeding of poultry. Ed. J. Wiseman. Pub. Nottingham University Press.

Leghorns. Poultry Sci. 69:105–112.

Masette, M. 2005. Improved Mukene *Rastrineobola argentea* processing technologies. FAO report.

Masette, M. & Atyang. 2007. The status of dagaa handling and processing in Uganda. Technical Report for Lake Victoria Fisheries Organization (LVFO).

Okoche, J. 2008. Post-harvest losses in Mukene (*Rastrineobola argentea*): A case study – Busana Landing site. A dissertation submitted to Makerere University in partial fulfilment of BSc Degree in Fisheries and Aquaculture.

Potter, N.N. & Hotchkiss, J.H. 1995. Food Science. 5th Edition. Chapman and Hall.

Roland, D.A., Sr. .1990. The relationship of dietary phosphorus and sodium aluminosilicate to the performance of commercial.

Said, N.W., Sullivan, T. W., Sunde, M.L. & Bird, H.R. 1984. Effect of dietary phosphorus level and source on productive performance and egg quality of two commercial strains of laying hens. Poultry Science. 63:2007–2019.

Sohail, S.S. & Roland, D.A. 2002. Influence of Dietary Phosphorus on Performance of Hy-Line W36 Hens. Poultry Science Association, Inc. 81:75–83.

ÉVOLUTION HISTAMINIQUE ET MICROBIOLOGIQUE DURANT LE STOCKAGE DE SEMI-CONSERVES D'ANCHOIS

[HISTAMINE AND MICROBIOLOGICAL CHANGE DURING THE STORAGE OF SEMI-PRESERVED ANCHOVIES]

by/par

Fayssal El Filali¹, S. Hanoune, B. Khbaya, N. Bou M'Handi and A. Kaaya

Résumé

Durant les différentes étapes de l'élaboration de la semi-conserve d'anchois, l'histamine enregistre des augmentations significatives. Cette élévation est favorisée par la fragilité de la chair de ce poisson d'une part, et sa richesse en histidine, acide aminé précurseur de l'histamine d'autre part. La décarboxylation de l'histidine se présente alors comme étant un problème important dans l'industrie de la semi-conserve, notamment au moment de la maturation de l'anchois. L'objectif de ce travail est de cerner les bactéries qui sont responsables de la dégradation de cet acide aminé et de déterminer les conditions optimums de leur développement.

Ce travail a été entrepris dans le but de suivre et mieux définir les changements intervenant dans le produit fini après incubation à 30 °C, température favorable pour accélérer son processus de vieillissement. Différents paramètres ont été suivis à fréquence mensuelle, à savoir l'histamine, le pH et le dénombrement bactérien sur différents milieux (PCA, PCA à l'eau de mer, VRBG, MRS et M17). Les entérobactéries semblent ne pas résister à la concentration en sel appliquée au produit et disparaissent en moins d'un mois de stockage, de même pour les lactobacilles sur milieu MRS. Le suivi de l'histamine reste en rapport avec l'état hygiénique de chaque société, un contrôle régulier et une parfaite maîtrise des procédures de nettoyage et désinfection s'imposent pour une bonne qualité du produit.

Mots clés: *Anchois, Bactérie, Histamine, Histidine, Semi-conserve d'anchois*

Abstract

During the various stages of the development of anchovy semi-preserved food, histamine content increase significantly. This increment is favoured because the flesh of this fish is known as fragile on the one hand and rich in histidine, precursor of histamine, on the other hand. The decarboxylation of histidine arises then as being an important problem in the industry of semi-preserved anchovy and constitutes a great disadvantage at the time of the ripening. The objective of this work is to understand the bacteria which are responsible for the degradation of this amino acid and to determine the optimum conditions of their development.

This work is undertaken with an aim of following and, better, of defining the changes intervening in the end product after incubation at 30 °C, ideal temperature for accelerating the product's process of ageing. Various parameters were followed on a monthly basis, namely histamine, the pH and the bacterial count on various media (PCA, PCA with sea water, VRBG, MRS and M17). The Enterobacteriaceae seem not to resist the salt concentration applied to the product and disappear within less than a month of storage, as well as the lactobacillus on medium MRS. Histamine level reflect the hygienic status of each company a regular and a perfect control of the cleaning and disinfection procedures are essential for a good quality of the product.

Key words: *Anchovy, Bacteria, Histamine, Histidine, Semi-preserved anchovy*

1. INTRODUCTION

La préparation des semi-conserves d'anchois *Engraulis Encrasicholus* correspond à un processus de salaison et de maturation (Hernández-Herrero *et al.*, 1999). Le processus de maturation est commun dans quelques secteurs méditerranéens et en Argentine où l'espèce est *engraulis anchoita* (Triqui and Reineccius, 1995). L'anchois (*Engraulis Encrasicholus*) est principalement commercialisé et transformée en Espagne, Italie, Grèce, France, et au Maroc (Hernández-Herrero *et al.*, 1999).

¹ Centre spécialisé de valorisation et de technologie des produits de la mer (CSVTPM), INRH, BP 1050, Pk 7, Route Essaouira, Agadir, Morocco. fayssal.elfilali@yahoo.fr

La maturation des anchois peut être divisée en deux étapes. La première étape est rapide et inclut la diffusion du sel dans les poissons et l'élimination de l'eau. Le taux de pénétration du sel change avec l'épaisseur du muscle, la température, la fraîcheur des poissons et la teneur en graisse (Clucas, 1982). La deuxième étape, plus longue et plus lente, et qui rend au produit ses caractéristiques uniformes de tendreté, d'arôme et de goût (Filsinger, 1987). La maturation de l'anchois salée inclut les processus biochimiques qui causent les changements typiques des caractéristiques chimiques et physico-chimiques des tissus de poissons. Ces changements sont induits par les enzymes qui décomposent les protéines et les graisses (Voskresensky, 1965).

Bien que le sel empêche la croissance des bactéries de détérioration, d'autres micro-organismes peuvent ne pas être affectés par sa présence. Des micro-organismes ont été commodément divisés en quatre groupes basés sur leur sensibilité pour saler: halotolérantes, légèrement halophiles, halophiles modérés et halophiles extrêmes. (Baross et Lenovich, 1992).

Notre étude a été lancée en octobre 2006 et a pour objectif étudier l'effet du vieillissement du produit par incubation prolongée à 30 °C sur des boîtes de semi-conserve d'anchois, en provenance de trois sociétés différentes, sur quelques paramètres microbiologiques et physico-chimiques et de révéler la persistance des bactéries formatrices d'histamine durant le stockage du produit fini.

2. MATÉRIELS ET MÉTHODES

Echantillonnage

Les échantillons de semi-conserve d'anchois sont en provenance de trois sociétés différentes (A, B et C). Les anchois utilisées sont pêchées au large des côtes marocaines et préparées de la même façon dans ces trois sociétés (étêtage et éviscération, maturation, lavage, filetage, immersion dans l'huile et emballage) 90 boîtes de chaque société sont incubées dans une étuve à 30 °C (SANYO MCO 175), dont les valeurs en histamine au départ sont respectivement de 3, 12 et 70 ppm pour les sociétés A, B et C. Les échantillons pour analyses sont prélevés d'un mélange de 5 boîtes pour déterminer la teneur en histamine et un dénombrement bactérien après une année de stockage à un mois d'intervalle. Une quantité d'échantillon a été déposé à l'air libre et à 4 °C pour servir de témoin.

Tableau 1. Répartition et caractérisation des échantillons utilisées

Provenance	Description du produit	Conditionnement
Société A	Filet d'anchois roulé à la cèpe	Boîte 1/15 ^{ème} métallique
Société B	Filet d'anchois allongés	Bocaux en verre
Société C	Filet d'anchois allongés	Boîte 1/15 ^{ème} métallique

Analyses physicochimiques

Le dosage de l'histamine se fait selon la méthode spectrofluorimétrique de Lerke et Bell 1978. 10 g d'échantillon sont homogénéisés dans 90 ml de tampon trichloracétique puis filtré. 200 µl du filtrat est transvasé avec 150 ml de tampon acétate dans une colonne échangeuse d'ions, l'histamine est ensuite élueée par l'acide chlorhydrique. La lecture de la DO se fait à 275 nm après complexassions de 20 µl du filtrat avec l'Ortho-phtaldéhyde. Pour la mesure du pH, un échantillon de 10 g est homogénéisé dans 10 ml d'eau distillée est utilisé après broyage, la lecture est ensuite réalisé à l'aide d'un pH mètre TOA DKK HM-20J.

Analyses microbiologiques

De chaque échantillon, 25 grammes sont prélevées aseptiquement et homogénéisées avec 225 ml d'eau peptonée tamponnée dans un sac stomacher pour un dénombrement de la flore totale sur milieu PCA (Plate Count Agar) à 30 °C pendant 72 heures, de la flore totale halophile sur milieu PCA à base d'eau de mer, filtrée à une porosité de 0,45 µm, à 25 °C pendant 5 jours (SANYO MIK-153), des entérobactéries sur milieu VRBG (Gélose Glucose au Violet Cristal, au Rouge Neutre et à la Bile) à 30 °C pendant 24 heures (ISUZU FR-114S), de la flore lactique sur milieux MRS (De Man, Rogosa and Sharpe) et M17 respectivement pour les bacilles et les coques à 30 °C pendant 48 heures (ISUZU FR-115S). L'ensemencement se fait en double couche pour le milieu VRBG, MRS et M17 et en profondeur pour les deux autres milieux.

Après dénombrement sur différents milieux, 665 souches sont isolées sur milieux correspondant puis testée sur milieu Niven (L-Histidine 2HCl 27%, Tryptone 5%, Extrait de levure 5%, Chlorure de sodium 5%, Carbonate de

calcium 1%, Agar 30%, Pourpre de bromocrésol 0.6%). et sur milieu Yamani and Unterman (Peptone 2%, Lab lemco powder 1%, Chlorure de sodium 5%, L-Histidine Hcl 10%, Vert de bromocrésol 0.1%, Rouge de chlorophénol 0.2%). La lecture se fait après incubation à 30 °C pendant 24 heures (ISUZU FR-114S), les souches sont considérées positives si elles présentent un halo bleu mauve sur gélose Niven, ou par virage du bouillon du vert au bleu sur milieu Yamani and Unterman.

3. RÉSULTATS ET DISCUSSIONS

La teneur en histamine enregistrée durant le stockage du produit fini évolue de manière différente pour les trois sociétés. La société C affiche les valeurs les plus élevées avec un pic de 450 ppm au bout d'une année de stockage.

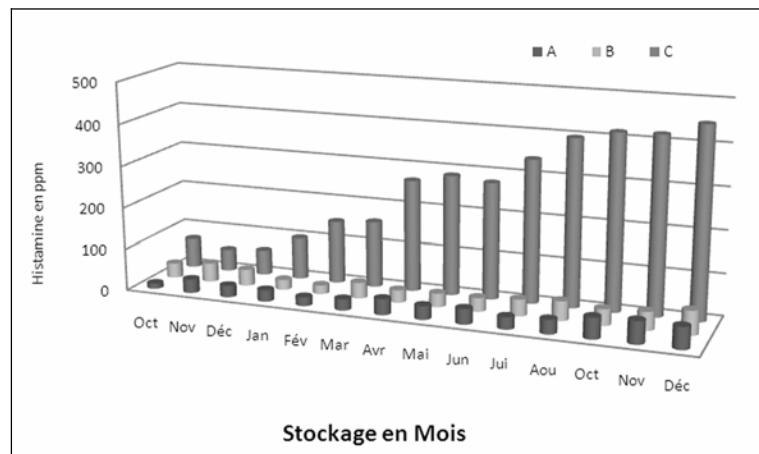


Figure 1. Evolution de l'histamine au cours de l'incubation des semi-conserves d'anchois à 30 °C en provenance de trois sociétés différentes A, B et C

Les deux sociétés A et B ont des valeurs d'histamine voisines et qui restent faible par rapport aux normes exigées à l'export (Figure 1). Dans une étude similaire, Veciana-Nogue *et al.*, ont montré que les teneurs en amines biogènes dans des semi-conserves d'anchois en provenance de trois sociétés différentes et stockées à 20 °C augmentent au fur et à mesure. L'élévation de l'histamine est remarquable après le troisième mois du stockage à 20 °C et évolue de manière différente pour les trois sociétés étudiées. Les valeurs de pH enregistrées suivent l'évolution de l'histamine et sont comprises entre 5,4 et 6.

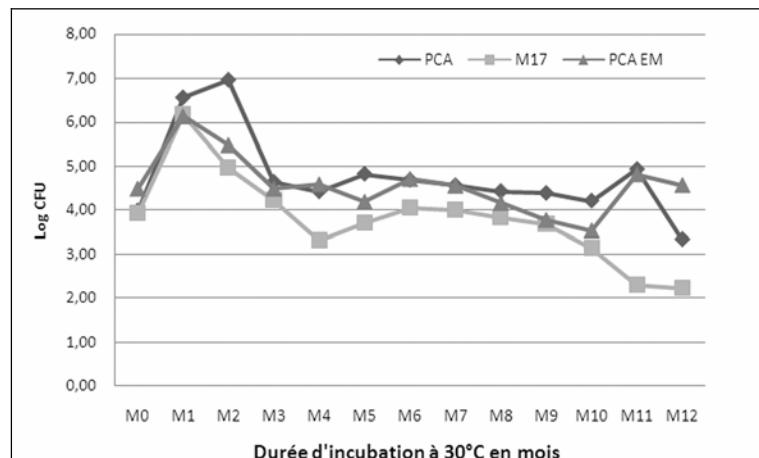


Figure 2. Evolution moyenne de la flore bactérienne au cours de l'incubation des boîtes de semi-conserves d'anchois à 30 °C en provenance de trois sociétés différentes

Le dénombrement bactérien affiche une évolution quasi parallèle sur les différents milieux utilisés et presque identique pour les trois sociétés étudiées. On note une légère augmentation durant les deux premiers mois suivie d'une baisse progressive jusqu'à la fin de la période du stockage (Figure 2). Il faut signaler que les entérobactéries disparaissent au bout du premier mois de stockage, ceci est dû à leur incapacité de tolérer des

teneurs élevées en sel. Quant à la flore lactique, les lactococcus prédominent sur les lactobacilles du moment que le dénombrement sur milieu MRS reste nul.

Sur les 665 souches testées sur milieu Niven et Yamani and Unterman, 137 souches sont positives et jugées formatrices d'histamine (Figure 3). La majorité des souches est représentée par la flore totale, la flore halophile et la flore lactique. Les entérobactéries dénombrées sont issues des différentes étapes de la journée de production des échantillons probablement à cause d'une contamination directe induite par le personnel des usines étudiés. Une étude de caractérisation sera lancée ultérieurement pour pouvoir identifier ces souches et étudier l'effet de certains facteurs limitant dans le but de cerner la problématique de la formation d'histamine dans la semi-conserve d'anchois.

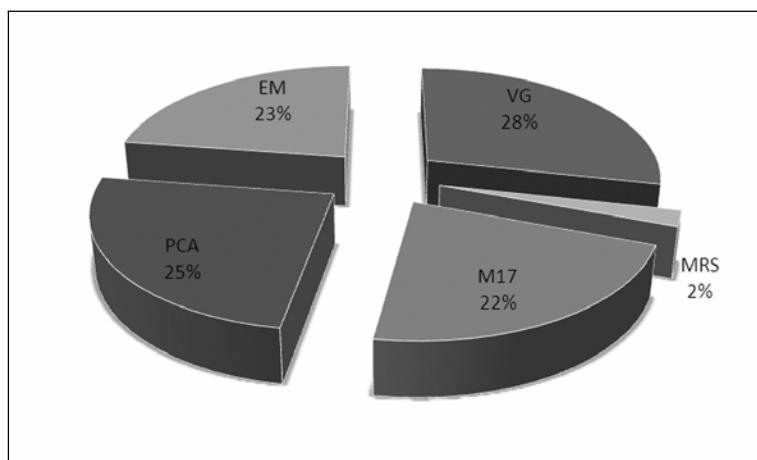


Figure 3. Répartition par type de milieux des souches formatrices d'histamine issues des boîtes de semi-conserves d'anchois incubées à 30 °C

4. CONCLUSIONS

Les valeurs d'histamine enregistrées durant l'incubation des boîtes des semi-conserves d'anchois à 30 °C permettent de conclure que chaque société contribue au sort qualitatif de son produit. Durant notre étude, la société C, à laquelle correspondent les fortes valeurs d'histamine, enregistre aussi des niveaux élevés des entérobactéries durant le processus de fabrication. Ces bactéries reflètent l'état hygiénique de chaque société et sont réputées les plus formatrices d'histamine.

Les résultats préliminaires de ce travail vont contribuer à mieux cerner le processus de formation de l'histamine au cours du stockage du produit fini. La formation d'histamine étant un facteur limitant de la qualité du produit, ainsi la maîtrise des bactéries formatrices d'histamine dans la semi-conserve d'anchois va permettre aux producteurs locaux de réduire la production de l'histamine dans le produit fini et de la sorte préserver sa qualité initiale. Pour ce faire, une bonne contribution des responsables qualité s'impose auprès de leurs unités et entre eux pour renforcer et exiger une bonne manutention de la matière première et une parfaite maîtrise de la qualité du produit durant le processus de fabrication.

5. BIBLIOGRAPHIE

Baross, J. A. & Lenovich, M. 1992. Halophilic and osmophilic microorganisms. In Compendium of Methods for the Microbiological Examination of Foods. C. Vanderzant and D.F. Splitstoesser (Ed.), p. 199–212. American Public Health Association, Washington, DC.

Clucas, I.J. 1982. Salting of fish: salt and methods. In Fish Handling, Preservation and Processing: Part 2, p. 4–8. Report of the Tropical Products Institute, London.

Filisinger, B.E. 1987. Effect of pressure on the salting and ripening process of anchovies (*Engraulis anchoita*). *J. Food Sci.* 52: 919–921, 927.

Hernández-Herrero, M. et al. 1999. Total Volatile Basic Nitrogen and other physicochemical and Microbiological Characteristics as Related to Ripening of Salted Anchovies. *Journal Of Food Science*, Volume 64, No. 2, 344–347

Triqui, R. & Reineccius, G. A. 1995. Flavor development in the ripening of anchovy (*Engraulis encrasicholus* L.). *J. Agric. Food Chem.* 43: 453–458.

Veciana-Nogue's, M. T. et al. 1997. Changes in Biogenic Amines during the Storage of Mediterranean Anchovies Immersed in Oil. *J. Agric. Food Chem.* 45, 1385–1389.

Voskresensky, N.A. 1965. Salting of herring. In *Fish as Food*. Vol. III. G. Borgstrom (Ed.), In Hernández-Herrero, M. *et al.* 1999. Total Volatile Basic Nitrogen and other physicochemical and Microbiological Characteristics as Related to Ripening of Salted Anchovies. *Journal of Food Science*, Volume 64, No. 2, 344–347.

QUALITY CHANGES AND HEAVY METAL ANALYSIS OF MARINE WATER PRAWN AND FRESH WATER PRAWN STORED IN ICE – *Penaeus notialis/Macrobrachium vollenhovenii*

[*CHANGEMENTS DE QUALITÉ ET ANALYSE DES MÉTAUX LOURDS DE CREVETTES D'EAU DE MER ET DE CREVETTES D'EAU DOUCE CONSERVÉES SOUS GLACE*]

by/par

M.M. Salaudeen¹, G.R. Akande and E.O. Oyewo

Abstract

Sensory evaluation, microbiological examination and heavy metal analysis of marine water prawn (*Penaeus notialis*) and freshwater prawn (*Macrobrachium vollenhovenii*) during storage in ice were determined. Sensory evaluation of raw prawns based on colour, odour and texture showed deterioration after the 8th day in ice. The successions of bacterial genera during the storage in ice were *Bacillus*, *Corynebacteria*, *Escherichia coli*, *Klebsiella* sp., *Salmonella* and *Shigella* for both types of prawns. The mean total bacterial counts were 1.17×10^7 CFU/g and 1.23×10^7 CFU/g for *P. notialis* and *M. vollenhovenii*, respectively. There was no significant difference ($p > 0.05$) in the total bacterial counts for both types of prawn. However, there was a correlation ($r = 0.7$) between storage days in ice and total bacterial counts for the two types of prawn. The levels of cadmium, lead, copper, zinc, chromium, iron, cobalt, nickel and manganese in the tissues of *P. notialis* and *M. vollenhovenii* were 0.28 μ g/g, 0.96 μ g/g, 6.15 μ g/g, 0.56 μ g/g, 15.0 μ g/g, 1.14 μ g/g, 5.52 μ g/g, 2.05 μ g/g, 1.82 μ g/g, and 0.33 μ g/g, 1.25 μ g/g, 5.40 μ g/g, 1.54 μ g/g, 2.61 μ g/g, 2.04 μ g/g, 5.69 μ g/g, 1.52 μ g/g, 0.45 μ g/g, respectively. These levels for both types of prawn were lower than the maximum permissible international standards, implying that there is little or no possibility of heavy metal toxicity hazards associated with consumption of the prawns and suggesting that they were caught from waters relatively free from pollution by heavy metals.

Key words: *Quality changes, Prawns, Heavy metals, ice, Bacteria counts, Penaeus notialis, Macrobrachium vollenhovenii*

Résumé

Une évaluation sensorielle, un examen microbiologique et une analyse des métaux lourds de crevettes d'eau de mer (*Penaeus notialis*) et de crevettes d'eau douce (*Macrobrachium vollenhovenii*) ont été déterminés pendant la conservation sous glace. L'évaluation sensorielle de crevettes crues portant sur la couleur, l'odeur et la texture a montré une détérioration après le huitième jour dans la glace. Les genres bactériens successifs pendant la conservation sous glace étaient *Bacillus*, *Corynebacteria*, *Escherichia coli*, *Klebsiella* sp., *Salmonella* et *Shigella* pour tous les deux types de crevettes. Le total de colonies bactériennes était respectivement $1,17 \times 10^7$ UFC/g et $1,23 \times 10^7$ UFC/g pour *P. notialis* et *M. vollenhovenii*. Il n'y avait pas une différence significative ($p > 0,05$) dans le total des colonies pour tous les deux type de crevettes. Toutefois, il y avait une corrélation ($r = 0,7$) entre les jours de conservation sous glace et le total de colonies bactériennes pour les deux types de crevettes. Les niveaux de cadmium, plomb, cuivre, zinc, chrome, fer, cobalt, nickel et manganèse dans les tissus de *P. notialis* et du *M. vollenhovenii* étaient respectivement 0,28 μ g/g; 0,96 μ g/g; 6,15 μ g/g; 0,56 μ g/g; 15,0 μ g/g; 1,14 μ g/g; 5,52 μ g/g; 2,05 μ g/g; 1,82 μ g/g; et 0,33 μ g/g; 1,25 μ g/g; 5,40 μ g/g; 1,54 μ g/g; 2,61 μ g/g; 2,04 μ g/g; 5,69 μ g/g; 1,52 μ g/g; 0,45 μ g/g. Ces niveaux pour les deux types de crevettes étaient inférieurs aux normes maximales internationales admissible, c'est-à-dire qu'il y a un faible risque ou pas de possibilité de risques de toxicité de métaux lourds associés à la consommation de crevettes, ce qui sous-entend qu'elles ont été capturées dans des eaux relativement exemptes de pollution par les métaux lourds.

Mots clés: *Changements de qualité, crevettes, métaux lourds, glace, colonies bactériennes, Penaeus notialis, Macrobrachium vollenhovenii*

¹ Nigerian Institut for Oceanography and Marine Research (NIOMR), PMB Box 12729, 3 Wilmot Point Barbeach, VI Lagos 234, Nigeria. salaudeen06@yahoo.com.

1. INTRODUCTION

Seafood is one of the major food items in Nigeria. It is often the cheapest principal source of animal protein, especially for the low-income group. Today, more people are turning to finfish and shellfish as a healthy alternative to meat because they provide high quality protein and have a broad spectrum of fatty acids especially polyunsaturated fatty acids (PUFA).

Frozen shrimp is the most important seafood produce export by Nigeria. Annual export of frozen shrimp earns considerable foreign exchange for the country. However, produce are often seized, detained, rejected or destroyed by health authorities of various importing countries due to problems such as decomposition, high total viable bacterial count, filth, food-borne microbial pathogens and foreign materials (Pong Pen *et al.*, 1990).

Shrimp is the principal traded fisheries commodity in value and volume. It accounted for about 20% of world fisheries trade by value in the late 1990's (FAO, 2001). The flow of trade is primarily from the developing to the developed world. A wide range of fish and fishery products is produced in Nigeria for the international markets. Shrimps account for about 84% of seafood exported to Europe in 2002 (FDF 2002), followed by crabs (6%) fish (4%) and cephalopods (4%). Export of frozen shrimp from Nigeria generates an average of US\$50 million annually.

The increasing globalization of fish trade, the need to export fish and shellfish and the increasing consumer awareness of quality and safety requires that all institutions in the fish industry should ensure that produce put on market pose no health risks. For these reasons, it is very important that issues of quality and safety of fish products should start from the production segment through the chain of consumption.

Concerns about heavy metals and other contaminants in marine fish and shellfish arose from the "Minimata" and "Itai Itai" incidences in Japan involving Mercury and Cadmium, respectively (Gerlach, 1980), but Arsenic, Zinc, other metals and polychlorinated biphenyls (PCB's) from industrial wastes are also worrisome, as are air-borne pollutants from industrial smoke emissions.

The present work examined the quality changes in terms of sensory, microbiological and heavy metal levels in marine and fresh water prawns caught in Nigerian waters. Marine water prawns and freshwater prawns were investigated for this work because of their export potential and foreign exchange capacity.

2. MATERIALS AND METHODS

Marine water prawns and freshwater prawns were collected on the same day from the landing centres at Ebute Chief, Ayetoro, Epe and Ebute Ilaje, Bariga, respectively. The prawns were mixed with ice made from clean potable water (1:1 ratio) in different insulated boxes.

Sensory evaluation

Samples of both types of prawn were arranged on the 1st, 5th, 8th, 12th and 15th day in ice for sensory evaluation. Sensory evaluation of both types of prawn was done based on appearance, colour, odour and texture according to Clucas and Ward (1996). Seven individuals were trained to make informed judgments. Scoring was expressed with grade I, grade II, just acceptable and reject.

Microbiological examination

Samples of both types of prawns were drawn on the 1st, 5th, 8th, 12th and 15th day of storage in ice in sterile bottles for microbiological studies.

One gram of the muscle of both freshwater and marine water prawns were separately and aseptically introduced into 9 mls of sterile distilled water in sterile MacCartney bottles to provide 10⁻¹ dilution, which were then used for further dilutions up to 10⁻⁷. Then 0.1 ml of the diluted samples were inoculated into the media in duplicates and incubated at 37 °C for 18–24 hours following the pour plate method.

Nutrient Agar was used for Total Viable Counts (TVC), Mac Conkey Agar and Eosin Methylene Blue agar were used for *E. coli* and *Klebsiella* sp. while *Salmonella*, *Shigella* agar was used for examination of *Salmonella* and *Shigella* species.

In order to identify each isolate, pure cultures were examined for cultural and morphological characteristics based on their colour, shape and pigmentation, by Gram staining.

Heavy metal analysis

Samples of freshwater and marine water prawns were also drawn on the first day of storage in ice in sterile bottles for heavy metal analysis.

Wet-ashing of the prawns was done and metal concentrations for all extracts were determined by Atomic Absorption Spectrophotometry, using air-acetylene flame.

Statistical analysis

The statistical analysis was done by using mean correlation coefficient equation and chi-square tests.

3. RESULTS

Details on sensory evaluation of freshwater prawn and marine water prawn are shown in Table 1 and 2, respectively.

Microbiological examination

Different genera of bacteria were isolated and identified on the basis of their morphological characteristics. The succession of bacteria genera during the storage in ice is presented in Tables 3 and 4.

The total bacterial count on the 1st day in ice was 4.0×10^5 Cfug for *P. notialis* and 4.5×10^5 Cfug for *M. vollenhovenii*.

The total bacterial count decreased slightly during the first week in ice. After the 8th day in ice, the bacterial count increased rapidly as shown in Table 5.

Heavy metal analysis

Results on heavy metal analysis of both prawns are shown in Table 6.

Of the nine heavy metal species measured in the freshwater prawn, Cd and Co occurred at the lowest and highest concentrations of 0.33 $\mu\text{g/g}$ and 5.69 $\mu\text{g/g}$, respectively. In the marine prawn, Cd and Cr occurred at the lowest and highest concentrations of 0.28 $\mu\text{g/g}$ and 15.0 $\mu\text{g/g}$, respectively.

4. DISCUSSION

The prawns used in this study were un-iced up to the time of landing which was about 8–10 hours after they were caught. The prawns were rejected based on dull colours, strong bad odour, black spots and very soft texture after the 8th day in ice. If icing was done earlier, the shelf life may have been even longer.

Immediate icing of the catch is important especially in the tropical areas where the surface temperature of the seawater and the ambient air is about 27 °C to 33 °C. At this temperature, bacteria may cause significant spoilage only 8–12 hours after the death of the fish (Jensen and Hansen, 1973). The higher the temperature of storage, the shorter the shelf-life, as a general rule, for every hour that fish are kept at ambient temperature, the equivalent of one day storage life in ice is lost and for every 5 °C above 0 °C that they are stored, the storage life in ice is reduced by half (Clucas and Ward, 1996).

The formation of black spots is due to melanosis occurring during the storage of prawns. Though this is not connected directly with spoilage, it gives a poor appearance to the consumer.

The bacterial counts on the 1st day in ice were 4.5×10^5 and 4.0×10^5 for *M. Vollenhovenii* and *P. notialis*, respectively. The total bacterial count increased rapidly as shown in Table 5. The counts indicate onset of spoilage after the 8th day rather than the level of freshness. The results obtained in this work is similar to that of Cann (1977), the change in total bacterial count was not significant at 5% degree of freedom till after the 8th day in ice. The coefficient of correlation 'r' between days in ice and total bacterial count was 0.7045 and 0.7019 for *P. notialis* and *M. vollenhovenii*, respectively. There was no significant difference at ($p > 0.05$) in the total bacterial counts for both types of prawn used in this study.

The succession of bacteria genera during the storage in ice were *Bacillus*, *Coryne-bacteria*, *E. coli*, *Klebsiella* sp., *Salmonella* and *Shigella*. The succession of bacteria genera is the same in both types of prawn as presented in Tables 3 and 4 with no significant difference on the percentage of occurrence. Like prawns from most tropical environments, the prawns in this study had a fairly high bacterial load. However, organisms of public health significance e.g. *Salmonella* and *Shigella* were found at very low levels in this study. The presence of coliforms such as *E. coli* and *Klebsiella* sp. in the prawns used in this study indicate that their environments were contaminated with faeces because the natural habitat of the family *Enterobacteriaceae* to which these bacteria belong is the faeces of man and other mammals. Cann, 1977 reported that the number and types of bacteria in a shellfish product reflect the changes that have occurred in the initial flora and the degree of contamination that has taken place in the course of handling on shore.

The results of heavy metal analysed in this study showed that metal uptake by *P. notialis* and *M. vollenhovenii* was a function of concentration of the effluent to which the prawns were exposed. The levels reported for both types of prawn in this study (Table 6) were lower than the WHO/FEPA maximum permissible limit in foods (FEPA, 1991 and WHO, 1971). This suggests little or no possibility of heavy metal toxicity hazard associated with their consumption, and the waters where these prawns were caught are relatively free from pollution by heavy metals. Generally, low levels of heavy metals have been reported for Nigerian inland and near-shore waters as well as in sea foods from these environments: In the freshwater and marine water, (EIA, 1998) did not detect Cd. zinc occurred at concentrations ranging between 0.04 μ g/g and 0.07 μ g/g while Pb occurred at concentrations between 0.30 μ g/g and 0.35 μ g/g. (EIA, 1998) . Aremu and Inajoh (2007) did not detect Cd and Pb in seafoods from Nigerian inland waters. In the case of marine water prawn, the low level may be due to effective control and monitoring of the drilling operations of the oil companies by Agencies charged with the responsibility. The law prohibiting dumping of untreated industrial effluents is effective. The industries are treating their effluents which therefore do not find their way into the rivers and reservoirs, as was the case in the past.

5. CONCLUSIONS

The quality of marine water prawns and freshwater prawns stored in ice was evaluated by sensory, microbiological and heavy metal analyses .The prawns were acceptable up to the 8th day in ice.

The succession of bacteria genera during the storage in ice were *Bacillus*, *Corynebacteria*, *E.coli*, *klebsiella* sp., *Salmonella* and *Shigella* for both types of prawn.

Prawns in this study had a fairly high bacterial load; however organisms of public health significance, e.g. *Salmonella* and *Shigella*, were found at very low levels and were within the limits specified by ICSMF (1974).

Heavy metal levels reported for both types of prawn in this study were lower than the WHO/FEPA maximum permissible limit in foods .This suggests little or no possibility of heavy metal toxicity hazard associated with their consumption and that the waters where these prawns were caught are relatively free of pollution from heavy metals.

Table 1. Changes in raw appearance and grade of *M. vollenhovenii* stored in ice

Days in ice	Grade	Raw Appearance
1	I	Fresh characteristic odour; texture firm, colour normal
5	II	Neutral odour; head loose; texture slightly firm
8	Just acceptable	Slight off odour, head very loose and black spots on head, texture of flesh soft
12	Reject	Strong off odour, heads very loose, most heads broken from body, black spots more texture of flesh very soft
15	Reject	Putrid odour, black spots very severe, texture of flesh very soft

Table 2. Changes in raw appearance and grade of *P. notialis* stored in ice

Days in ice	Grade	Raw appearance
1	I	Fresh characteristic odour, texture firm, colour normal.
5	II	Neutral odour, head slightly loose; texture firm.
8	Just acceptable	Slightly off odour, head loose and black spots on head, texture of flesh soft.
12	Reject	Strong off odour, head very loose, black spots more, texture of flesh soft.
15	Reject	Putrid odour, most heads broken from body, black spots severe, texture of flesh very soft.

Table 3. Succession of microflora during ice storage of *M. vollenhovenii*

Microorganism	Days in ice (% occurrence)				
	1	5	8	12	15
<i>Bacillus</i>	20	15	15	10	5
<i>Corynebacteria</i>	35	30	20	10	5
<i>E. coli</i>	18	20	25	33	40
<i>Klebsiella</i> sp.	15	20	20	25	25
<i>Salmonella</i>	5	5	8	10	10
<i>Shigella</i>	7	10	12	12	12

Table 4. Succession of microflora during ice storage of *P. notialis*

Microorganism	Days in ice (% occurrence)				
	1	5	8	12	15
<i>Bacillus</i>	20	15	15	10	5
<i>Corynebacteria</i>	35	30	20	10	5
<i>E. coli</i>	18	20	25	33	40
<i>Klebsiella</i> sp.	15	20	20	25	25
<i>Salmonella</i>	5	5	8	10	10
<i>Shigella</i>	7	10	12	12	12

Table 5. Total bacterial count of *M. vollenhovenii* and *P. notialis* during storage

	Days in ice and total bacterial count (CFU/g)				
	1	5	8	12	15
<i>M. vollenhovenii</i>	4.5×10^5	4.0×10^5	3.5×10^5	2.5×10^6	5.8×10^7
<i>P. notialis</i>	4.0×10^5	3.5×10^5	3.2×10^5	2.4×10^6	5.5×10^7

Table 6. Comparison of heavy metal levels in *M. vollenhovenii* and *P. notialis* (µg/g)

	Cd	Pb	Cu	Zn	Cr	Fe	Co	Ni	Mn
<i>M. vollenhovenii</i>	0.33	1.25	5.40	1.54	2.61	2.04	5.69	1.52	0.45
<i>P. notialis</i>	0.28	0.96	6.15	0.56	15.0	1.14	5.52	2.05	1.82

6. REFERENCES

Aremu, M.O. & Inajoh, A. 2007. Current World Environment. Vol.2 No 2, 205–212

Cann, D.C. 1997. Proc. Conf. Handle Process, Mark Trop. Fish, Tropical Products Institute, London 1976. 377–394 pp.

Clucas, I.J. & Ward, A.R. 1996. Post-harvest fisheries development. A guide to handling, preservation, processing and quality. Chatham Maritime, Kent ME4 4TB. United Kingdom. 443pp. FAO. 1994.

EIA. 1998. Environmental Impact Assessment of Yoyo Field Development Project. Mobil Producing Nigeria Unlimited, Lagos.

FAO. 2001. Fisheries Circular No 974. Tropical shrimp fisheries and their impact on living resources. 188–213 pp.

FDF. 2002. Federal Department of Fisheries. National Fisheries Statistics 2002 publication.

FEPA. 1991. Federal Environmental Protection Agency. *Guidelines and standards for Environmental Pollution Control in Nigeria.* March 1991, Lagos.

Gerlach, S.A. 1981. *Marine Pollution, Diagnosis and Therapy.* Springer Verlag, Berlin 218 pp.

ICMSF. 1974. International Commission on Microbiological Specifications for foods. Microorganisms in Foods. Vol. 2. Toronto University Press, Toronto.

Jensen, J. & Hansen, P. 1973. New system for boxing iced fish. Fish News Int. 12 (4):36–40.

Pongpen, R., Niracha, W., Preeda, M. & Naruemon, S. 1990. Hygienic processing of shrimp in Thailand. FAO Fisheries Report No, 40/ suppl. Rome, 1990. 1–5.

WHO. 1971. World Health Organisation. *International Standards for Drinking water* 3rd Ed. Geneva.

PRODUCTION AND EXPORT OF FISHERY PRODUCTS: CHALLENGES FACING THE INDUSTRY IN SEYCHELLES

[PRODUCTION ET EXPORTATION DES PRODUITS DE LA PÊCHE, DÉFI DE L'INDUSTRIE AUX SEYCHELLES]

by/par

Christopher Hoareau¹

Abstract

Export of fish and fishery products is the second most important source of foreign exchange earning for Seychelles after tourism. In 2006, Seychelles produced 45,223 tonnes of fish products, of which 40,222 tonnes were canned tuna and the remaining were fresh fish whole and fillets exported on ice, smoked fish, fish oil and frozen prawns. More than 95% of the canned tuna produced are exported to the European Union (EU).

The major sanitary concern for the export market has been the high level of histamine in canned tuna for which two rapid alerts were notified in 2007. However, no alerts were notified in 2005, 2006 and 2008. Another sanitary issue of major concern is the non compliance to the stringent limit for heavy metals in the large pelagic, namely swordfish. Industrial tuna fishing is dominated by the EU purse seiners licensed to fish in Seychelles' waters and adjoining seas. In 2006, 371,000 tonnes of brine frozen tuna was landed and 90,000 tonnes were processed by the local canning factory, whilst the rest were directly transshipped in Port Victoria. About 79,340 tonnes from the above figure was landed by Seychelles- flagged vessels owned by European companies.

The artisanal sector produces around 4,000 to 4,500 tonnes of fish per year and 90% of this quantity is consumed domestically. This sector has reached a point of sustainability and more fishing effort could lead to over-exploitation of demersal species, such as groupers, snappers, jobfish and emperors. Projects are in progress to start on an industrial scale the production of value-added seafood products, such as fish fingers, fish burgers, fish nuggets and fish soup, with the aim of maximizing earnings from export. One of the biggest challenges for the making of fishery products in Seychelles is the cost of production which is indeed much higher than that of most other countries in the region. With the projected erosion of preferential tariffs given by the EU in years to come, products from Seychelles may lose their competitiveness in the export market. Opportunities exist in the semi-industrial longline sector targeting tuna and swordfish, currently underexploited when comparison is made to the number of vessels practising this fishery and the size of Seychelles' exclusive economic zone (EEZ).

Key Words: *Export of fishery products, Rapid alerts, Industrial tuna fishing, Semi-industrial fishing, Artisanal fishing, Value- added products, Preferential tariff*

Résumé

L'exportation de poissons et produits de la pêche est la deuxième source de devises étrangères pour les Seychelles après le tourisme. En 2006, les Seychelles ont produit 45.223 tonnes de produits de la pêche desquels 40.222 tonnes étaient des conserves de thon et le reste poisson frais entier et en filets exportés sous glace, poissons fumés, l'huile de poisson et des crevettes surgelées. Plus de 95% des conserves de thon produites est exporté vers l'Union européenne (UE).

La principale préoccupation sanitaire sur le marché d'exportation a été le niveau élevé d'histamine dans les conserves de thon dont deux alertes rapides ont été notifiées en 2007. Cependant, il n'y a eu aucune alerte en 2005, 2006 et 2008. L'autre préoccupation sanitaire majeure est la non conformité à la limite rigoureuse pour les métaux lourds dans les grands pélagiques, notamment l'espadon. La pêche industrielle du thon est dominée par les senneurs de l'UE autorisés à pêcher dans les eaux des Seychelles et les mers contiguës. En 2006, 371.000 tonnes de thon congelé en saumure ont été débarquées et 90.000 tonnes ont été traitées par la conserverie locale tandis que le reste a été transbordé directement au Port Victoria. Environ 79.340 tonnes de cette figure ont été débarquées par les navires battant pavillon des Seychelles et propriétés de compagnies européennes.

¹ Veterinary services, Fish Inspection and Quality Control Unit, PO Box 166, Victoria, Mahe, Seychelles. vetfiqcu@seychelles.net

Le secteur artisanal produit environ 4.000 à 4.500 tonnes de poissons par an et 90% de cette quantité est consommé sur le marché local. Ce secteur a atteint un point de durabilité et davantage d'effort de pêche pourrait mener à la surexploitation des espèces démersales telles que des mérous, des cordelettes, le jobfish et des empereurs. Des projets sont en cours pour commencer à une échelle industrielle la production des produits à valeur ajoutée de fruits de mer tels que le bâton de poisson, l'hamburger de poissons, les pépites de poissons et le potage de poissons, dans le but de maximiser des gains provenant de l'exportation. Un des plus grands défis à la production des produits de la pêche des Seychelles est le coût de production qui est en effet beaucoup plus élevé que celui de la plupart des autres pays dans la région. Avec l'érosion prévisionnelle dans les années à venir des tarifs préférentiels qui étaient offerts par l'UE, les produits de Seychelles pourraient perdre leur compétitivité sur le marché d'exportation. Les chances existent dans le secteur semi-industriel de la pêche aux palangriers ciblant le thon et les espadons, qui sont actuellement sous exploités, par comparaison au nombre de navires qui pratiquent ce type de pêche et la taille de la zone économique exclusive (ZEE) des Seychelles.

Mots clés : Exportation des produits de la pêche, Alertes rapides, Pêche industrielle de thon, pêche semi-industrielle, Pêche artisanale, Produits à valeur ajoutée, Tarif préférentiel

1. INTRODUCTION

The Seychelles Islands - geography and development status

Seychelles is a small island state in the western Indian Ocean, situated just south of the Equator. It comprises an archipelago of three main, and more than a hundred, small islands. The country's total land area is only 455 km² (177 square miles), and there is only limited cultivatable land. There are no known mineral resources. The country's vast EEZ covers an area of 1.35 million km², and is located on one of the most productive fishing grounds in the South-West Indian Ocean. Seychelles is relatively isolated from neighbouring countries and the nearest continental coastline is 1,600 km away.

The population is static and estimated at 82,000 (estimated mid-year 2006 - MISD statistical abstract). GDP per capita is about US\$8,000 and the development indicator compares favourably with other countries in the region. Seychelles ranks first in Africa (and 47th in the world) in the Human Development Index (HDI) of UNDP 2007–2008.

2. A BRIEF ACCOUNT ON THE FISH INDUSTRY

The fish industry is the second most important source of income for the country after tourism, and the primary source of visible exports. In 2006, domestic production of fish and fish products was an estimated 45,223 tonnes. About 371,000 tonnes of tuna were landed in Port Victoria, Mahé, from EU and Seychelles' flagged purse seiners and 90,000 tonnes went to the local tuna canning plant, whereas the rest were directly transshipped and destined for canning in other African Caribbean and Pacific (ACP) countries or the EU.

The fishery sector is diverse. Apart from industrial purse seining for tunas, there are both domestic (semi industrial longliners) and international surface longline fleets targeting large pelagic fish, including shark and swordfish. There are also smaller line fishing vessels and the artisanal fleet targeting snappers and demersal fish species. Trawling is banned. A government-owned shrimp hatchery and farm is located on the remote island of Coetivy, about 160 km southwest of Mahé. Aquaculture also supplies ornamental clams and pearls for export. The processing and export sector includes the Indian Ocean Tuna cannery (IOT) (which also supplies frozen loins), by far the largest single employer in the country, with a workforce of over 2,500. In addition there are two establishments processing fresh and frozen fish (including tuna loins and demersal fish consigned by air to EC markets). Several exporters deal in dried shark fins and sea cucumbers, a shrimp processing and packing facility associated with the Coetivy shrimp farm, fishmeal and oil processing, and a new high technology plant extracting fish oils for human consumption from tuna heads. Aquaculture feeds are also manufactured in Mahé, supplying shrimp farming in Seychelles, Tanzania and Madagascar. Direct and indirect employment in the fishery sector is estimated to be approximately 6,000 people, representing around 13% of the total formal employment in the country.

Given the economic importance of the fishery sector, maintaining market access through compliance with sanitary conditions is a strategic imperative for the Government of Seychelles and the diversity of the sector presents a significant challenge.

The artisanal sector

This fishery is reserved for the local fisherman only. About 90% of the catch produced by this sector is consumed locally; a good percentage of this is supplied to tourism establishments. Currently there are about 450 to 500 artisanal fishing vessels, ranging from 5 to 13 metres in length. Most are equipped with inboards engines, although the smaller ones around 5 to 8 metres in length have outboard engines. The larger vessels are fitted with fibreglass-built insulated fish boxes and preserve their catch with ice. A typical fishing trip would last around 5 to 6 days. The smaller boats rarely carry ice, spend less than a day at sea and all their catch is sold on the domestic market. Fishing is done mostly on the large continental shelf surrounding the granitic islands, known as the Mahe plateau. The main species landed are the snapper, grouper, emperor, trevally, job fish, Indian mackerel, etc.

The semi-industrial sector

This sector was recently developed around the mid-nineties with the support of the EU and its main objective was to supply the export market with fresh tuna, swordfish and other bycatch species. Semi-industrial longlining was very strongly promoted since it was viewed as being very profitable and expected to provide employment opportunities to several full-time fishermen. One of the expected results was to reduce pressure on coastal fisheries which have themselves reached a point of near over-exploitation. Incentives were provided by the government to encourage investment in this sector, e.g. favourable loans granted by the local development bank. Despite these efforts, the results have not been as expected for several reasons, such as:

- high predation rate by false killer whales;
- high cost of imported squid bait;
- an EU ban on the export of swordfish from Seychelles in 2003–2004 due to high level of cadmium/mercury;
- more profit is earned in shark fishing for the fin than in fishing tuna and swordfish; and
- generally low catch during certain period of the year.

Currently there are only four boats practising this fishery on a full-time basis out of 12 that initially started. The authority is in the process of reviewing its policies with the aim of revitalizing this important fishery.

Industrial sector

This sector is the largest contributor to Seychelles' economy (refer to Table 1). Fishing is practised by European purse seiners mostly belonging to the French and Spanish, ten of these flying the Seychelles' flag. About fifty of these vessels were licensed to fish in Seychelles waters and their adjoining seas. About 95% of the catch (SFA Annual Report 2006) landed in Port Victoria in 2006. One third of that was supplied to IOT and the rest transshipped and exported to other ACP and EU countries for tuna canning.

Economic contribution of the fisheries sector

Similarly to the previous year, mixed results were observed in the fisheries sector in 2007. In value terms, satisfactory growths were observed in trade and total revenue generation, whilst local production and volume traded recorded unfavourable results. As a result of this and compounded with rising fuel prices and poor catches in the Indian Ocean, per unit price of fish and fish products, both on the local and external markets experienced a general upward trend.

There was a slight growth in the production of the traditional artisanal sector. Landed catch grew by 8.8% and despite a decrease in export of fish from this subsector there was a general increase of about 5.8% in the average price of fish in 2007. This increase follows the general inflationary upward trend in the economy.

The semi-industrial subsector performed remarkably well in 2007 with an increase in total landing, but still very far from the peak achieved in 1999. Gross inflow of foreign exchange generated by the industrial tuna fishing activity continued to grow as a result of the continuing increase in fuel prices on the global market.

Employment

It is estimated that employment in the fisheries and related sectors for the year 2007 have remained fairly constant compared to the previous year. Direct and indirect employment is estimated to be about 6,000 people representing around 15% of total formal employment in the country, a slight increase of 2% compared to 2006. Direct employment in this sector includes factory employees, fisherman, stevedores and employees from the Fishing Authority, accounting to more than 75% of the above stated figure. The number of full-time and part-time commercial fishermen oscillates between 1,700 and 1,800 primarily due to the seasonal mobility associated with this sector. The Indian Ocean Tuna cannery, by far the largest single employer in the country, had a workforce of over 2,500 workers.

Production

In 2007, there was a significant drop in domestic production of fish and fish products compared to 2006. Total production fell by almost 19% to reach 36,771 tonnes, compared to 42,263 tonnes produced in 2006 when total output dropped by 3%. Increases were registered in the artisanal catch (+8.8%), the semi-industrial sector (+10.8%) and output of other processed fish (+26.6%). Production of smoked fish increased by 15% to reach 29 tonnes, whilst sea cucumber and dried shark fins amounted to 53 tonnes, a slight increase of about 2.5% over the previous year.

Table 1. Production of Fish and Fish Products 2005–2007 (tonnes)

	2005	2006	% Change	2007	% Change
Artisanal catch	4,583.10	3,849	-16.02	4,189	8.83
Semi-industrial catch	312.08	237	-24.06	268.65	13.35
Canned tuna	40,606	40,222	-0.95	31,569	-21.51
Other processed tuna	334	218	-34.73	276	26.61
Prawns	772	638	-17.36	368	-42.32
Smoked fish	14.80	25.20	70.27	29	15.08
Others	36.80	51.70	40.49	53	2.51
Total	46,658.78	45,240.90	-3.04	36,752.65	-18.76
Purse seiner catch*	87,534	79,340	-9.36	49,938	-37.06
Longliner catch*	14,359	8,374	-41.68	8,462	1.05

* Seychelles flagged vessels

Output from the Coetivy Prawn Farm dropped quite significantly by 42.3% over the previous year to reach only 368 tonnes, far from its total production capacity. Canned tuna production also suffered, realizing an output of 31,569 tonnes in 2007, a drop of 21.5% over the previous year when output topped 40,222 tonnes.

The landed catch from the semi-industrial subsector showed a moderate increase in 2007 after a drop in 2006. The landing of tuna, swordfish and shark meat increased by 13.4% to reach 268.7 tonnes.

After a drop of 9.4% in 2006, the catch of tuna by Seychelles' flagged purse seiners dropped by a considerable 37% in 2007 to reach only 49,938 tonnes. This is a drop of 29,400 tonnes over the previous year. Seychelles' flagged longliners hauled in 8,462 tonnes 1% more than the 8,374 tonnes catch in 2006.

For the last two years a downward trend is being observed in the total domestic output of fish and fish products and, as in previous years, the total output is almost entirely dependent on the trend in production of canned tuna. Figure 1 below shows the trend in total output of fish and fish products over the last 18 years.

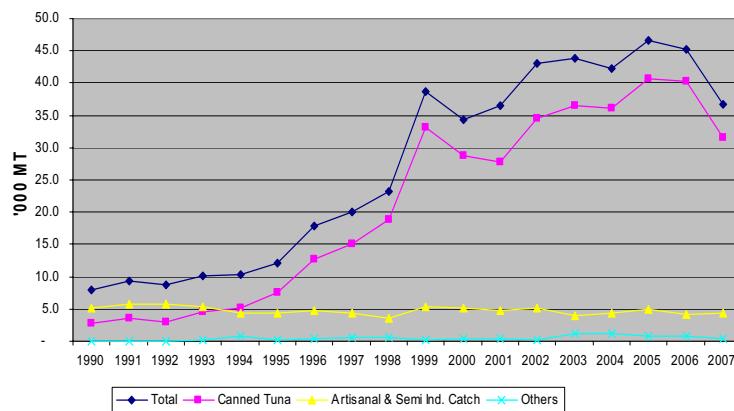


Figure 1. Trends in the output of fish and fish products 1990–2007 (tonnes)

Revenue from industrial tuna fishing activity

The industrial tuna fishing activity by purse seiners and longliners remains an increasingly important source of foreign exchange for the local economy. Gross income from this activity is derived mainly from payments on goods and services in Port Victoria by foreign fishing vessels and companies based in Port Victoria, as well as through payment for licences and financial compensation paid by the EU for fishing rights in Seychelles' EEZ. In 2007 the total gross income derived from these sources amounted to SR¹ 986.080 million, 22.5% more than the SR 804.8 million generated in 2006 (see Table 2).

Table 2. Main sources of revenue from the industrial tuna fishing activity 2005–2007 (SR million)

	2005	2006	% change	2007	% change
Vessels' spending	559.60	737.70	31.83	931.44	26.26
Companies' expenditure	5.55	5.59	0.72	3.79	(32.20)
Licence fees/EU payments	71.95	61.53	(14.49)	50.85	(17.36)
Total	637.10	804.82	26.32	986.08	22.52

Spending by vessels in Port Victoria remains by far the biggest component of foreign exchange earnings from the industrial tuna fishing activity. This component increased by 26.3% in 2007 compared to the previous year. Spending by foreign companies based in Seychelles dropped by 32.2% whilst licence fee payment and EU financial contributions dropped by 17.4%. It is to be noted that the payment for the 2006 excess catch, which should have been paid in 2007, was not honoured during the year due to the clarification of under-reporting by EU vessels fishing in the EEZ.

Export of fish and fish products

Exports of fish and fish products constitute the biggest source of foreign exchange earnings by the industry and related activities. As can be observed in Table 3, there were mixed changes in both the volume and value of exports of fisheries products in 2007. Overall, whilst there was a 16% decrease in the total volume of processed marine products exported, the total value showed an increase of almost 18% over the same period.

¹ US\$1 = SR 8.50

Table 3. Volume and value of export of fish and fish products 2006–2007

	2006		2007		% Change	
	Tonnes	SR thousand	Tonnes	SR thousand	Tonnes	SR thousand
Fresh and frozen fish	369.70	13,674	299	13,922	(19.12)	1.81
Canned tuna	38,498	1,034,498	32,328	1,231,207	(16.03)	19.01
Frozen prawns	624	25,252	365	17,214	(41.51)	(31.83)
Other processed fish	170	3,134	323	6,450	90	105.81
Dried shark fins and sea cucumber	52.23	2,790	53	5,657.	1.47	102.76
Others	1.10	1,979	-	-	-	-
Total	39,715.03	1,081,327	33,368	1,274,450	(15.98)	17.86
Total Domestic Exports		1,194,600		1,346,527		12.72
% of Domestic Exports		90.52		94.65		

Sources: National Bureau of Statistic and Seychelles Fishing Authority

The opposite shifts in volume and revenue earned reflect an overall increase in the unit price for Seychelles' fish products. This trend has been primarily driven by the export of canned tuna which jumped by 19% in earnings despite a 16% drop in volume exported. This is in line with development in the EU market for canned tuna where prices have been on the increasing trend.

Positive developments were also recorded in the export of other processed fish, dried sea cucumber and shark fins. On another positive note, despite an increase in total domestic exports, the share of exports of fish and fish products managed to show an increase of about 4.2% over the previous year to reach 94.7% in 2007. For the year, 92% of the value of export went to the traditional European markets.

Imports of fish and fish products

In 2007, mixed changes were observed in import of fish and fish products. Whilst the volume of imports dropped by 22.7% over the twelve month period, the value of imports increased by 28.3% over the same period, revealing a general increase in the average price per unit of fish and fish products imported.

Table 4. Volume and value of import of fish and fish products 2006–2007

	2006		2007		% Change	
	Tonnes	SR thousand	Tonnes	SR thousand	Tonnes	SR thousand
Fish, fresh or chilled	0.22	14.82	2.21	114.57	906.36	673.10
Fish, frozen	91,929.53	517,548.00	71,005	659,659	(22.76)	27.46
Fish, Fillets and other fish meat	0.50	35.56	1.29	85.37	158.40	140.07
Fish, dried, salted or in brine	46.21	1,434.38	11.00	1,630.96	(76.20)	3.71
Molluscs and crustaceans	159.20	7,425.88	218.80	14,146.57	37.44	90.50
Others	7.01	303.14	6.55	412.90	(6.53)	36.21
Total	92,142.67	526,761.78	71,245.08	676,048.88	(22.68)	28.34

Sources: National Bureau of Statistic and Seychelles Fishing Authority

There was a significant increase in the imports of fresh and frozen fish, fish fillets and other fish meat and to a lesser extent molluscs and crustaceans. This rise may be attributed to the increased demand by the hotel, restaurant and catering industry. A considerable drop was observed in the import of frozen tuna for the canning factory accompanied by an increase in price for that commodity. Frozen fish imports are mainly due to poor catches of *Thunnus alalunga* (germon) in the region, thus compelling the canning factory to import most of this species, which it processes quite frequently.

Rapid alerts notification

No rapid alert was notified in 2006, whilst in 2007 three alerts were notified against Seychelles. Two were in relation to the high level of histamine in canned tuna from Indian Ocean Tuna Ltd. The third was in relation to canned tuna produced by a factory in Italy of which the raw material (brine-frozen whole tuna) was linked to a Seychelles-registered freezer vessel. On follow-up by the Competent Authority, this last alert (AAM) could not be confirmed (Table 5 refers). The alerts BRF and BZE revealed some major non-conformances in the handling of products being processed under delayed packaging procedure. The investigation led to modification in the packing procedure and all corrective actions by the Fish Inspection and Quality Control Unit Project (FIQCU) are being implemented.

Table 5. Rapid alerts notified against Seychelles

Alert No	Product	Establishment	Reasons for Alert
AAM 2007 - week 09	Caned tuna	Erroxape	High level of histamine
BRF 2007 - week 27	Canned Tuna	IOT	High level of histamine
BZE 2007 - week 34	Caned tuna	IOT	High level of histamine

Source: Fish Inspection and Quality Control Unit - Seychelles

3. ANALYSIS OF THE FISHING INDUSTRY

Strengths

One of the main strengths of the industry in Seychelles is that it provides employment to a good sector of Seychelles' workforce. As mentioned earlier, about 15% of people in formal employment are in the fisheries sector. This is significant for a small island state such as Seychelles which has very limited resources and a small industrial base. Many of the fisherman/skippers are themselves owners of their vessels. This has been possible through schemes established by the government to enable the borrowing of money on favourable terms and conditions. To further boost productivity and encourage investment in this sector, tax concessions on imported items used by the industry are in place. These include: processing equipment for the industry, vehicles, engines and spares for vessels, reduced fuel cost for registered boat operators, etc.

Looking on the side of safety and quality, products from Seychelles on the EU market (mainly fresh fish) have generally commanded a good reputation. Less than ten rapid alerts have been published over the past ten years and were mostly associated with heavy metals in swordfish and histamine in canned tuna.

Another factor which arguably constitutes a strength to the industry is the location of the main fishing grounds, generally at reasonable distance from the main fishing port. Therefore, not too much time is spent by the vessels steaming from port and back. Currently all processing establishments are centrally located and landing of product is focused in that particular area. There is limited transportation of fish from remote landing sites to processing plants and this provides a huge advantage in the maintenance of the cold chain and quality of products.

Weaknesses

One of the most visible difficulties that the industry is facing is the high cost of production in Seychelles compared to most other countries in the region. This puts the country in a very unfavourable position when one compares the cost of producing processed products with countries in the region, such as Madagascar, Mauritius, Thailand and Sri Lanka. With the erosion of the preferential tariffs provided by the EU in the years to come, Seychelles' products will face much stiffer competition from other suppliers on the EU market.

The availability of necessary infrastructures such as dry docks, net landing facilities for net repairs and approved cold storage facilities for bulk storage of brine-frozen tuna awaiting reefer vessels, also contribute to making the operations more costly.

On the artisanal side, a good many of the fishermen are fairly aged, not professional and it is very difficult to train them and convince them when it comes to aspects of sustainability of the industry. They cannot understand the need for managing the resources in a sustainable manner and its relation to the benefit of future generation. These fishermen are generally perceived as unreliable, have a tendency to abuse alcohol and, therefore, are unable to project the right image of the importance of their job and its contribution to the national economy.

Unfortunately, this has led to artisanal fishing being portrayed as a low status job and, therefore, it is not attractive to the upcoming generations.

The threat of overfishing is beginning to show signs, especially among the coastal fisheries for certain species such as lobsters, octopus, sea cucumber and other reef fish, where restrictions are in place to prevent over exploitation. Another factor contributing to overexploitation is pleasure or sport fishing. Many individuals, especially the more affluent members of society, own boats and enjoy fishing for pleasure. They compete directly with the full-time fisherman and sometimes land a substantial quantity of fish, especially during fishing competitions.

Comprehensive data on stock assessment is currently inadequate for certain types of fisheries to enable informed decisions to be made on the sustainability of certain fish stocks. This area calls for investment in research programs and assistance is being sought from countries such as Japan and the EU which have signed certain agreement to assist Seychelles in managing and developing its fisheries resources.

Seychelles' vessels involved in tuna fishing are in constant competition with foreign vessels fishing in Seychelles' EEZ and some of these vessels are listed as Illegal, Unreported and Unregulated (IUU). In the past, several vessels of different nationalities fishing illegally in Seychelles' EEZ have been apprehended by Seychelles' authorities. However, it is believed that many of the boats fishing illegally are not apprehended due to the difficulty associated with costs in undertaking proper surveillance and monitoring of the EEZ.

Opportunities

The development of a sustainable fishery for high value resources such as the red snapper (*Lutjanus sebae*) is regarded as an opportunity that, if successful, will enable stakeholders to obtain a much higher price for their product on the EU market. This project is aimed at providing a certification system for this particular species based on the sustainability of the fishing method (line and hook). This is in combination with the level of freshness of the fish assessed mainly by the length of time from harvest until it reaches the consumers in the EU. Each fish shall be accompanied by all necessary information required for a full traceability.

The large EEZ, of approximately 1.4 million km², would allow Seychelles the opportunity to have a reasonable fleet of industrial longliners and purse seiners to exploit and maximize benefits from the tuna resources (currently both fisheries are dominated by foreign-owned vessels, namely European purse seiners and Asian longliners). However, this matter has been discussed for a long time now but, due to a number of reasons, primarily funding related, its realization is still a distance away.

The exploitation of the bycatch from purse seiners has the potential to earn Seychelles valuable foreign exchange. Currently a small percentage of the bycatch is able to penetrate the export market in the form of frozen gutted fish of which the species are dominated by the *Coryphaena hippurus* (dorado) and the *Acanthocybium solandri* (king fish). The bulk of these species landed are brine-frozen and inadequately handled during unloading. Efforts are being made to improve handling so as to satisfy the quality requirement of the export market.

As mentioned earlier, the semi-industrial longlining sector depends heavily on imported squid for its supply of baits, which significantly add cost to the whole operation. Currently a project is underway to catch bait locally, mainly mackerel, to subsidize this dependency. The trials conducted so far have shown encouraging signs and the project is well in progress.

There is potential for Seychelles to conduct more research on the exploitation of other marine resources found in the deeper waters. Trials have started on the fishing of deep-sea prawns using traps with baits. Results have shown that the resource is present but more information is required on the stock biomass and the cost-effectiveness of its exploitation.

Threats

The semi-industrial longline sector is threatened by the ever-present predator species, such as the false killer whale that may consume as much as 40% of the catch of a vessel. Scientific methods to deter killer whales have been tried, but not with too much success. These marine mammals are protected species and, therefore, their destruction is strictly prohibited. At the moment no real long-term solutions have been found and the result is a serious loss in earnings by the boat operators.

The erosion of tariff preferences granted by the EU to ACP countries in the coming years is a real concern for the industry. The main threat is due primarily to the high cost of production in Seychelles when compared to other producers in the region where the cost of living is generally much lower. Unless Seychelles is able to produce high-value products able to attract a specific market sector, or try to bring down its cost of production, it may lose its traditional EU markets to the cheaper products coming mainly from the Far East.

Signs of overfishing are beginning to show, especially on the side of the coastal fisheries. Restrictions on the fishing of some species such as lobsters, octopus, sea cucumber and other reef fish, have been put in place to prevent overexploitation. The red snapper (*Lutjanus sebae*) inhabiting the relatively shallow waters of the Mahe plateau and other nearby banks is one of the highly commercial species heavily exploited. According to reliable sources, the average size of the majority of fish landed is reducing, which shows that, in general, they are not reaching full adult growth.

4. VALUE ADDITION IN SEAFOOD PRODUCTS IN SEYCHELLES

Value addition in seafood is not new to Seychelles. For quite some time, value added products such as fish fingers, fish burgers and fish balls, have been produced on a rather small scale for the local market. The emphasis is now to produce them on an industrial level mainly for the export market. As a result, a project on Value Addition in Seafood started a couple of years ago and had as its main objectives to increase foreign exchange earning from the export of value-added fishery products and to maximize the use of valuable fish by-products ending as raw material for the manufacturing of animal feed or pet food. Valuable products could be produced from parts of the fish or from species that are not well commercialized if only the processing technology was available and if investment could be cost-effectively justified.

Seychelles government sought assistance from the Centre for Development of Enterprises (CDE) of the EU. Consultants from ID.MER (Institut technique de développement des produits de la mer) based in France were recruited in 2006 to start working on a project identifying several products that could be manufactured from the available resources. Out of twelve potential products identified, five were selected by the local stakeholders and after careful study of these products by ID.MER pilot production commenced in 2008 to 2009. A market trial is to take place both locally and internationally in 2009 and, if the response is positive, industrial production will start late 2009 and 2010. The project involves the government providing the basic infrastructure (main building) which will be partitioned and rented to the processors who, in turn, will provide their processing equipment and other facilities needed. Loan facilities with favourable terms will be made available to assist the processors in procuring equipments.

Assistance is also being given by the Japanese Overseas Fisheries Corporation Foundation (OFCF). This includes the construction of a technical centre for research and development of value-added products. A Japanese consultant in fish processing technology was on mission to design the centre and train the local technicians. The technology is to be disseminated to local processors willing to produce both for the local market and for export. This project is in progress and will be fully operational in mid 2009.

5. CONCLUSIONS

The way forward for the industry remains a considerable challenge considering the many issues that the authorities need to address. Export of fish and fishery products remains the second most important pillar of Seychelles' economy and much of the focus of the industry and government is to maintain access to the EU market. Maximizing the socio-economic benefits obtainable from the industry is also a great priority for the government. Assistance mainly from the EU and the Japanese Government goes a long way in assisting the development of the industry as a whole.