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Report and papers presented at the

FAO WORKSHOP ON FISH TECHNOLOGY, UTILIZATION AND QUALITY ASSURANCE

Bagamoyo, United Republic of Tanzania, 14–18 November 2005

Rapport et documents présentés à

L'ATELIER DE LA FAO SUR LA TECHNOLOGIE, L'UTILISATION ET L'ASSURANCE DE QUALITÉ DU POISSON

Bagamoyo, République-Unie de Tanzanie, 14-18 novembre 2005

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PREPARATION OF THIS DOCUMENT

This document contains the report and papers of the Workshop on Fish Technology, Utilization and Quality Assurance. The Workshop was held in Bagamoyo, Tanzania, from 14 to 18 November 2005. It was attended by 26 experts who reviewed progress and problems in post-harvest fish utilization with particular attention to fresh fish, fish processing, quality assurance, and marketing and socio-economic issues. The issues were introduced through:

- presentation by the secretariat of a report on progress and events since the Expert Consultation in Fish Technology held in 2001 in Saly-Mbour, Senegal;
- presentation of 26 papers;
- abstracts of 2 additional papers;
- a field trip to MFDC in Mbegani, a fish market and a processing unit in Dar es Salaam.

In the discussions a number of recommendations were made. These were noted by the secretariat and discussed, amended and adopted by the experts in the final session. The recommendations are made to FAO, its member countries and to all institutes, institutions and persons interested or involved in fish utilization in Africa.

The Workshop was organized by the Fish Utilization and Marketing Service (FIIU) of FAO's Fishery Industries Division [renamed *Fish Products and Industry Division* in January 2007] in collaboration with the Mbegani Fisheries Development Centre (MFDC) under the Fisheries Directorate of Tanzania and the FAO Regional Office for Africa. The Workshop was funded by the Regular Programme of FAO and the project GCP/GLO/120/SWE-Fisheries in West Africa on market related fisheries issues

The report and papers have been edited for publication by Dr Yvette Diei-Ouadi, Fishery Industry Officer (Fish Industry), FIIU. The views expressed in this publication are those of the authors and do not necessarily reflect the views of the Food and Agriculture Organization of the United Nations.

PRÉPARATION DE CE DOCUMENT

Ce document contient le rapport et les contributions de l’Atelier de la FAO sur la technologie, l’utilisation et l’assurance de qualité du poisson. L’atelier, auquel assistaient 26 experts en technologie du poisson, s’est tenu du 14 au 18 novembre 2005 à Bagamoyo, Tanzanie. Il a passé en revue les progrès et les problèmes dans l’utilisation du poisson après capture avec une attention particulière au poisson frais, à la transformation du poisson, l’assurance qualité, la commercialisation et les aspects socio-économiques. Ces questions étaient présentées à travers:

- la présentation par le secrétariat du rapport sur les progrès et évènements depuis la Consultation d’experts FAO sur la technologie du poisson en Afrique qui s’est tenue en 2001 à Saly-Mbour au Sénégal;
- la présentation de 26 communications;
- des extraits de 2 contributions supplémentaires;
- une visite de terrain au MFDC à Mbegani, au marché au poisson et dans une unité de transformation de poisson à Dar es Salaam.

Un certain nombre de recommandations ont été faites lors des discussions. Celles-ci ont été notées par le secrétariat et discutées, amendées et adoptées par les experts en session finale. Les recommandations sont faites à la FAO, à ses pays membres et tous les instituts, institutions et personnes intéressés ou impliqués dans l’utilisation du poisson en Afrique.

Cet atelier a été organisé par le Service de la commercialisation et de l’utilisation du poisson (FIIU) de la Division des industries de la pêche de la FAO [nommée *Division des produits et de l’industrie de la pêche* en janvier 2007], en collaboration avec le Mbegani Fisheries Development Centre (MFDC) de la Direction des Pêches de la Tanzanie et avec le Bureau régional de la FAO pour l’Afrique. L’atelier a été financé par le Programme régulier de la FAO et le projet GCP/GLO/120/SWE-Pêches sur les questions relatives au commerce en Afrique de l’Ouest.

Le rapport et les contributions ont été édités pour publication par Dr Yvette Diéi-Ouadi, Spécialiste des industries de la pêche (industrie du poisson), FIIU. Les idées exprimées dans cette publication sont celles des auteurs et ne reflètent pas forcément les points de vue de la FAO.

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ABSTRACT

The FAO Workshop on Fish Technology, Utilization and Quality Assurance was held by the Fish Utilization and Marketing Service of FAO's Fish Product and Industry Division in collaboration with the FAO Regional Office for Africa. The Workshop was held to review progress and problems in post-harvest fish utilization in Africa and formulate recommendations to FAO, its member countries and all institutes, institutions and persons interested in fish utilization in Africa. The experts reviewed in particular fresh fish utilization, fish processing, quality assurance, and marketing and socio-economic issues. The review was done through presentation by the secretariat of a report on progress and events since the Consultation in Fish Technology held in 2001, presentation of 26 papers, abstracts of two additional papers, and a field trip to the Fisheries Development Centre, Mbegani, a fish market and a processing unit in Dar es Salaam. The report includes the recommendations as well as the papers that were available to the experts.

RÉSUMÉ

L'Atelier de la FAO sur la technologie, l'utilisation et l'assurance de qualité du poisson a été organisé par le Service de la commercialisation et de l'utilisation du poisson de la Division des produits et de l'industrie de la pêche de la FAO, en collaboration avec le Bureau régional de la FAO pour l'Afrique. L'atelier a été organisé pour passer en revue les progrès et problèmes dans l'utilisation du poisson après capture en Afrique, et formuler des recommandations à la FAO, à ses pays membres et tous les instituts, institutions et personnes intéressés par l'utilisation du poisson en Afrique. Les experts ont examiné notamment l'utilisation du poisson frais, la transformation du poisson, l'assurance de qualité, la commercialisation et les questions socioéconomiques. Cet examen s'est effectué à travers la présentation, par le secrétariat, du rapport sur les progrès et événements depuis la Consultation d'experts FAO sur la technologie du poisson en Afrique qui s'est tenue en 2001, des présentations de 26 communications, des résumés de deux contributions supplémentaires, et une visite de terrain au Fisheries Develoment Centre à Mbegani, au marché au poisson et dans une unité de transformation de poisson à Dar es Salaam. Le rapport inclut les recommandations de même que les communications qui étaient à la disposition des experts.

Distribution:

FAO Fisheries and Aquaculture Department/Département des pêches et de l'aquaculture de la FAO
FAO Regional and Subregional Fishery Officers/Fonctionnaires régionaux et sous-régionaux des pêches de la FAO
Selected FAO field projects (Africa)/Projets choisis de la FAO sur le terrain (Afrique)
Participating experts/Experts participants
Fisheries Directors (Africa)/Directeurs des pêches (Afrique)
Selected research institutes on fish technology/Instituts choisis de recherche en technologie du poisson

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ORGANIZATION

1. The FAO Workshop on Fish Technology, Utilization and Quality Assurance was organized by the Fish Utilization and Marketing Service, Fishery Industries Division of the Food and Agriculture Organization of the United Nations (FAO), in collaboration with the Mbegani Fisheries Development Centre (MFDC) under the Fisheries Directorate of the United Republic of Tanzania. This is a follow up to the hitherto FAO Expert Consultation on Fish Technology in Africa; the last one was held in Senegal, from 10 to 13 December 2001.

OPENING

2. The Workshop was held at Hotel Paradise Holiday Resort, Bagamoyo, the United Republic of Tanzania, from 14 to 18 November 2005.

3. The Director of Fisheries, Mr Geoffrey Nanyaro, said he was honoured to open the Workshop, which was the second of its kind for Tanzania within 25 years and the eighth in Africa. He welcomed the participants from various countries and fields of expertise and said he hoped that the meeting would help advance post-harvest fisheries in the region. He then expressed his gratitude to FAO for having organized the Workshop, for technical support during the preparatory phase and for having helped Tanzania comply with the stringent requirements in the export market. After stating his appreciation for the national focal point for this Workshop, he recalled the need for development in artisanal fisheries, which provides almost 90 percent of the catches.

4. The Workshop was addressed on behalf of the Director General of FAO by Ms Louise Setshwaelo, FAO Resident Representative in Tanzania. She thanked the Government of Tanzania for having kindly accepted to host the meeting and the experts for having taken time out of their busy schedules to attend it. The necessity to help fishermen and women and their communities to reduce post-harvest losses and improve the safety and quality of fish was highlighted. She recalled past and present support from FAO and its partners in the development of the post-harvest fisheries sector.

5. The Workshop was then addressed by the Permanent Secretary, Minister of Foreign Affairs and International Cooperation of the United Republic of Tanzania, Philemon Luhanjo. He welcomed the participants to Tanzania in general and in particular to the historical town of Bagamoyo. He expressed with honour the gratitude to FAO for having planned and organized this very important platform. The importance of the fisheries sector to the Tanzanian economy was highlighted. However, attention was focused on the challenges concerning fish technology, utilization and quality assurance to be addressed during the deliberations of the Workshop. These include the documentation and improvement of traditional methods of fish curing, the search for affordable solar energy technology, linkage of certification of fishery products with sustainability of the resource, use of simple ways of transporting fresh fish in ice, high priority assistance to women, development of value-added products rather than export of raw or semi-processed fish, and access to capital by fishers. He then wished for fruitful deliberations and formally opened the meeting.

6. The programme is presented as Appendix A.

PARTICIPANTS

7. The workshop was attended by 26 experts from France, Ghana, Italy, Kenya, Mali, Morocco, Senegal, Spain, Uganda, United Kingdom, United Republic of Tanzania, from the Lake Victoria Fisheries Organization (LVFO), from the SADC unit of the Intergovernmental Organization for Marketing Information and Cooperation Services for Fishery Products in Africa (INFOSA) and from FAO. The list of attending experts is presented as Appendix B.

NOMINATION OF MEETING OFFICERS

8. Mr Yahya Mgawe of MFDC, Ms Nancy Gitonga of Kenya, Mr John Esser from United Kingdom, and Mr Richard Abila from Kenya were the respective chairpersons of the Workshop from day 1 to day 4. Ms Absa Gueye Ndiaye, Mr Jean-Pascal Berge and Ms Margaret Masette, the pairs Ms Cisse Oumou Traore/Javier Borderias, Sylla Khalifa/Carol Kirema-Mukasa, and Younes Zenati/Margaret Attikpo were elected as Rapporteurs while Mr Alhaji Jallow (Senior Fisheries officer, FAO Regional Office for Africa), Mr Hector Lupin and Ms Yvette Diei-Ouadi, of the Fish Utilization and Marketing Service, Fishery Industries Division of FAO, served as technical secretaries of the Workshop.

PROGRAMME

9. The experts reviewed progress and problems in the area of post-harvest fish utilization, technology and quality assurance, and made a series of recommendations. Emphasis was placed on fresh fish utilization, fish processing, quality assurance, and on marketing and socio-economic issues. The issues were introduced through:

- presentation by the technical secretariat of a report on the progress made on the recommendations of the seventh FAO Expert Consultation on Fish Technology in Africa held in Saly-Mbour, Senegal, in December 2001. The participants accepted the report and the change as presented.
- presentation of 26 papers;
- two additional papers that were not presented;
- a field trip to MFDC in Mbegani, a fish market and a processing unit in Dar es Salaam.

10. The papers have been edited and are reproduced in Appendix C.

11. On the basis of the presentations and discussions, draft recommendations were prepared by the secretariat; these were discussed, amended and adopted by the experts in the final session of the Consultation.

RECOMMENDATIONS

12. The experts adopted the following recommendations to FAO, its Africa member countries and to all institutes, institutions and persons involved or interested in fish utilization in Africa.

Fresh fish

1) *The effect of size and holding temperatures on rigor mortis in Nile tilapia (*Oreochromis niloticus*) was presented regarding the significance of icing the fish immediately after catch and maintaining the cold chain for a better product. In the ensuing discussion it was suggested that similar work on other species of commercial importance should be promoted.*

Processing

2) *The technological effect of adding wheat fibre to minced hake (*Merluccius merluccius*) and horse mackerel (*Trachurus trachurus*) muscle was presented as a technique for adding value to low-value fish fillets. It was reported that the addition of fibre increased the water holding (WHC) and binding (WBC) capacity of the fish fillets. Restructured products with fibre were whiter and their rigidity and cohesiveness were lower. No strange flavours were apparent when the wheat fibre was added. This new technology was of interest, especially when there was concern for its use in product weight increase.*

3) *The technique of producing frozen pulp from tropical sole (*Cynoglossus sp*) filleting waste in Senegal was presented as a useful product development in the region. The pulp is obtained through the extraction from carcasses of sole after filleting (clearing of meat left on the skeleton). As much as the significance of the technique was noted, it could be used in the region more for other species than for sole, which is mostly processed and packaged whole.*

4) *The participants were informed of oil extraction from* Brycinus leuciscus *in Mali. This species is a highly fatty fish that is less utilized. Value was, therefore, added to it by extracting its oil for frying and for the preparation of sauce in cooking. The oil had been of low quality and that attracted interest in improving it. The improvement resulted in a golden colour, good taste and smell, which the processors prefer. Malian fish processors are increasingly adopting the technique of extracting oil from the species, but there is a need for more research on the chemical composition of the fatty acids, mineral elements and other attributes in the oil. The participants also recommended that the sustainability of the oil production from the Brycinus species resource, if the demand increases, be taken into account in the new research on the technique.*

5) *It was observed that the Lake sardine (*Rastrineobola argentea*) is a very important food item, particularly in ensuring food security. Unfortunately, however, there are huge post-harvest losses associated with this fishery. Experts recommended that appropriate handling, and processing techniques that have proved cost effective around the Lake must be improved and disseminated to needy areas with large catches of the species and that marketing patterns be addressed.*

6) *The fish smoking oven (AFSMO-150) seems to have technical and economic advantages over the Chorkor smoker. However, in the absence of a comparative study with the Chorkor smoker, it is recommended that further studies be conducted on its efficiency, cost and profitability.*

7) *The recovery of valuable fractions from seafood processing waste leads to a diverse range of useful by-products that may be enzymatically hydrolysed to provide useful compound, such as food and feed ingredients (aroma, peptide, protein, lipids), and also bio-active ingredients (for nutraceutical, cosmetic or pharmaceutical purposes). However, access to specific enzymes for this type of processing could be in certain cases rather difficult, and some adaptations have to be found (such as using fruit or vegetable juice naturally rich in enzymes, i.e. papaya, pineapple for example). The use of external enzyme is much more efficient than natural ones (autolysates); however such traditional practices have to be explored and developed in Africa.*

8) *In enzyme hydrolysis, a potential has been identified for utilizing fish trimmings from Nile perch fish processing plants around Lake Victoria and fish waste from other fish industries in other regions.*

9) *Utilization of fresh and cooked fish waste in mushroom cultivation was presented as a successful practice in the West Africa region. Because mushrooms are in high demand in many African countries, the promotion of the technique by FAO was, therefore, recommended.*

10) *Systems-based approach to blowfly control has been evaluated during community-based field trials conducted at small-scale fish processing sites located in India. The research has demonstrated that the approach offers a safe, efficient and cost-effective remedy to the problem of blowfly infestation. The participants suggested that demonstrated-based research and development of training materials that are relevant for African countries be conducted to address the common loss on sun-dried fish associated with insect pests.*

Quality assurance

11) *The participants were informed of the impact of the new EU regulatory framework on the export of fishery products. Regulations (CE) 178/2002, 852/2004, 853/2004, 854/2004 and 466/2004 were explained. The participants welcomed the information and suggested that fish inspectors be retrained in the new requirements.*

12) *The participants benefited from presentations on risk assessment and traceability of seafood products. After a lengthy discussion on the advantages of these processes, it was recommended that a workshop on risk analysis and another one on traceability for the Africa region be organized by FAO in liaison with the project management unit of the EU/ACP Strengthening of Fishery Products Health Conditions programme. It was also suggested that national authorities exercise in risk analysis and industry implements the result of risk assessment and that they encourage local fish processing industries to improve their capacity in risk analysis and traceability.*

13) *On improving the quality of salted and dried fish products, the control of the beetle,* Dermestes sp, *in the salting and drying of catfish (*Arius gambiensis*) was presented to the participants, who observed the significant effect of high salting levels (20 percent) and low water contents (14 percent) on the control of the beetle. However, it was strongly recommended that future trials continue to involve the women processors and similar studies on salt concentration, size of fish, brining time and other key parameters for other commercial species be conducted and disseminated.*

Marketing and socio-economic issues

14) *Presentations were made on the progress of fish trade and harmonization in the East African Community (EAC) and participants appreciated the efforts being made towards regional integration. However the need for harmonizing data and information on socio-economic, marketing and other important aspects was emphasized.*

15) *Considering the common problem of product evacuation from remote landing sites and eventual distribution in the respective countries in the Africa region, it was recommended that the infrastructure elements be addressed in fish technology and utilization programmes. The significant increase in fish and fishery product exports from the region is a positive development that is welcomed, but the participants expressed concern about the resultant trade-offs in the national food fish availability. In the ensuing discussion following a presentation on the challenges of promoting fish exports, it was unanimously agreed that more effort should be put in promoting the utilization of hitherto unutilized species by introducing value-adding techniques and promoting commercial aquaculture to complement capture fish production.*

On the issue of quality and safety requirements in the fish and fishery product export trade, it was agreed that countries in the region should strengthen institutional capacity building, particularly the training of fish inspectors and related personnel.

16) *The fish and fishery import potential of the European Union (EU) was presented to the participants and they realized the increasing opportunities for African countries to continue exporting their products to the huge EU market. However, they were also informed of the border controls and the reasons for detention and rejection of fish and fishery products from Africa and the world. It was realized in the ensuing discussion that there was a communication gap between the European Commission, national competent authorities, the importers and the exporters. It was, therefore, recommended that communication lines between the parties concerned be improved*

17) *The participants were informed of a proposed African Fish Safety Network. The network idea was conceived in 2000 to help African countries gain access to a huge untapped regional market and other markets outside the region. It can also assist countries build their capacity in fish technology, safety and quality. Players in the fish industry from 11 countries (Seychelles, South Africa, Tanzania, Kenya, Uganda, Zambia, Namibia, Angola, Mozambique, Ghana and Senegal) have so far shown interest in the network.*

The proposed network attracted much interest, and the participants encouraged the coordinators to develop a road map, which will include the modus operandi of the network and its co-ordination outside the proposed eventual hosting of the secretariat within the INFOPECHE office facility.

CLOSURE OF THE WORKSHOP

13. The Workshop on Fish Utilization, Technology and Quality Assurance was officially closed on 18 November 2005 by Mr Odunga Salmon, Permanent Secretary of the Ministry of Natural Resources and Tourism, after the remarks from the Representative of the Director of Fisheries, Ms Yvette Diei-Ouadi (on behalf of the FAO Resident Representative) and the vote of thanks of the participants.

ORGANISATION

1. L'Atelier de la FAO sur la technologie, l'utilisation et l'assurance de qualité du poisson a été organisé par le Service de la commercialisation et de l'utilisation du poisson de la Division des industries de la pêche de la FAO, en collaboration avec le Mbegani Fisheries Development Centre (MFDC) de la Direction des pêches de la Republique-Unie de Tanzanie. Ceci est une suite de la précédente Consultation d'experts FAO sur la technologie du poisson en Afrique, dont la dernière a eu lieu au Sénégal du 10 to 13 décembre 2001.

OUVERTURE

2. L'atelier s'est tenu à l'hôtel « Paradise Holiday Resort », Bagamoyo, République-Unie de Tanzanie, du 14 to 18 novembre 2005.

3. Le Directeur des pêches, Mr Geoffrey Nanyaro, a exprimé son honneur de prononcer l'allocution d'ouverture de l'atelier qui est le second de ce genre pour la Tanzanie en 25 ans et le 8eme en Afrique. Il a souhaité la bienvenue aux participants venus de nations et de champs d'expertise variés et a formulé le souhait que la réunion aide à faire avancer le secteur post-capture dans la région. Il a ensuite exprimé sa gratitude à la FAO pour l'avoir l'organisé et aidé la Tanzanie à compétir à l'exportation des produits de la pêche. Après avoir exprimé son appréciation au point focal national de cet atelier, il a rappelé les besoins en développement de la pêche artisanale, qui contribue pour presque 90 pour cent aux prises.

4. Mme Louise Setshwaelo, Représentante résidente de la FAO en Tanzanie s'est adressée à l'atelier au nom du Directeur Général de la FAO. Elle a remercié le Gouvernement de Tanzanie pour avoir gentiment accepté d'abriter la réunion et les experts pour avoir pris de leur temps malgré leur calendrier chargé, pour y prendre part. La nécessité d'aider les pêcheurs et femmes et leurs communautés pour réduire les pertes post-capture et améliorer la sécurité sanitaire et la qualité a été soulignée. Elle a rappelé le soutien passé et présent au développement du secteur post-capture de la pêche de la FAO et de ses partenaires.

5. Le Secrétaire permanent, Ministère des affaires étrangères et de la coopération internationale de la République-Unie de Tanzanie, Philemon Luhanjo s'est ensuite adressé à l'atelier. Il a souhaité la bienvenue aux participants en Tanzanie en général et en particulier dans la ville historique de Bagamoyo. Il a exprimé avec honneur sa gratitude à la FAO pour avoir programmé et organisé cette importante plateforme. L'importance du secteur des pêches dans l'économie tanzanienne a été soulignée. Toutefois l'attention a été attirée sur les défis qui devraient faire l'objet des délibérations de l'atelier. Ce sont la documentation et l'amélioration des méthodes traditionnelles de transformation du poisson, la recherche de technologie d'énergie solaire abordable, le lien de la certification des produits de pêche à la durabilité de la ressource, l'utilisation de moyens simples de transport du poisson frais sous glace, la forte assistance prioritaire aux femmes, le besoin de développer des produits à haute valeur ajoutée plutôt que d'exporter de la matière première ou du poisson semi-fini, et l'accès au capital des pêcheurs. Il a ensuite souhaité de riches délibérations et ouvert formellement la réunion.

6. Le Programme de la réunion se trouve à l'annexe A.

PARTICIPANTS

7. Ont participé à l'atelier 26 experts de l'Espagne, de la France, du Ghana, de l'Italie, du Kenya, du Mali, du Maroc, de l'Ouganda, de la République-Unie de Tanzanie, du Royaume Uni, du Sénégal, du Lake Victoria Fisheries Organization (LVFO), de l'unité du SADC de l'Organisation intergouvernementale d'information et de coopération pour la commercialisation des produits de la pêche en Afrique (INFOSA), et de la FAO. La liste des experts se trouve à l'annexe B.

DÉSIGNATION DES MEMBRES DU BUREAU

8. Monsieur Yahya Mgawe de MFDC, Mme Nancy Gitonga du Kenya, M, John Esser du Royaume-Uni, et M. Richard Abila du Kenya étaient les Présidents de l'atelier respectivement du jour 1 au jour 4; Mme Absa Gueye Ndiaye, M, Jean-Pascal Berge et Mme Margaret Masette, les binômes Mme Cissé Oumou Traoré/Javier Borderias, Sylla Khalifa/Carol Kirema-Mukasa, et Younes Zenati/Margaret Attikpo ont été élus Rapporteurs quand M. Alhaji Jallow (Fonctionnaire principal des pêches, Bureau régional de la FAO pour l'Afrique), M. Hector Lupin et Mme Yvette Diéi-Ouadi du Service de la commercialisation et de l'utilisation du poisson de la Division des industries de la pêche de la FAO assuraient le Secrétariat technique de l'atelier.

PROGRAMME

9. Les experts ont passé en revue les progrès et problèmes dans le domaine de l'utilisation du poisson, de la technologie et de l'assurance de qualité, et ont fait une série de recommandations. L'accent était mis sur l'utilisation du poisson frais, la transformation du poisson, l'assurance qualité, la commercialisation et les questions socio-économiques. Ces aspects étaient présentés à travers:

- la présentation par le secrétariat technique du rapport sur le progrès des recommandations de la 7eme Consultation d'experts FAO sur la technologie du poisson en Afrique, tenue à Saly- Mbour, Sénégal en décembre 2001. Les participants ont accepté le rapport et le changement tels que présentés.
- la présentation de 26 communications;
- 2 contributions supplémentaires qui n'ont pas été présentées;
- une visite de terrain au MFDC à Mbegani, au marché au poisson et dans une unité de transformation de poisson à Dar es Salaam.

10. Les contributions ont été éditées et reproduites à l'annexe C.

11. Sur la base des présentations et des débats un projet de recommandations a été préparé par le secrétariat; celles-ci ont été discutées, amendées et adoptées par les experts dans la session finale de l'atelier.

RECOMMANDATIONS

12. Les experts ont adopté les recommandations suivantes à l'attention de la FAO, de ses pays membres, de tous les instituts, institutions et personnes impliqués ou intéressés par l'utilisation du poisson en Afrique.

Poisson frais

1) *L'effet de la taille et des températures de conservation sur la rigor mortis chez le tilapia du Nil, (Oreochromis niloticus) a été présenté dans le contexte de l'importance du glaçage du poisson immédiatement après capture et du maintien de la chaîne de froid pour un meilleur produit. Dans la discussion qui s'en est suivie, il a été suggéré qu'un travail similaire sur d'autres espèces d'importance commerciale soit promu.*

Transformation

2) *L'effet technologique de l'adjonction de la fibre de blé au muscle haché de la morue (Merluccius merluccius) et du maquereau (Trachurus trachurus) a été présenté comme une technique pour ajouter de la valeur aux filets de poisson à faible valeur. Il a été rapporté que l'adjonction de fibre augmente la capacité de rétention d'eau (CRE) et la capacité de liaison de l'eau (CLE) des filets de poisson. Les produits restructurés avec la fibre étaient plus blancs, leur rigidité et capacité de cohésion étaient basses. Aucune flaveur étrangère n'était apparente quand la fibre de blé était ajoutée. Cette nouvelle technologie était d'intérêt, surtout quand il y a une préoccupation concernant son utilisation pour augmenter le poids du produit.*

3) *La technique de production de pulpe congelée des déchets de filetage de la sole tropicale (*Cynoglossus *sp.) au Sénégal a été présentée comme un utile développement de produit dans la région. La pulpe est obtenue par l'extraction de la carcasse de Sole après filetage (raclage de la viande laissée sur le squelette). Autant qu'a été notée l'importance de cette technique, elle pourrait être utilisée dans la région plus pour des espèces autres que la sole qui est principalement transformée et emballée entière.*

4) *Les participants ont été informés de l'extraction d'huile à partir de* Brycinus leuciscus *au Mali. Cette espèce est un poisson fortement gras qui est moins valorisé. La valeur a été par conséquent ajoutée, par extraction de son huile pour la friture et préparation de sauce en cuisson. L'huile a été de faible qualité et ceci a attiré l'intérêt de son amélioration. L'amélioration a conduit à une couleur dorée, de bons goût et odeur, appréciés par les transformateurs. Les transformateurs maliens de poisson sont en croissante adoption de la technique d'extraction d'huile à partir de cette espèce, mais il y a un besoin de plus de recherche sur la composition chimique des acides gras, éléments minéraux et autres attributs dans l'huile. Les participants ont aussi recommandé que la durabilité de la production d'huile des ressources de l'espèce Brycinus, si la demande augmente, soit prise en compte dans la nouvelle recherche sur la technique.*

5) *Il a été observé que la sardine du lac, Rastrineobola argentea, est un important aliment, particulièrement en assurant la sécurité alimentaire. Malheureusement toutefois, de lourdes pertes post-capture sont associées à cette pêcherie. Les experts ont recommandé que des techniques appropriées de manutention et de transformation d'efficacité prouvée autour du lac, soient améliorées et diffusées aux zones nécessiteuses faisant de fortes prises de ces espèces et que les aspects de commercialisation soient abordés.*

6) *Le AFSMO-150 semble avoir des avantages techniques et économiques par rapport au fumoir Chorkor. Toutefois, en absence d'étude comparative avec le fumoir Chorkor, il est recommandé que les études suivantes soient conduites sur son efficience, son coût et rentabilité.*

7) *La récupération de fractions valorisables de déchets de transformation du poisson conduit à une diverse gamme de co-produits utiles qui peuvent être enzymatiquement hydrolysés pour générer des composés comme les ingrédients alimentaires et pour la nutrition humaine (arômes, peptides, protéines, lipides) et aussi des ingrédients bio-actifs (pour des buts neutraceutiques, cosmétiques ou pharmaceutiques). Toutefois, l'accès aux enzymes spécifiques pour ce type de transformation pourrait dans certains cas être plutôt difficile et des adaptations devront être trouvées (comme l'utilisation de jus de fruit ou de légume naturellement riche en enzymes, i.e. papaye, ananas, par exemple). L'utilisation d'enzyme externe est moins efficace que les (autolysats), toutefois ces pratiques traditionnelles doivent être explorées et développées en Afrique.*

8) *En hydrolyse enzymatique, un potentiel de valorisation des restes des usines de transformation de la Perche du Nil autour du Lac Victoria et des déchets de poisson des autres industries halieutiques dans d'autres régions, a été identifié.*

9) *La valorisation de déchets de poisson frais et cuit dans la culture de champignon a été présentée comme une pratique réussie dans la région de l'Afrique de l'Ouest. Etant donné que les champignons sont en forte demande dans beaucoup de pays africains, la promotion de la technique par la FAO a été par conséquent recommandée.*

10) *L'approche systémique pour la maîtrise de la mouche a été évaluée pendant des essais communautaires de terrain sur des sites de transformation à petite échelle situés en Inde. La recherche a démontré que l'approche offre un remède sain, efficient et efficace au problème de l'infestation par la mouche. Les participants ont suggéré que des essais similaires soient conduits dans la région Afrique pour aborder la perte associée aux déprédateurs du poisson séché au soleil.*

Assurance qualité

11) *Les participants ont été informés de l'impact du nouveau cadre réglementaire UE sur l'exportation des produits de la pêche. Les réglementations (CE) 178/2002, 852/2004, 853/2004, 854/2004, et 466/2004 ont été expliquées. Les participants ont salué l'information et ont suggéré que les inspecteurs du poisson soient re-formés sur les nouvelles exigences.*

12) *Les participants ont eu droit à des présentations sur l'évaluation du risque et la traçabilité des fruits de la mer. Après une longue discussion sur les avantages de ces processus, il a été recommandé qu'un atelier soit organisé par la FAO sur l'évaluation du risque et un autre sur la traçabilité, au profit des pays de la région Afrique, ceci en liaison avec l'unité de gestion du programme UE/ACP Renforcement des conditions sanitaires des produits de la pêche. Il a été aussi suggéré que les autorités nationales s'entraînent en analyse des risques et que l'industrie mette en œuvre le résultat de l'évaluation des risques, encourage les industries locales de transformation du poisson à renforcer leur capacité en analyse des risques et traçabilité.*

13) *En amélioration de la qualité des produits halieutiques salés et séchés, la maîtrise du coléoptère Dermestes sp*, *dans le salage et le séchage du machoiron (Arius gambiensis) a été présentée aux participants qui ont noté un effet significatif des forts niveaux de salage (20 pour cent) et basses teneurs en eau (14 pour cent,) sur le contrôle du coléoptère. Il a été toutefois fortement recommandé que des essais futurs continuent d'impliquer les femmes transformatrices et que des études similaires soient conduites et disséminées sur la concentration du sel, la taille du poisson, le temps de saumurage et autres paramètres clés pour d'autres espèces commerciales.*

Commercialisation et questions socioéconomiques

14) *Des présentations ont été faites sur les progrès enregistrés au niveau du commerce du poisson et de l'harmonisation au sein de la CAA (communauté de l'Afrique australe) et les participants ont apprécié les efforts en cours visant l'intégration régionale. Toutefois le besoin d'harmoniser les données et les informations socio-économiques, commerciales et autres aspects a été souligné.*

15) *Considérant le problème commun de l'évacuation du produit des sites de débarquement éloignés et l'éventuelle distribution dans les pays respectifs dans la région Afrique,il a été recommandé que les aspects liés aux infrastructures soient abordés dans les programmes de technologie et d'utilisation. L'augmentation significative des exportations du poisson et produits de la pêche de la région est un développement positif qui est salué, mais les participants ont exprimé une préoccupation concernant les compromis inhérents, dans la disponibilité du poisson au niveau national. Dans la discussion suivant la présentation sur les défis de la promotion des exportations du poisson, il a été unanimement reconnu que davantage d'effort est nécessaire pour la promotion de l'utilisation des espèces jusqu'ici non utilisées, par l'introduction de techniques de valeur ajoutée et la promotion de l'aquaculture commerciale comme complément à la production du poisson de capture.*

    Sur la question des exigences de qualité et de sécurité sanitaire dans le commerce d'exportation du poisson et des produits de la pêche, il a été unanimement convenu que les pays de la région devraient renforcer leur capacité institutionnelle, particulièrement la formation des inspecteurs du poisson et autre personne apparenté.

16) *Le potentiel de l'Union Européenne d'importation du poisson et produits de la pêche a été présenté aux participants et ils se sont rendus compte des opportunités croissantes d'exportation pour les pays africains de leurs produits sur l'énorme marché UE. Toutefois ils ont été aussi informés des contrôles aux frontières et des raisons des détentions et des rejets du poisson et des produits de la pêche de l'Afrique et du monde. Le constat a été fait durant la discussion suivante qu'il y avait un deficit de communication entre la Commission Européenne, les autorités compétentes nationales, les importateurs et les exportateurs. Il a été par conséquent recommandé que les chaînes de communication entre les parties concernées soient améliorées.*

17) Les participants ont été informés du réseau africain de sécurité sanitaire du poisson proposé. L'idée du réseau a été conçue en 2000 pour aider les pays africains à accéder à l'énorme marché régional non exploité et des autres marchés en dehors de la région. Il peut aussi assister les pays à renforcer leur capacité en technologie, sécurité sanitaire et qualité du poisson. A ce jour, des techniciens de 11 pays (Seychelles, Afrique du Sud, Tanzanie, Kenya, Uganda, Zambie, Namibie, Angola, Mozambique, Ghana et Sénégal) ont marqué leur intérêt pour le réseau.

Le réseau proposé a attiré beaucoup d'intérêt et les participants ont encouragé les techniciens à développer une feuille de route, qui inclura le modus operandi du réseau et sa co-ordination en dehors de la proposition que les facilités de bureau d'INFOPECHE abritent éventuellement le secrétariat.

CLÔTURE DE L'ATELIER

13. L'atelier de la FAO sur la technologie, l'utilisation et l'assurance de qualité du poisson a été officiellement déclaré clos le 18 novembre 2005 par M. Odunga Salmon, Secrétaire permanent, Ministère des ressources naturelles et du tourisme, après les allocutions du représentant du Directeur des pêches, de Mme Yvette Diei-Ouadi (de la part du représentant résident de la FAO) et la motion de remerciements des participants.

APPENDIX/ANNEXE A

PROGRAMME

Monday 14 November 2005

Opening address by Geoffrey Nanyaro
Director of Fisheries, United Republic of Tanzania

Address by Louise Setshwaelo
FAO Resident Representative in Tanzania, on behalf of the FAO Director General

Welcoming address by Philemon Luhanjo
Permanent Secretary, Ministry of Foreign Affairs and International Cooperation, United Republic of Tanzania

Election of Chairman and meeting officers

FAO report on progress made since the seventh FAO Expert Consultation on Fish Technology in Africa
Yvette Diei-Ouadi, FAO Rome – Italy

The effect of size and holding temperatures on rigor mortis phenomenon in Nile tilapia O*reochromis niloticus*
Margaret Masette, FOSRI – Uganda

Use of wheat fibre as an ingredient in restructured fish products
Javier Borderías, CSIC – Spain

Discussion

Blocks of frozen pulp of raw tropical sole (*Cynoglossus* sp): technology, bacteriology and HACCP
Khalifa B. Sylla, EISMV – Senegal

Discussion

Utilization trials of croacker (*Argyrosomus regius*) by multi-processing.
K.L'hichou/Y. Zenati, ISTPM – Morocco

Improvement of *Brycinus leuciscus* oil extraction technology
Oumou Cissé-Traoré, IER – Mali

Discussion

Tuesday 15 November 2005

Low-cost processing technologies for Mukene
Margaret Masette, FOSRI – Uganda

Discussion

Design and construction of AFSMO – 150, an improved fish smoking oven
Daniel Blay/Margaret O. Atikpo, FRI – Ghana.

Discussion

For a better use of marine by-products and wastes
Jean-Pascal Bergé, IFREMER – France

Discussion

Impact of the new EU regulatory framework on the export of fishery products
Gabriele Gandini – Italy

Discussion

Utilization of fish waste for mushroom cultivation
Margaret O. Atikpo, FRI – Ghana

Discussion

Presence of *Listeria* spp in marine environment in Morocco
Naima Bou-M'handi – Morocco

Discussion

Evaluation of a systems-based approach to controlling blowfly infestation of traditionally processed fish at small-scale processing sites
John Esser, NR International – UK

Discussion

The ACP strengthening of fishery products health conditions in East Africa Project
John Esser, NR International – UK

Discussion

Wednesday 16 November 2005

Risk assessment and seafood products in developing countries
Maurizio Ferri, Ministry of Health – Italy

Discussion

Effect of the level of drying of the fermented salted dried fish on its infestation by *Dermestes* spp
Absa Gueye-Ndiaye, UCAD – Senegal

Discussion

Evolution of Nile perch into a significant trade commodity in the global market
N.K. Gitonga, DOF – Kenya

Traceability in seafood
Hector M. Lupin, FAO Rome – Italy

Discussion

Utilization of marine salt to control *Dermestes maculates* and D. *frischii (Coleoptera dermestidae)* insect pests of dried fish in Senegal
Absa Gueye-Ndiaye, UCAD – Senegal

Discussion

The regional role of LVFO in promoting sustainable fisheries utilization
Kirema-Mukasa, LVFO – Uganda

Assessment of fisheries products values along Kenya's export marketing chain
Richard O. Abila, KMFRI – Kenya

Impact of globalization on post-harvest fisheries sector around Lake Victoria in Uganda
Margaret Masette, FOSRI – Uganda

Discussion

Sensory panels of small pelagic species in the SADC region
Luisa Arthur, INFOSA – Namibia

Thursday 17 November 2005

Detentions and rejections of fish products from Africa in European Union market
Gabriele Gandini, Ministry of Health – Italy

African fish safety network
Frimpong Clifford/Nancy Gitonga/Luisa Arthur

Challenges in promoting export of fish from artisanal marine fishery in Tanzania
Yahya Mgawe, MFDC – Tanzania

Discussion

Field trip (Kaole Ruins and Mbegani FDC)

Friday 18 November 2005

Field trip to Dar es Salaam (Banda beach fish landing station, Bahari foods processing plant

Resolution, discussion and adoption of the recommendations of the Workshop

Closing

Workshop secretaries
14 November 2005
1. Jean-Pascal Bergé
2. Ms Margaret Masette
3. Ms Absa Gueye

15 November 2005
1. Mr Javier Borderias
2. Ms Cissé Oumou Traoré

16 November 2005
1. Khalifa Sylla
2. Ms Carol Kirema-Mukasa

17 November 2005
1. Ms Younes Zenati
2. Ms Margaret Attikpo

Technical Secretariat
1. Yvette Diei-Ouadi, FAO Rome, Italy
2. Hector M. Lupin, FAO Rome, Italy
3. Alhaji Jallow, FAO Regional Office, Ghana

APPENDIX/ANNEXE B

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APPENDIX/ANNEXE C

SELECTED PAPERS PRESENTED AT THE FAO WORKSHOP ON FISH TECHNOLOGY, UTILIZATION AND QUALITY ASSURANCE

DOCUMENTS SÉLECTIONNÉS PRÉSENTÉS À L’ATELIER DE LA FAO SUR LA TECHNOLOGIE, L’UTILISATION ET L’ASSURANCE DE QUALITÉ DU POISSON

THE EFFECT OF SIZE AND HOLDING TEMPERATURES ON *RIGOR MORTIS* PHENOMENON IN NILE TILAPIA *Oreochromis niloticus*

by

Margaret Masette and Tom Kasiga
FOSRI, Uganda

Abstract

A preliminary short study to establish the onset, duration and resolution of rigor mortis phenomenon in Nile tilapia (*Oreochromis niloticus*) was conducted along the banks of the river Nile at Jinja, Uganda from February to March 2005. Although the phenomenon has technological significance in fish processing, not much work has been done on any fish species in Ugandan tropical freshwaters.

Fish of different sizes were held at either ambient or chilled temperatures. Essentially, duplicate samples consisting of three fish per size were held at either ambient (25 °C) or chilled (0 °C). Using a stopwatch, time was recorded for onset, duration and resolution of rigor. During each stage of the phenomenon, 10 g of flesh was aseptically removed 2 cm behind the operculum and 2 cm below the lateral line and macerated in distilled water. A digital portable pH was inserted into the mixture and the reading read off the screen. In addition, the time lag between onset and resolution was established.

The preliminary results indicated that small-sized fish (25 cm) went into and out of rigor faster than the bigger-sized fish (32 cm). Fish held on ice were twice as fast as to enter rigor than fish held at ambient temperatures. The post-mortem pH of all fish was slightly below 7 and although it decreased with size, there was not much difference between the fish of the same size kept at different temperatures. The decrease was gradual from the pre-rigor pH of 6.80 to post-rigor pH of 6.40 for the small fish and 6.97 to 6.61 in large fish respectively. It was also observed that rigor in fish began from the tail and it was stronger in fish kept at ambient than chill temperatures. It was concluded that icing hastens the onset of rigor in Nile tilapia and that pH was more influenced by fish size than holding temperatures. It was recommended that tilapia should be iced immediately after capture to avert consequential quality defects in fillets, such as gapping, toughness and drip loss.

Résumé

Une brève étude préliminaire pour établir le début, la durée et la résolution du phénomène de rigor mortis chez le tilapia du Nil (*Oreochromis niloticus*) a été effectuée le long des rives du Nil près de Jinja, en Ouganda, de Février à Mars 2005. Bien que le phénomène ait une signification technologique dans la transformation du poisson, peu de travaux ont été menés sur une espèce de poisson d'eaux douces tropicales en Ouganda.

Du poisson de dimensions diverses a été gardé à températures ambiantes et froides. Essentiellement, des échantillons dupliqués qui consistent en 3 poissons par taille ont été conservés soit en atmosphère ambiante (25 °C) ou froide (0 °C). Tout en utilis°ant un chronomètre, le temps était relevé pour le début, la durée et la résolution du phénomène de rigor. Au cours de chaque étape du phénomène, 10 g de chair a été aseptiquement prélevé sur 2 cm derrière l'opercule et 2 cm en dessous de la ligne latérale puis macéré dans de l'eau distillée. Un pH-mètre digital portatif était inséré dans le mélange et la lecture faite sur l'écran. En plus l'intervalle de temps entre le début et la résolution a été établi.

Les résultats préliminaires indiquent que les poissons de petite taille (25 cm) entrent et sortent de rigor plus vite que ceux de plus grande taille (32 cm). Le poisson maintenu sur glace était deux fois plus rapide à entrer en rigor que ceux à températures ambiantes. Le pH post mortem de tous les poissons était légèrement en dessous de 7 et quoiqu'il décroisse avec la taille, il n'y avait pas grande différence entre les poissons de la même taille maintenus à différentes températures. La baisse était graduelle d'un pH pré-rigor de 6.80 à un pH post-rigor de 6.40 pour les petits poissons et de 6.97 à 6.61 chez les gros poissons respectivement. Il a été aussi observé que la rigor commence chez le poisson à partir de la queue et est plus forte chez le poisson à températures ambiantes qu'à températures froides. Il a été conclu que le glaçage accélère la mise en place de la rigor chez le Tilapia du Nil et que le pH était plus influencé par la taille du poisson que par les températures de conservation. Il a été recommandé que le tilapia devrait être glacé immédiatement après capture pour prévenir les défauts de qualité afférents dans les filets, comme le gapping, la dureté et le suintement d'eau.

1. INTRODUCTION

The rigor mortis phenomenon is a natural process that results from a series of complicated chemical changes in post-mortem fish (Stroud 2001; Huss, 1995; Webb and Trentham, 1983; Huxley, 1957). According to Huss (1995), the changes may entail a drop in pH from neutral to slightly acidic, which inactivates spoilage microbes (Gram, 1989). Kobayashi (1996) defines the phenomenon as the stiffening of animal muscles shortly after death. Immediately after death the muscle is relaxed and limp with an elastic texture, which may persist for several hours before contraction. In fish, rigor usually starts at the tail and gradually moves along the body towards the head until the whole fish is stiff and inflexible (Stroud, 2001). At this occurrence, the fish is said to be in rigor and it will not contract or respond to stimuli (Huss, 1995). The fish will remain rigid for hours or days depending on species, holding temperature, handling practices, size and physical condition. Thereafter, the fish will become limp again but it would have lost the contraction property. This stage is referred to as resolution of rigor.

Rigor mortis index is the ratio of tail deflection to total fish length. According to Bito *et al*. (1983), it is used as a parameter to determine the stage of rigor mortis. The rigor mortis states of the fish were classified according to the following criteria (1) pre-rigor mortis: no stiffening, full movement of muscle. (rigor mortis index ≤ 10 percent), in rigor; (2) full rigor mortis (8 percent < rigor mortis index); (3) post rigor, state when rigor mortis is ≥ 10 percent. In farmed salmon (Wang *et al.* 1998), onset period was indicated by 10 percent < rigor index ≤ 100 percent.

The onset, duration and resolution of rigor has been extensively documented in marine fish (Stroud, 2001; Huss, 1995; Regenstein and Regenstein, 1991; Bruce *et al.,*1983; Cappelin and Jessen, 1997) As highlighted above, the occurrence and duration of the phenomenon varies with species, size, holding temperature, handling practices, fishing method, physical condition and other factors. Stroud (2001) noted that Whiting went in and out of rigor faster than Ocean perch. He attributed the difference to their varied chemical composition and other intrinsic factors. Size of fish influenced the onset, duration and resolution of rigor because small fish entered into rigor faster than large-sized fish (Doug, 2004). Generally, the warmer the fish the sooner it will go into and pass through rigor (Stroud, 2001)). However, when some tropical fish are immediately iced, there is superficial stiffening described as “cold shock”, which is similar to rigor mortis phenomenon (Clucas and Ward, 1996) but it is a different phenomenon associated with inhibition of calcium pump that initiates muscle contraction because of the chilling effect (Curran *et al.,* 1986 [II]). Cold shock or “shortening” according to ibid. relates more with the way fish is handled in the tropics. Throwing and treading of fish enhances the onset of rigor (Stroud, 2001). Manipulation or flexing of the fish while in rigor can shorten the time they remain stiff (Love, 2001). Besides, rough handling of whole fish can cause physical damage that may lead to quality defects because of gaping of fillets (Lavety, 2001). Fish harvested using the active methods of fishing, such as trawling, struggle in the net for a long time before being hauled aboard. It will go into rigor more quickly than fish caught by a passive method (Doug, 2004). The difference was attributed to loss of energy as a result of struggling prior to hauling. The physical condition of the fish at death can markedly affect the onset and resolution of rigor (Huss, 1995). Spawning, under nourishment and stress depleted reserve energy in the muscle, results in the immediate onset and resolution of rigor (Stroud, 2001). Spawning involves exhaustion of the energy of the fish for gonadal development and spawning fish therefore go into rigor faster than those in the spent period.

However, information on the phenomenon in tropical fish is largely missing except for Abe and Okuma (1991) who generated some data on farmed carp. The limited or lack of technological information/data on various aspects of the fisheries industry in Uganda has been a disservice insofar as formulation of appropriate and relevant codes of practices, quality as well as safety standards and strategic intervention measures, are concerned. Quite often technical personnel in Uganda have had to rely on information generated by their counterparts in temperate areas and predictably the information/data obtained would have been generated on marine or temperate freshwater fish. Consequently, the technical backstopping to policy makers has been deficient and sometimes misleading and yet fisheries plays a vital role in the social and economic lives of a large number of Ugandans as source of employment, nutrition and foreign exchange earnings. For example, it contributed about US$90 million to national coffers in 2002/2003, which was the highest contribution to the economy of any commodity. About 300 000 people are directly involved in the fisheries industry (Bahiigwa *et al.,* 2003) while 700 000 have indirect linkages to the sector. The fisheries contribution to the total GDP was estimated to be 2.4 percent (MFPED, 2003) although fisheries economists in the sector put the figure as high as 7 percent.

Competitive participation in the international fish trade demands ardent compliance to the respective international quality and safety standards to ensure ready markets and high prices. Compliance becomes easier with identification of bottlenecks and respective intervention measures.

The need for high quality and safe fish cannot be overemphasized because the competition becomes stiff every passing day. The rigor phenomenon plays a discrete role in reduction of quality depending on the post-harvest management practices of the fish. Fish quality refers to appearance and freshness or the degree of spoilage that the fish has undergone (Huss, 1995). Fish spoilage may also involve safety aspects, such as being free from harmful bacteria, parasites or chemicals. Factors that influence fish quality and safety include microbial load, handling practices, toxins, hygiene and sanitation. According to Gram and Huss, (1996), microbial spoilage is exacerbated by improper handling of fish especially under high tropical temperatures (25–30 $^{\circ}$C). Poor handling practices are also known to hasten natural processes, such as rigor mortis (FAO, 1998), which may be defined as the stiffening of fish after death. There are several technological consequences of mishandling fish pre-rigor and during the phenomenon. Throwing and treading of fish hastens onset and resolution of rigor and partly contributes to gapping in the fish fillets (Love, 2001). According to Stroud (2001), filleting of pre-rigor fish causes shrinkage, toughness and drip loss in final product upon thawing. Fish frozen in rigor pack less well in freezers and a buffer store is required if whole fish is frozen post-rigor. High processing capacities are required for fish frozen pre-rigor to cope with the high catching rates. Fillets frozen pre-rigor are unsuitable for smoking, are difficult to fillet by machine or hand and always yield less if filleted by hand. Rigor can affect the quality of whole fish in three main ways, by causing gaping in wet and frozen fish, toughness and excessive drip loss on thawing in frozen fish (Stroud, 2001). Chilled fillets lose water slowly during processing and distribution. The loss is usually small, but it may be increased by high temperature, excessive pressure on the product, and by delay in distribution (Aitken, 2001). The higher the temperature at which a fish goes into rigor, the greater will be the drip loss on thawing. When the fish is cooked, it will be tough and stringy and most consumers will regard this attribute as a quality defect. Whole fish frozen pre-rigor tend to have a higher drip loss than similar fish frozen in rigor or post-rigor (Stroud, 2001).

The highlighted consequences have a direct impact on quality attributes of fish and fish products. Besides, consumers in the importing countries have become fastidious and quite demanding with regard to quality and safety (Brown and Sylvia, 1994), and their respective countries have in turn placed stringent regulations and requirements on the exporting countries (FDA, 1997; EEC, 1991). The increased emphasis on implementation of Hazard Analysis Critical Control Point (HACCP) programmes over the last decade has compelled processing establishments to scrutinize every processing stage.

Although the above regulations and directives are regarded as informal trade barriers in developing countries, there is an urgent need to generate relevant data on rigor mortis that will provide a basis for formulation of befitting national and regional standards and codes of practice. Compliance to the set codes can avert the quality defects brought about by the influence of the rigor phenomenon. The influences of rigor mortis have been well documented in temperate fish species and cultured fish species in the tropical countries. Information on freshwater species is lacking, and hence this research will help provide more information about the tropical fish and thus act as a guide for fish processors on how to reduce or prevent quality defects of rigor mortis, such as gapping, shrinkage, drip loss and spoilage, which are all attributed to *rigor mortis*.

Overall objective

To narrow the information gap on the rigor mortis phenomenon in tropical freshwater fish.

Specific objectives:

- to establish the time for the onset, duration and resolution of rigor mortis in Nile tilapia at both ambient and chilled temperatures for different sizes of fish;
- to determine the pH variation during the rigor for different fish sizes held at ambient and temperatures;
- To establish the rigor mortis index in Nile tilapia at different stages of rigor.

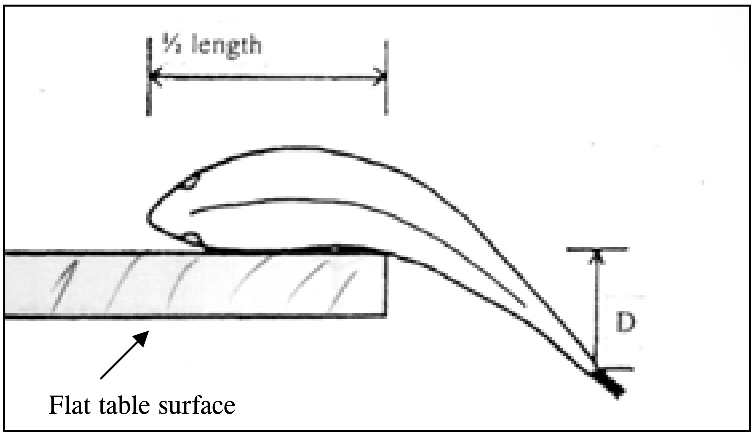
2. MATERIALS AND METHODS

Materials

Knife, hook and line for fishing; icing box with flake ice; portable table; digital thermometer; portable pH meter with a sensitive electrode; distilled water, stopwatch and homogenizer

Method

Fish was captured using handline method. Only fish with a total length (snout-tail) between 25 to 32 cm were immediately killed by thrusting a sharp knife in the dorsal part of the head to the brain. In total, 18 fish were caught and divided into two portions and then coded: one for holding at average ambient temperatures (25 °C) and the other on ice (0 °C). Each size category consisted of three fish. Timing begun immediately after the fish died and temperature of the respective medium recorded. The initial rigor mortis index for each of the 18 fish was determined by measuring the deflection (D) dividing by total length (TL) and multiplying by 100 as shown in Figure 1. Fish intended for chilling were then put in icebox then on ice. The box was then covered securely with a lid to minimize temperature fluctuation. Fish held at both holding temperatures were observed intently to determine the time for onset, duration and resolution of rigor. At each stage, a piece of flesh 10 g was cut 2 cm behind the gill cover but underneath the lateral line. The sample was homogenized using distilled water and pH detected by using a digital portable sized pH meter with a sensitive electrode.



Rigor Index = 100xD/TL
Where
D = Deflection length
TL = Total length from snout to tail

Figure 1: Illustration for determination of rigor mortis index

3. RESULTS AND DISCUSSION

Results from this preliminary study confirmed other studies conducted on tropical fish (Curran *et al.,* 1986, and Abe and Okuma, 1991). Temperature is perhaps the most important factor governing the onset, duration and resolution of rigor because it may dictate subsequent processing operations such as icing. The onset of rigor mortis was faster in Nile tilapia (*Oreochromis niloticus)* kept at chilled temperatures (0 °C) than fish held at ambient temperatures (25 °C) (Figure 2), which is contrary to the findings of Stroud (2001). He found that gutted Pacific cod (*Gadus macrocephalus)* kept at 32–35 °F (0 °C) took about 60 hours to pass through rigor, whereas a second batch kept at 87 °F (30 °C) took less than 2 hours. According to Regenstein and Regenstein (1991) tropical fish show the opposite effect of temperature on the onset of rigor. They observed that rigor was accelerated at 0 °C compared to 10 °C, which was in correlation with a stimulation of biochemical changes at 0 °C. However, Curran *et al.* (1986 [I]) and Regenstein and Regenstein (1991) partly attributed it to "cold shock". According to the l atter, the fish stiffens but does not really contract like cold shortening observed in mammalian muscles. Apparently, as the temperature decreases and the pH drops, the ATP degrades and increases the cellular metabolism but in the absence of oxygen the lactic acid increases, which consequently initiates rigor (Curran *et al.,* 1986 [II]).

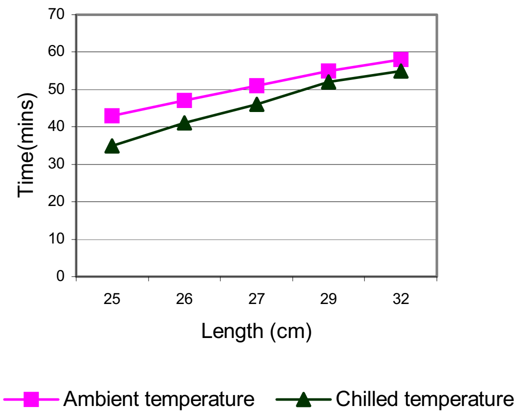


Figure 2: Time for onset of rigor mortis at ambient and chilled temperatures

Abe and Okuma (1991) had similar results with carp (*Cyprinus carpio),* which achieved full rigor mortis after 24 hours on ice when acclimatized to 30 °C. In contrast, fish stored on ice in the present study reached full rigor mortis after 2 to 3 hours at 27 °C depending on size. The difference was attributed to acclimatization or speciation. They also suggested that rigor mortis proceeds faster with increasing difference between live acclimation temperatures and storage temperatures. When the difference was large, the time from death to onset of rigor was short and vice versa. There appears to be a difference in rigor mortis onset between temperate and tropical fish species (Tomlinson *et al.,* 1961). Rigor started from the tail because of the small heat capacity required (Regenstein and Regenstein, 1991). All fish regardless of size went into rigor within 1 hour although smaller fish generally went into rigor faster than bigger fish (Figure 2), which was in agreement with Doug (2004) work.

The duration of rigor varied with fish size held at both ambient temperature and chilled temperatures. However, the resolution of rigor in fish held at chilled temperatures was faster than those held at ambient temperatures by an average margin of 4 hours between the respective fish sizes held at different temperatures. Chilled fish took between 8 and 10 hours while the fish kept at ambient temperature took between 12 and 15 hours to fully resolve from rigor as shown in (Figure 3). Smaller fish went through rigor faster than bigger fish. This is in agreement with the work done by Regenstein and Regenstein (1991) to correlate biochemical changes as a result of stimulation of fish kept at 0 °C and 27 °C.

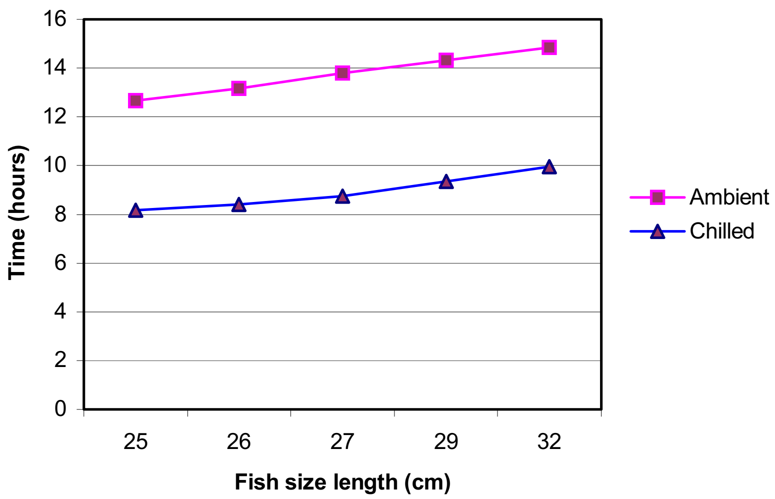


Figure 3: Duration of rigor mortis at ambient and chilled temperatures

Borgstrom (1961) attributed the difference in duration of rigor for the same size of fish to the lactic acid created. This may account for the difference in the chemical composition of the different fish of the same species and size. After the resolution of rigor mortis, possible tenderization include weakening of the z discs of the myofibril (Hultin, 1985/Seki and Tsuchiya, 1991), degradation of the connective tissue (Seki and Watanabe, 1984/Ando *et al*., 1993) or the weakening of the myosin-actin junctions (Yamanoue and Takahashi, 1988). The resolution of rigor is a process still not completely understood but always results in the subsequent softening (relaxation) of the muscle tissue and is thought to be related to the activation of one or more of the naturally occurring muscle enzymes, digesting away certain components of the rigor mortis complex (Huss, 1995). Rigor mortis occurs when the cross bridge cycling between actin and myosin in myofibril ceases and permanent actin and myosin linkages are formed (Pate and Brokaw, 1980).

The pH decreased from near neutral to slightly acidic with the progress of the phenomenon from pre-rigor or onset to post-rigor or resolution (Figure 4). However, the decrease in pH did not go below 6.4 regardless of fish size. The minimum pH achieved was probably because of the active fishing method employed, which meant that the fish was not stressed and therefore retained substantial amounts of glycogen (Huss, 1995). Such as in most teleost, pH in Nile tilapia was a result of post-mortem glycolysis that led to accumulation of lactic acid, which in turn lowered the pH of the muscle. The post-mortem pH for all the fish was slightly lower than 7 (Huss, 1995), which concurs with the study findings that varied between 6.43 and 6.94 depending on size and stage of rigor (Fig 4). Probably the nutritional status of the fish effected the levels of stored glycogen and consequently on the ultimate post-mortem pH. As a rule, well-rested, well-fed fish contain more glycogen than exhausted fish as found in the Japanese loach by Chiba *et al.* (1991). Smaller sized fish had a lower pH than the bigger fish because they probably had corresponding high amounts of glycogen per unit volume at the time of death (Huss, 1995). Comparing with marine species, the post-mortem pH of cod dropped from 6.8 in rigor to an ultimate pH of 6.1–6.5; post-rigor was almost similar to the drop in pH observed in tropical fish of present study.

In some fish species, the final pH may be quite lower, for example in large mackerel, the ultimate rigor pH may be as low as 5.8-6.0 and as low as 5.4-5.6 in tuna and halibut; however such low pH levels are unusual in marine teleost. The post-mortem reduction in the pH of fish muscle has an effect on the physical properties of the muscle. As the pH drops, the net surface charge on the muscle proteins is reduced, causing them to partially denature and lose some of their water-holding capacity. Love (1975) noted that there was an inverse relationship between muscle toughness and pH, such that unacceptable levels of toughness as a result of water-loss upon cooking occurred at lower pH levels.

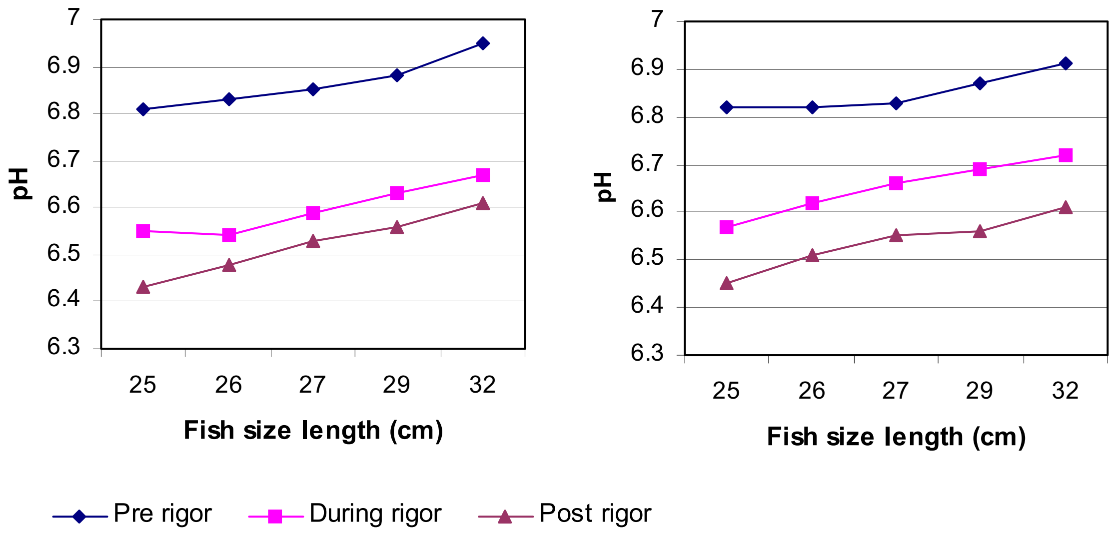


Figure 4: The pH variation in fish held at ambient (A) and chilled (B) temperatures during rigor mortis

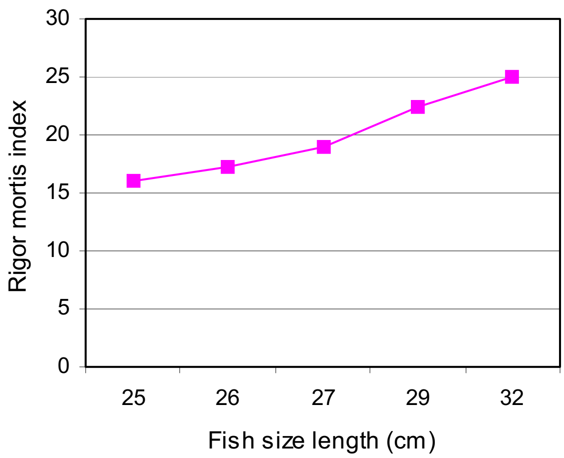


Figure 5: Rigor mortis index for fish held at ambient temperature

The rigor mortis index measured upon full resolution of rigor increased with size and it ranged from 12 percent to 25 percent as shown in Figure 5. In most cases the fish texture became so soft when approaching the resolution of rigor, but the fish was still stiff and this was because of the weakening of the Z discs of the myofibril (Hultin, 1984) and the degradation of the connective tissue (Seki and Watanabe, 1984) .The rigor mortis index varied within fish of the same size, and this was attributed to the difference in the chemical composition (Stroud, 2001). Autolysis spoilage occurs during rigor but there is little microbial spoilage during rigor mortis because of the lactic acid formed that suppresses the activities of spoilage micro-organisms (Borgstrom, 1961). As such, it is advisable to chill the fish immediately after capture so that the fish go through rigor as fast as possible to minimize the rate of autolysis.

4. CONCLUSION

The fish by size and holding temperature seemed to have an influence on the onset, duration and resolution of rigor mortis phenomenon in Nile tilapia. It was observed that rigor started from the tail and it was stronger in fish kept at ambient (25 °C) than at chill temperatures. At low temperatures (0 °C) – brought about by the icing operation – onset, duration and resolution of rigor were hastened. The pH, on the other hand, decreased or became more acidic with the progress of the phenomenon from pre- to post-rigor. In addition, small-sized showed lower pH values than large-sized fish. Finally, the rigor mortis index measured at ambient temperature increased with fish size

5. RECOMMENDATIONS

Several recommendations were made:

- Fishers should ice fish immediately after capture to induce fast onset and resolution of rigor and cold chain maintained. Fish should be adequately iced because inadequacy may enhance autolytic spoilage.
- Fish harvested during warm weather should be handled with care to avoid subsequent quality defects.
- Further comprehensive work involving more samples and parameters should be conducted to generate more relevant data; for example, the effect of rigor on palatability of cooked samples. Similar work should be conducted on other fish species of commercial importance especially the Nile perch (*Lates niloticus).*

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USE OF WHEAT FIBRE AS AN INGREDIENT IN RESTRUCTURED FISH PRODUCTS

by

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Abstract

The technological effect of wheat fibre as an ingredient in minced fish was tested. Thus 3 and 6 percent of wheat fibre with different-sized particles were added to minced hake (*Merluccius merluccius)* and horse mackerel (*Trachurus trachurus)* muscle, and water was also added to maintain the original moisture of the sample. The addition of fibre increased the water holding capacity (WHC). The water binding capacity (WBC) also increased, but only when water was not added to keep the moisture constant. The cooking drip was lower when 3 or 6 percent of fibre was added. In general, when the drip was released by gravity, the 250 µm particle fibre bound more water than the 80 µm particle fibre, but when the water was extracted by a centrifugal force the opposite occurred. Restructured products with fibre were whiter and their rigidity and cohesiveness were lower. Products with 3 percent of fibre were well rated by the sensory panel, unlike the products with 6 percent of fibre. No strange flavours were apparent when the wheat fibre was added. The effect of fibre as a stabilizing agent on protein and lipid was not apparent, either.

Résumé

L'effet technologique de la fibre de blé comme ingrédient dans le poisson haché a été testé. Ainsi des fibres de blé de 3 et 6 pour cent, avec différentes dimensions de particules ont été ajoutés au muscle de morue hachée (*Merluccius merluccius)* et au maquereau (*Trachurus trachurus)* et de l'eau ajoutée pour maintenir l'humidité originale de échantillon. L'adjonction des fibres a augmenté la capacité de rétention de l'eau (CRE). La capacité de liaison de l'eau (CLE) a aussi augmenté, mais seulement si l'eau n'était pas ajoutée pour maintenir constant le taux d'humidité. L'égouttage à la cuisson s'est révélé plus bas avec l'introduction de 3 ou 6 pour cent, de fibre. En général, quand l'égouttage a été provoqué par la force de gravité, des particules de fibre de 250 µm retiennent l'eau mieux que des particules de fibre de 80 µm, mais quand l'eau était extraite par une force centrifuge le contraire se vérifiait. Les produits restructurés avec la fibre étaient plus blancs et la rigidité et la cohésion étaient inférieures. Les produits avec 3 pour cent, de fibre ont été bien cotés par le jury de contrôle, à la différence des produits avec 6 pour cent, en fibre. Aucune saveur étrange n'était apparente en ajoutant la fibre de blé. L'effet de la fibre comme agent stabilisateur des protéines et des lipides n'était pas non plus apparente.

1. INTRODUCTION

Restructured fishery products are products made from minced and/or chopped muscle and which, with or without ingredients, are used to make other products with a new appearance and texture. For some time now there have been products in the form of fingers or other shapes intended basically for children's foods, which are covered in breadcrumbs or batter then frozen for use as fried products. Also, recent years have seen the development of a new generation of fishery products called analogues or substitutes, most of which mimic seafood or other high-value products. These have not only become popular in the Far East but have gained wide acceptance in North America and more recently in Europe. Such products are made essentially from "*surimi*", which is ground, thoroughly washed and refined fish muscle.

The reason for restructuring fish muscle is that the supply of high quality fishery products is limited and many are becoming exhausted because of severe overfishing. There are therefore not many options that do not entail the utilization of species that have not traditionally been commercialized or using remains of filleting of commercial species. One of the chief advantages of restructured products is that the composition of the end product can be modified by reformulation of the original product once this has been chopped or ground. In this sense, the process might be said to be one of eliminating some constituents or the addition of other new ingredients or additives. These ingredients or additives may be categorized as (a) favouring storage, (b) functional from a technological standpoint and (c) functional from a nutraceutical standpoint.

Fish is a good example of a "nutraceutical" food because it is an important source of nutraceutical products such as fish oil. It also contains a readily digested protein and hence is ideal for people with delicate stomachs. Nevertheless, such a good food would be more complete if it contained fibre. Many children and adolescents in Western Europe consume products containing essentially proteins or fats but consume hardly any foods providing the necessary intake of fibre.

Many of the fibres currently used for technological purposes in fishery products are very soluble and come from algae, such as carrageenans (Daponte *et al.,* 1985; Borderías *et al.,* 1996; Gómez-Guillén *et al.,* 1996) or seeds, such as garrofin, guar, xanthan and others (Montero *et al*., 2000; Pérez-Mateos *et al.,* 2001). There is very limited experience on using insoluble fibres, such as cellulose, in fishery products (Yoon and Lee, 1990; Ang and Miller, 1991). There are two ways of introducing these fibres into fishery products. One is by injecting dispersions of fibre into fillets and another more effective way is by introducing fibre into restructured products.

The present study is going to test the technological effect of a very purified insoluble wheat fibre (Vitacel®) consisting mainly of cellulose and hemicellulose as a functional ingredient on two types of frozen-stored minced fish muscle. It has the advantage of being white, odourless and tasteless, so it seems ideal for introducing into white fish-based products. Another advantage of this kind of fibre is that it is inert towards other ingredients and practically calorie-free, what is very important in western countries (Ang and Crosby, 2005; Ang, 1993). Its high water binding capacity is also described (Ang, 1991; Ang and Miller, 1991; Ang, 1993).

2. MATERIALS AND METHODS

2.1 Raw material and additives

Two fish species were used in the experiments: frozen on board hake (*Merluccius capensis)* fillets caught 45 days before and stored at -25 ºC and ice-stored horse mackerel (*Trachurus trachurus)* caught in the northwest of Spain two days before. The fibre used was wheat fibre Vitacel® (Campi y Jové, S.L., Barcelona, Spain). This fibre consists of 74 percent cellulose, 26 percent hemicellulose and <0.5 of lignin; two types of fibre were studied: WF200 with 250 µm long and 25 µm wide particle and WF600 with 80 µm long and 20 µm wide particle.

2.2 Reagents

All of the chemicals used were of analytical grade and were obtained from Panreac Química S.A. (Barcelona, Spain), Sigma-Aldrich Co. or Merck (Darmstadt, Germany).

2.3 Preparation of fish and samples

For the preparation of the restructured minced hake muscle, the fillets were thawed (approx 16 hours at 4 ±2 ºC) and passed once through a meat mincer model FTS111 (Mainca, Granollers, Spain) with a plate with 0.42 cm holes. Five different samples were formulated. The procedure was as follows: the fish was mixed in a mixer-machine model RM-20 (Mainca, Granollers, Spain). The wheat fibre was dispersed in the cold water (according to the formulation) and added to the minced fish muscle. The mixing time was standardized to 6 minutes (the final temperature was below 6 ºC in all cases). Lots were formulated as follows: Control without fibre (H0); 3 percent long particle fibre added with water to adjust the moisture (HL3); 6 percent long particle fibre added with water to adjust the moisture (HL6); 3 percent long particle fibre added (HL3*); 3 percent short particle fibre (HS3) added with water to adjust the moisture. In all the lots except HL3* the moisture was adjusted at 81.5 percent.

Horse mackerel were filleted without removing the skin at the local seafood company and transported to the pilot plant. The muscle was extracted using a Baader model 694 deboner machine (Lübeck, Germany) equipped with a drum with 3 mm holes. Three different samples were formulated: Control without added fibre (M0); 3 percent long particle fibre added with water to adjust the moisture (ML3); 6 percent particle fibre added with water to adjust the moisture (ML6). The final moisture in the different samples was 77.5 percent such as in the original muscle. The procedure was the same as for hake.

The samples were placed on 21.5 x 15 x 3.5 cm aluminium trays and were then frozen in a Saubre "Benjamin" model horizontal plate freezer (Hanst-Moller, Germany) that cooled the thermic core to -20 ºC. The samples were then vacuum packed in bags Wipak7gryspeert, PAE 110KFP, using a Multivac Geprüfer Scherheit machine packer (Germany). Afterwards they were stored at -20 ºC. The samples were analysed at the beginning of the experiment and then every month for 6 months.

2.4 Proximate analyses

Moisture, fat and ash content of the raw samples was determined (AOAC, 1995) in quadruplicate. The crude protein content was measured in quadruplicate using a Nitrogen determinator LECO FP-2000 (Leco Corporation, St Joseph, MI).

2.5 Mechanical properties

The instrumental texture analysis was conduced using a TA-TX2 Texture Analyser (Texture Technologies Corp., Scarsdale, NY). Measurement of the cooked samples was carried out at room temperature. Texture profile analysis (TPA) was performed as described by Bourne (1978). Three probes (Ø =2 cm height=1.5 cm) of cooked samples were axially compressed to 40 percent of their original height to avoid fracturability. Force-time deformation curves were derived with a 50 N load cell applied at a crosshead speed of 0.8 mm/sec. Attributes were calculated as follows: hardness: peak force (N) required for first compression; cohesiveness: ratio of active work done under the second compression curve to that done under the first compression curve (dimensionless) and springiness: distance (mm) the sample recovers after the first compression. Chewiness (N x mm) is the product of the attributes mentioned and from the sensory point of view corresponds to the energy required to chew a solid food product (Bourne, 2002).

The shear strength was measured with a Kramer shear cell attachment (model HDP/KS5). For this purpose, three sample portions (5.5 x 1.5 x 2.5 cm) per formulation were cooked. A load cell of 50 N was used and the cross head speed was 2.0 mm/sec. Data were expressed as a maximum load per gram of sample (N/g).

2.6 Water binding capacity (WBC)

A frozen sample (2 g) cut into small pieces was placed in a centrifuge tube (Ø=10 mm) along with enough filter paper (3 filter Whatman nº1 Ø=110 mm). Centrifugation took place after thawing the muscle in the tube. A Jouan MR1812 centrifuge (Saint Nazaire, France) was used: 5000 rpm (3000xg) for 10 minutes at room temperature. WBC was expressed as percent water retained per 100 g water present in the muscle prior to centrifuging.

2.7 Water holding capacity (WHC)

Paralepipedic 7 x 3 x 1.5 cm frozen pieces of the sample were cut from the mince blocks and placed in a plastic bag where small holes had been made to drain the drip. This bag with the sample inside was put inside another bag and hung with the holes at the bottom at a constant temperature of 2–4 ºC. The samples were in this condition overnight and the drip was measured. Then the samples were cooked in the same way in an oven (Rational Combi-Master CM6) at 100 ºC for 15 minutes. After, the oven was set at room temperature and the drip collected was measured.

2.8 Protein solubility

This was determined in triplicate essentially according to the Ironside and Love procedure (1958) by analysing the amount of soluble protein in a chilled aqueous solution of 5 percent NaCl. The protein was analysed in a LECO FP2000 analyser, and the results were expressed as a percentage of soluble protein over total protein.

2.9 Measurement of colour

Colour measurements consisted of determining L*, a* and b* using a CIELab scale (Young and Whittle, 1985; Park, 1995) where L* is the parameter that measures lightness, +b* the tendency towards yellow and +a* the tendency towards red. Measurements were done in a HunterLab model D25-9 colorimeter (D45/2°) (Hunter Associates Laboratory Inc., Reston, VA, USA), with measurements standardized with respect to the white calibration plate. Whiteness was determined using the following formula: 100-[(100-L*)^2+a*^{2}b*^{2}]$^{1/2}$ (Park 1995).

2.10 The thiobarbituric acid index (TBA-i)

It was determined according to Vyncke (1970) on a 5 percent trichloracetic acid extract of the restructured fish muscle. The results were expressed as mg malondialdehyde per kilogram of sample. The spectrophotometer used was a Perkin-Elmer Lambda 15, UV/VIS Spectrophotometer.

2.11 Sensory analyses

The triangular test (UNE 88 006 92) and hedonic analyses (UNE 87 020 93) were performed in every lot. Thus 0.7 cm thick slices were cut from semi-frozen blocks and battered with a special mix and fried in sunflower oil at 180 ºC for 3 minutes. Seven semi-trained panellists tasted the samples in a standard sensory panel room following the norms mentioned above. For the hedonic analyses, a 10 cm non-structured scale with verbal anchors at the ends and in the centre (like very much, neither like nor dislike, dislike very much) was used for three properties: flavour, texture and overall rating acceptance. The panellists had to mark a vertical line on the scale; afterwards these marks were measured with a ruler.

2.12 Statistical analysis

One and two-way ANOVA was analysed using Statgraphics 2.1 (STSC Inc., Rockville, MD). The difference in means was analysed using a Tukey HSD test ($p<0.05$).

3. RESULTS AND DISCUSSION

3.1 Protein solubility

Differences among protein solubility mean values for the two kinds of muscle samples with and without fibre were not significantly different throughout frozen storage. However, Yoon and Lee (1990) conferred cryoprotectant properties on cellulose when it partially substituted sucrose in formulas using sorbitol and sodium tripolyphosphate. DaPonte *et al.* (1985) reported stabilization of frozen fish muscle when some fibres, other than cellulose, were added.

3.2 WBC

If the sample of hake muscle without fibre (H0) is compared with the sample with 3 percent of fibre where the moisture was not kept constant (HL3*), it is observed (Table 1) that this fibre helps retain water ($p<0.05$) when pressure is exerted, especially from day 60 of frozen storage. These data can be compared bearing in mind that the value of the retained water is a ratio with the total water in the sample, so that the difference in moisture is corrected. If when we add the fibre we also add water to maintain the moisture (HL3, HL6), it is observed that the added fibre (3 and 6 percent) cannot efficiently bind the extra quantity of water, so there are significant differences with the control sample (H0), although there are hardly any differences between the samples with 3 (HL3) and 6 percent (HL6) of fibre. The same thing occurs with the horse mackerel samples (Table 1), but the difference between the control (M0) and the samples with added fibre (ML3, ML6) is still greater than in the hake muscle. There are also hardly any differences between the horse mackerel samples with 3 (ML3) and 6 percent (ML6) of fibre, whereas these differences are always significant and more than 10 percent with the control sample. Yoon and Lee (1990) recommended adding a maximum of 2 percent of cellulose to the surimi, because with a greater proportion of cellulose gels more expressible moisture and firmness were obtained.

If the samples of minced hake with 3 percent different grain length fibre are compared, it is observed that the water is more firmly bound in most of the controls when the grain is shorter (80 µm) (HS3) and not the longest (250 µm) (HL3). This is in accordance with the work done by Yoon and Lee (1990) where it was observed that in cellulose particles longer than 20 µm the expressible moisture (by compression) was higher, although the size range used in the present work was different (80 µm and 250 µm). On the other hand, Ang and Miller (1991) reported that the water retention of cellulose increases as the fibre length increases, but they also reported that water retention with fibre lengths greater than 110 µm did not vary as much as fibre lengths between 35 and 100 µm.

Table 1: Water binding capacity (percent)[1]

DAYS	H0	HL3	HL6	HL3*	HS3	M0	ML3	ML6
0	58.20 a/1	54.84	52.26 a/3	57.39	53.13	45.09	29.72	27.60
30	53.02	41.97	37.51 c/4	53.44	47.82	46.54	32.60	29.57
60	49.58	41.55	40.85 c/2	53.10	41.75 d/2	42.99	31.24	29.29
90	48.22	47.32	44.67	50.80	44.43	49.35	31.97	27.44
120	49.47 d/1	40.81 d/2	45.13	54.89	49.58	45.86	32.92	27.02
150	45.92 e/1	40.01 d/2	43.94	56.66	55.48 a/3	46.22	34.52	25.57
180	47.91	44.19	43.00 bc/1	63.58	57.57 a/3	43.93	30.38	25.82

[1] Different letters in the same column indicate significant time differences ($p < 0.05$). Different numbers in the same row for each type of fish indicate significant differences ($p < 0.05$) among the samples.

3.3 WHC

In minced hake muscle, only the long grain fibre (HL3, HL6) absorbed the thaw drip effectively ($p<0.05$) (Table 2). Ang and Crosby (2005) report that the larger the particle size (or fibre length), the more water can be retained as a result of the greater internal pore volume. There were very few significant differences when 3 (HL3) or 6 percent (HL6) of fibre was used. The same results were obtained when the fibre was added to minced horse mackerel (ML3, ML6).

If 3 percent of fibre was added to minced hake muscle without adjusting the final moisture (HL3*), the water was absorbed significantly more than when water was added (HL3). In applications using minced beef, insoluble fibres from cereals help reduce the amount of free water that can occur during pre-frying, which is very important to improve the yield of the final cooked product and prevent the breadcrumb coating from breaking during frying because of the excessive drip release (Anonymous, 1999).

Table 2: Water holding capacity (percent)[1]

DAYS	H0	HL3	HL6	HL3*	HS3	M0	ML3	ML6
0	89.64 a/1	97.94	99.38	100 a/2	89.67	92.15	96.64	100 ab/3
30	95.12 b/1	97.76	99.85	100 a/2	91.63	92.31	99.40	99.98
60	91.85	97.62	99.53	100 a/2	93.08	95.52	99.95	99.94 c/2
90	90.18	94.87 b/2	97.90	100 a/3	89.95	93.31	98.44	99.95
120	94.65	96.57	99.77	100 a/3	93.80	99.71	99.97	99.98
150	94.09	97.93	99.38	100 a/3	96.36	99.77	99.98	99.99
180	93.27	96.08	99.53	99.98	96.13	98.21	100 c/2	100 a/2

[1] See note to Table 1.

3.4 Cooking yield

Data are shown in Table 3. Three percent of fibre (long or short grain) added to hake (HL3, HS3) and minced horse mackerel muscle (ML3) did not bind significantly more water than the respective control (H0, M0) when the moisture in both samples was adjusted to the original muscle moisture. The addition of 3 percent of fibre without adjusting the water (HL3*) was effective to bind the cooking drip; this is an important point to take into account in order to avoid dripping during broiling or frying. Six percent of fibre (HL6, ML6) helped bind the water and the data were significantly different from the respective control (H0, M0) and the samples with 3 percent (HL3, ML3) of fibre in both muscles.
When water was lost, the muscle fibres shrank upon heating, but when high-fibre ingredients were added, the structural integrity was maintained (Nelson, 2001). Troutt *et al.* (1992) reported that 2 percent of oat fibre, which is a cereal fibre, incorporated into meat hamburger (with no water added) reduced cooking losses by 20–40 percent. This reduction is about 2–4 times more than in the present experiment in fish. Moreover, Pszczola (1991) reported that the addition of oat brand to ground beef resulted in increased cooking yield. Katsanidis *et al.* (2001) reported the important role of introducing cellulose into comminute beef because it reduced the cooking drip; this water is not retained at all if an external force

(it can be shrinkage during cooking) is applied because it takes out the water that is physically and not chemically entrapped. On the other hand, Ang (1993) reported that the increase in water retention during cooking could be because of the hydrogen bonds forming between the water molecules and cellulose fibres. What can happen is that the hydrogen bonds weaken with the cooking temperatures and water cannot be bound so easily. Consequently, a larger amount of fibre is necessary.

Table 3: Cooking yield (percent)[1]

DAYS	H0	HL3	HL6	HL3*	HS3	M0	ML3	ML6
0	86.41	87.07	90.30	88.04	85.31	74.48	76.19	77.11
30	85.57	86.33	88.01	87.92	83.49	73.82	74.87	81.28
60	84.64	85.94	86.73	87.53	83.72	75.39	76.10	85.35
90	82.68	84.15	87.44	90.45	84.29	75.57	75.14	81.59
120	86.51	85.94	91.76	89.55	84.91	74.83	75.47	83.46
150	82.22	83.95	86.01	88.22	82.30	72.40	76.80	84.18
180	84.55	83.17	88.25	89,00	83.37	72.29	77.32	84.02

[1] See note to Table 1.

3.5 Whiteness index

The addition of an increasing proportion of wheat fibre whitened the minced raw hake (HL3, HL6) and horse mackerel (ML3, ML6) samples significantly. The horse mackerel cooked samples were much whiter than the raw ones and the amount of fibre added also enhanced the colour. Non-enzymic browning that develops in frying when cellulose is used (Ang, 1993) was not observed in minced muscle probably because the coating protects the muscle from the very high temperatures responsible for enzymic browning. This is an important fact because European consumers consider whiteness as a quality factor for hake and other fish products (Ang, 1993).

3.6 Mechanical properties

Data are shown in Tables 4 and 5.Shear strength: There were no significant differences in the hake and horse mackerel control samples (H0, M0) and the samples with 3 percent fibre, irrespective of the size of the fibre when water was added to maintain the initial moisture of the muscle (HL3, HS3, ML3). If water was not added to keep the moisture in the sample constant (HL3*), hardness increased, probably because the fibre absorbed part of the water and this hardened the muscle particles. It is important to highlight that this test analyses shear strength with a method using complex combinations of compression, extrusion, shear, friction and other effects (Bourne, 2002) between small particles of food and the Kramer cell. Thus the measurement of shear strength is on these particles and the procedure is similar to the one we use when we chew. Hardness did not increase either in any sample during frozen storage.

Table 4. Shear strength (N/g)[1]

DAYS	H0	HL3	HL6	HL3*	HS3	M0	ML3	ML6
0	5.85 a/1	4.55	5.10	7.26 ab/1	6.14	7.70	6.84	7.35
30	5.75 a/1	5.45	6.35	8.71	5.75	7.42	6.93	7.58 a/1
60	6.30	5.95	7.92	7.52	4.72	6.73	8.54	7.48 a/1
90	5.39 a/1	5.89	7.52	5.24 a/1	6.35	8.41	7.83	8.36
120	6.02 a/1	5.99	7.09	11.43 d/2	6.84	9.18	7.64	9.70 c/1
150	5.84 a/1	6.53	5.98	9.56	5.90	8.42	8.76	7.71 a/1
180	5.87 a/1	5.72	7.17	10.36	6.74	8.60	8.58	9.30

[1] See note to Table 1.

Chewiness: At 0 days of frozen storage, when fibre was added (HL3, HL6, ML3, ML6), chewiness was lower than in the control samples (H0, M0) in both the minced hake and horse mackerel muscles, although there were no significant differences in many instances among the samples containing fibre. These results are in agreement with the results for fish surimi gel samples with cellulose added from wood or cotton, where hardness and cohesiveness were reduced by adding 2 percent cellulose (Anonymous, 1981). Aleson-Carbonell *et al.* (2005) report that the addition of fibres and other ingredients to meat products produce less rigid structures. Troutt *et al.* (1992) also reported that firmness and cohesiveness were reduced when oat fibre was added to ground beef with low fat content.

Table 5: Chewiness (N x mm)[1]

DAYS	H0	HL3	HL6	HL3*	HS3	M0	ML3	ML6
0	35.00	18.75	13.50	24.58	21.59 ab/2	61.34	44.36	37.79
30	34.98	12.54	13.11	27.71	23.05	79.66	65.58	43.84 c/3
60	37.52	18.17 a/3	22.68	28.09	22.26	43.93	44.64	35.09
90	31.69	17.93	15.26	18.17	22.44	55.14	43.28	36.44
120	33.65	18.63	16.16	15.81 a/2	30.11 c/1	57.41	49.23	40.56
150	42.77	26.27	25.38	32.77 de/2	29.45	47.71	48.39	30.84 a/2
180	33.57	28.38	21.45	35.89 e/1	23.20	47.79	40.02	31.10 a/2

[1] See note to Table 1.

Throughout frozen storage the hake muscle sample with 3 percent fibre (HL3) was not significantly different from the one with 6 percent (HL6), but both were different from the samples without fibre (H0). In the case of horse mackerel, the sample with 3 percent fibre (ML3) was significantly different from the sample without fibre (ML0) only at the beginning of frozen storage, but both were different from the samples with 6 percent of fibre (ML6). These data depend more on hardness and cohesiveness than on springiness. The values of the different analyses were similar for the samples with 3 percent of long and short particle fibre (HL3, HS3) throughout frozen storage. Yoon and Lee (1990) reported that the addition of 0–2 percent of cellulose in frozen surimi products decreased firmness and cohesiveness and increased cellulose concentration, although more than 2 percent of cellulose increased firmness. The effect on the texture parameters is different depending on the amount and type of insoluble fibre that is added to meat products (Cofrades *et al.,* 2000) and also on the water binding capacity and swelling properties of the fibre (Thebaudin *et al*., 1997).

3.7 Lipid oxidation

There is no significant variation in the evolution of the TBA-index throughout frozen storage in the different lots for both types of muscles with and without fibre. Aleson-Carbonell *et al.* (2005) report that some cereal fibres have antioxidant properties, but they use fibres that are not very purified containing phenolic compounds. This is not the case of the fibre used in this study.

3.8 Sensory analysis

The triangular analysis detected significant differences in all the samples and the two muscles studied. According to the panellists, the difference in the hake samples was more in the texture than in the flavour. In the case of the horse mackerel samples, as well as the differences in texture, the fibre reduced the strong taste of the muscle.

According to the hedonic analysis done with non-structured scales, the flavour of the hake samples without fibre (H0) was slightly better (6.0-7.0) than the lots with 3 percent (HL3, HS3, HL3*), although the score for these lots was always around the middle point (4.9–5.5, neither like nor dislike). The lot with 6 percent of fibre (HL6) had the lowest score (4.0–4.6). In the case of horse mackerel, the samples with fibre (ML3, ML6) exhibited slightly higher values (6.5–7.0) than the lot M0 without fibre (5.0–6.0), because the fibre reduced the strong flavour of the muscle. The panellists did not detect any strange flavour throughout frozen storage in either of the two muscles studied. The texture analysis of the hake samples also exhibited slightly higher values (5.0–6.3) in the control lot (H0), especially during the first 30 days of storage. The rest of the lots exhibited values slightly lower than the middle point of the scale (3.0–5.1) and the lowest values were in the lot HL6 with 6 percent of fibre (2.8–4.4). According to the panellists, this lot was too dry. It is strange that the lot with 6 percent of added fibre had a lower cooking loss and yet the panel of tasters mentioned that it was drier. Although there were fluctuations in the data throughout frozen storage, there was no deterioration in the texture during frozen storage. In the case of horse mackerel, the sample with 3 percent of fibre (ML3) was well accepted by the panel of tasters (values 6.0–7.0) compared with values 6.5–6.6 in the sample without fibre (M0). However, the horse mackerel sample with 6 percent of fibre (ML6) exhibited lower values (2.5–4.0) because of the “sandy” taste and low cohesiveness.

Regarding the overall rating of the hake samples, higher values (5.0–7.3) in the lot H0 without fibre and values near the middle point of the scale (3.9–6.2) in the lots with 3 percent of fibre (HL3) were observed, except for the lot where water was not added to keep the moisture constant (HL3*), which was drier (3.6–5.8). The lot with 6 percent of fibre (HL6) had lower acceptance (2.9–4.2). As for the overall rating of the horse mackerel samples, the samples with 3 percent of fibre (ML3) exhibited values of 6.0–7.0 compared to 6.5–6.6 in the sample without fibre (MO) throughout frozen storage. The sample with 6 percent of fibre ML6) exhibited a lower rating of 3.0–4.0.

4. CONCLUSIONS

No cryoprotectant effect of the wheat fibre was observed on the protein in the two muscles studied. The introduction of 3 percent of wheat fibre improved the water binding capacity when a force was used to extract it. However, if together with the 3 or 6 percent of fibre water was added to keep the moisture constant, this fibre could not bind more water than the control sample. The loss in thaw drip without applying any external force was significantly less when 250 µm grain cellulose was introduced, and no change was observed with the 80 µm particle.

The loss from the cooking drip was very similar throughout frozen storage when 3 percent of fibre and water was added to keep the moisture constant in the sample. However, it was less if 6 percent of fibre or 3 percent of fibre without water was added. The 80 µm particle fibre bound less cooking drip than the 250 µm particle fibre.

In all the cases studied, the addition of wheat fibre whitened the samples, especially those with a darker muscle as is the case of horse mackerel. This is considered to be a commercial advantage.
The restructured product with added fibre was less rigid and cohesive. However, the shear strength of the product particles was similar in the lots with and without fibre when water was added to maintain the same moisture as in the original muscle.

In the sensory analysis there were differences in the lots with and without fibre. The lots with 3 percent of fibre were all accepted, while the lots with 6 percent fibre were rated worse. This negative rating was primarily a result of the sensation of dryness. In the present work wheat fibre was not found to have an antioxidant capacity.

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BLOCS DE PULPE DE SOLE TROPICALE CRUE CONGELÉE (*Cynoglossus* sp.): TECHNOLOGIE, BACTÉRIOLOGIE ET HACCP

par

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Abstract

The pulp of tropical sole (*Cynoglossus* sp) frozen in blocks is a product not well known in Senegal (2 out of 78 factories of filleting-cooling-freezing produce it). The pulp is obtained through the extraction from carcasses of sole after filleting (clearing of meat left on the skeleton). This study, done at "Sénégal Pêche", has the objective to:

- know the processing technology;
- assess the bacteriological quality;
- propose a HACCP approach to control hazards linked with the pulp's processing.

This study consists, on the one side, in a description of the product (technology, specifications), and on the other in bacteriological analyses (548 samples of pulp). The results obtained and interpreted according to French microbiological criteria, revealed:

93.12 percent satisfactory
5.54 percent acceptable
1.34 percent non satisfactory

On the other hand, HACCP method has shown that there are two critical points to be controlled (degutting and extrusion of carcasses) and that hazards associated with these steps are rather contamination, multiplication and survival of germs. In order not to compromise the good quality of hygiene of sole pulp and adding more value, it is necessary to improve the system of collection of wastes deriving from filleting.

Résumé

La pulpe de sole tropicale (*Cynoglossus* sp.) congelée en blocs est un produit peu connu au Sénégal (2 des 78 entreprises de filetage-réfrigération-congélation la produisent). Elle est obtenue par l'extrusion des carcasses de sole issues du filetage (raclage des restants de chair laissés sur le squelette). La présente étude menée au niveau de Sénégal Pêche, a pour objectif:

- de connaître sa technologie de fabrication;
- d'apprécier sa qualité bactériologique;
- de proposer une démarche HACCP pour la maîtrise des dangers inhérents à sa fabrication.

Cette étude consiste d'une part, en une description du produit (technologie, spécifications) et d'autre part, en des analyses bactériologiques (548 échantillons de pulpe). Les résultats obtenus et interprétés selon les critères microbiologiques français ont révélé que:

93,12 pour cent sont satisfaisants
5,54 pour cent acceptables
1,34 pour cent non satisfaisants

Par ailleurs, la méthode HACCP a montré qu'il y a deux points critiques à maîtriser (éviscération et extrusion des carcasses) et que les dangers associés à ces étapes sont plutôt la contamination, la multiplication et la survie des germes.

Pour ne pas compromettre cette bonne qualité hygiénique de la pulpe de sole et lui donner plus de valeur ajoutée, il est nécessaire d'améliorer le système de collecte des déchets provenant du filetage.

1. INTRODUCTION

Les sociétés exportatrices de produits halieutiques occupent une place considérable dans l'industrie agroalimentaire au Sénégal. Le secteur de la pêche maritime sénégalaise a connu une croissance spectaculaire depuis trois décennies. Les captures débarquées, qui étaient de l'ordre de 50 000 tonnes en 1965, ont atteint 450 000 tonnes en 2000: elles ont été multipliées par plus de 7 en 35 ans, soit un taux de croissance de près de 7 pour cent par an en moyenne, sur la période 1965-2000 .

Constituant aujourd'hui le premier pôle d'exportation Sénégal avec un chiffre d'affaires global à l'exportation évalué à plus de 185 milliards de francs CFA, le secteur de la pêche représente, selon les dernières estimations de 2001, environ 12 pour cent du PIB du secteur primaire et 2 pour cent du PIB total du pays. Parmi les produits qui ont généré cette valeur monétaire, les poissons élaborés et dont particulièrement les filets de sole figurent en bonne place.

Cependant, si l'industrie de la sole est en pleine expansion, bon nombre d'entreprises se limitent essentiellement à la transformation des produits en filets de sole (6 283 tonnes exportées en 2003). Une variété de produit non moins prisée par les consommateurs européens gagnerait également à être bien valorisée. Il s'agit de la pulpe de sole congelée qui, longtemps considérée comme un produit de récupération, est devenue un produit à forte valeur ajoutée.

L'importance économique de ce produit est grande car au niveau du filetage (opération qui consiste à retirer la chair de part et d'autre de l'arête centrale du poisson), les rendements atteignent rarement 50 pour cent pour la sole langue. Ainsi, l'extrusion des carcasses de sole permet de récupérer les restants de chair laissés sur les squelettes et de ce fait limite considérablement les pertes.

Par ailleurs, la pulpe de sole est un produit très prisé par la clientèle européenne. En effet, comme en témoigne la production exportée en 2003 (500 tonnes) et son prix au kilogramme à l'exportation (0,7 dollars EU) ; le manque à gagner serait considérable sans elle.

Cette étude menée au niveau de Sénégal-Pêche retrace la technologie appropriée à ce produit, sa qualité bactériologique et propose un plan de maîtrise des risques inhérent à son élaboration suivant la méthode HACCP.

2. TECHNOLOGIE DE LA PULPE DE SOLE

La pulpe de sole est un produit à base de chair de sole crue sous forme de pâte. Cette pâte de sole de consistance molle et de couleur rose pâle (voir photo en annexe), est souvent mélangée avec un liant (fécule de pomme de terre) et congelée en bloc (cf figure. n° 1).

Les espèces utilisées pour l'élaboration de la pulpe de sole tropicale appartiennent au genre C*ynoglossus*.

3. BACTÉRIOLOGIE DE LA PULPE DE SOLE

3.1 Produits analysés

Il s'agit de 548 échantillons de blocs de pulpe de sole crue congelée (7,5 kg/bloc) prélevés au démoulage, c'est-à-dire à la sortie des armoires de congélation. Au total, 4 110 kg de pulpe ont été soumis aux analyses bactériologiques.

3.2 Méthode d'échantillonnage

Les échantillons ont été prélevés à la fin de chaque journée de production. Chaque prélèvement aléatoire de bloc est acheminé directement au laboratoire en vue de son analyse.

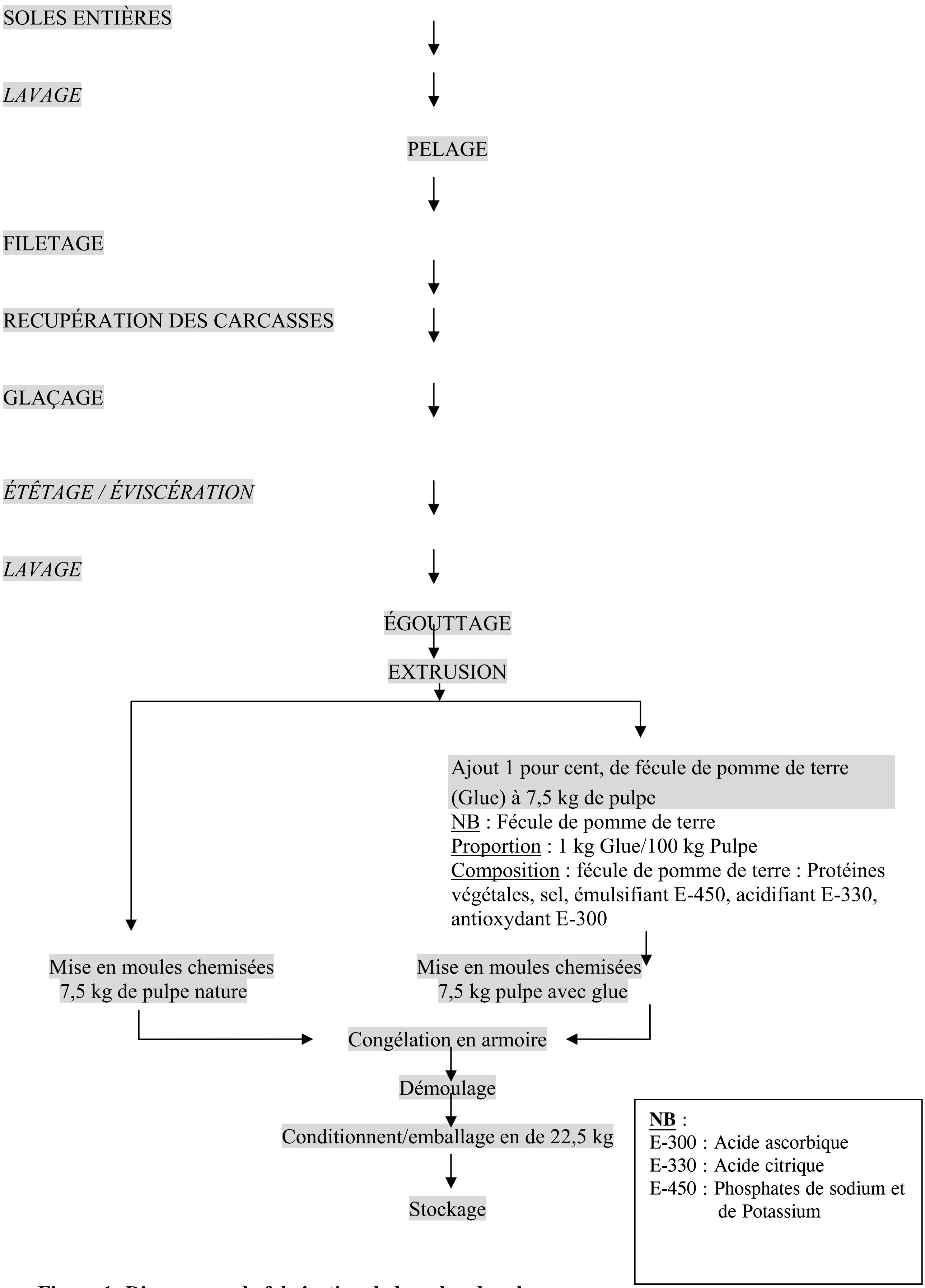

Figure 1: Diagramme de fabrication de la pulpe de sole

3.3 Méthode d'analyses bactériologiques

Tableau 1 : flore recherchées et méthodes utilisées

Germes recherchés	Milieux de culture utilisés		Température d'incubation	Durée d'incubation	Nature des colonies
Micro-organismes aérobies à 30°C	Plate Count Agar(PCA)		30 °C	72h	Blanchâtres
Coliformes thermotolérants à 44°C	Violet Red Bile Lactose Agar		44 °C	24 à 48h	Rouges foncées
Staphylocoques présumés pathogènes	Baird Parker		37 °C	48h	Noires brillantes
Anaérobies sulfito-réducteurs	Trypticase sulfite cycloserine		37 °C	24h	Noires
Salmonelles	Pré-enrichissement		37 °C	24h	-
	Enrichissement	Bouillon sélénite Rappaport Vassiliadis	37 °C 42 °C	24h 24h	- -
	Isolement	Gélose au vert brillant Hektoen	37 °C	24h	Rouges Bleues à centre noir
	Purification	Gélose nutritive	37 °C	18 à 48h	-
	Identification	API 20^{E}	37 °C	24h	-

3.4 Résultats des analyses

Les tableaux 2, 3, 4, 5 et 6 ci-dessous présentent la répartition de la contamination des 548 échantillons par les différentes flores en fonction de la norme (arrêté français de 1979 et note de service AFSSA 2002).

Tableau 2 : Contamination des blocs de pulpe de sole par les micro-organismes à 30 °C

Résultats	Fréquence	Pourcentage	Pourcentage cumulé
Acceptable	111	20,3	20,3
Non satisfaisant	26	4,7	25
Satisfaisant	411	75	100
TOTAL	548	100	

Tableau 3: Contamination des blocs de pulpe de sole par les coliformes thermotolérants à 44 °C

Résultats	Fréquence	Pourcentage	Pourcentage cumulé
Acceptable	30	5,4	5,4
Non satisfaisant	11	2	7,4
Satisfaisant	507	92,6	100
TOTAL	548	100	

Tableau 4 : Contamination des blocs de pulpe de sole par les Staphylocoques présumés pathogènes

Résultats	Fréquence	Pourcentage	Pourcentage cumulé
Acceptable	11	2,3	2,3
Satisfaisant	537	98	100
TOTAL	148	100	

Tableau 5: Contamination des blocs de pulpe de sole par les Anaérobie Sulfito-Réducteurs

Résultats	Fréquence	Pourcentage	Pourcentage cumulé
Satisfaisant	548	100	100

Tableau 6: Contamination des blocs de pulpe de sole par les Salmonelles

Résultats	Absence /25g	Présence /25g
Nombre échantillon	548	00

4. HACCP

4.1Description du produit

Spécifications générales

Espèce : *Cynoglossus* spp

Méthode et lieu de capture : Pêchée en Atlantique Centre-Est (Sénégal) et en Océan pacifique (Vietnam)

Définition du produit : Bloc de pulpe de poisson fabriqué à partir de sole tropicale, après avoir enlevé les filets entiers sur chacune des faces du poisson

Type de congélation : En armoire à plaques (T°= -40 °C, Tps=3 h 30 mn)

Type de préparation : Crue

➢ Spécifications organoleptiques

Spécifications	*Cible*	Tolérance
▪ Texture	Molle, juteuse	*Aucune*
▪ Couleur	Blanche / beige à rose pâle	*Aucune*
▪ Odeur	Spécifique, absence d'odeur étrangère	*Aucune*
▪ Goût	Spécifique, absence de saveur étrangère	*Aucune*
▪ Défectuosité	-Absence de parasite (nématode, anisakis) -Absence d'arêtes (les restes de colonne vertébrale ne sont considérés comme arêtes que si elles sont décelables après cuisson) -Absence de corps étrangers (restes de nageoire, peau, viscère) -Absence de brûlure de + de 100 cm^2 -Absence de poche d'air de + de 7 cm^2 ou 2 cm^3 -Absence de poche de glace de + de 7 cm^2 ou 2 cm^3	*Aucune* *1 arête/kg* *1 unité/kg* *1 bloc/80 blocs* *1 poche d'air / bloc* *1 poche de glace / bloc*

➢ Spécifications métrologiques

Spécifications	*Cible*	Tolérance
▪ Poids net du colis	20 kg : 2 blocs x 10 kg 22,5 kg : 3 blocs x 7,490 kg	*Aucune*
▪ Poids net du bloc	10 kg 7,490 kg	-*Ecart maximum toléré : 150 g* *Poids moyen µ 10 kg* -*Ecart maximum toléré : 112,5 g* *Poids moyen µ 7,490 kg*
▪ Dimension du bloc Lx1xh	550 x 338 x 50 482 x 255 x 62	*+ / - 5 mm*
▪ Forme du bloc	Parallélépipède régulier : longueur, largueur, hauteur constantes en tout point	*10 mm d'écart maxi, entre la valeur la plus basse et valeur la plus haute sur les 3 dimensions*

➢ Spécifications physico-chimiques

Spécifications	*Cible*	Tolérance
▪ ABVT (à la demande)		*25 mg d'NH_3 /100g*
▪ TMA/ABVT (à la demande)		*< 35 percent*
▪ Corps métallique	Absence	*Aucune*
▪ Contaminant	Absence à des taux présentant une toxicité aiguë ou chronique pour la consommation humaine (DSP/PSP, ciguatoxines, pesticides, métaux lourds, histamines)	*Aucune*

- Spécifications bactériologiques

Micro-organismres	Norme
▪ Micro-organismes aérobies mésophiles à 30°C	*500 000 germes/g*
▪ Coliformes thermotolérants à 44°C	*100 germes/g*
▪ Staphylococcus coagulase positive	*100 germes/g*
▪ Bactéries anaérobies sulfito-réductrices à 46°C	*10 germes/g*
▪ Salmonelles	*Absence dans 25 g*
▪ Listeria monocytogenes (à la demande)	*100 germes/g*
▪ *Vibrio cholerae, parahaemolyticus* (à la demande)	*Absence dans 25 g*

Plan d'échantillonnage et d'interprétation conforme à l'arrêté du 21.12.1979 :

- Plan à 3 classes retenu de résolution : n = 5 ; c = 2
- Sauf pour Salmonelles et Listeria monocytogenes pour lesquelles un plan à deux classes (n=5, c=0) est appliqué.

- Conditionnement et emballage

Conditionnement : Chemise en carton paraffiné
Emballage :
-Regroupement des blocs par (2 x 10) ou (3 x 7,5) en master carton
-Fermeture : par un cerclage *sans agrafe métallique* ou à l'aide de ruban adhésif.

- Etiquetage

▪ Dénomination de vente	*Blocs de pulpe de sole tropicale crus congelés*
▪ Espèce	*Cynoglossus spp*
▪ méthode et lieu de capture	*pêchée en / au…*
▪ Calibre	*7,5 kg ou 10 kg*
▪ Poids net	*22,5 kg (3 blocs x 7,5 kg) ou 20 kg (2 blocs x 10 kg)*
▪ Date de congélation	*jj / mm / aa*
▪ A consommer de préférence avant fin :	*jj / mm / aa*
▪ Conditions de conservation	*A conserver à –18°C*
▪ La mention	*Ne jamais recongeler un produit décongelé*
▪ N° d'Agrément sanitaire	*ADRIGEL AEROPOLE*
▪ Importateur	*Immeuble Rafale – 44 340 Bouguenais (France)*

- Livraison

- Température à cœur du produit : ≤-18 °C
- Mode : Colis en vrac en conteneur congélateur de type Reefer, maintenant la température ambiante ≤-18 °C
- Traçabilité : Communication pour chaque conteneur, des numéros de lot embarqués avec notification des quantités respectives et de leur emplacement dans le conteneur.
- Présentation : - Colis exempts de perforation : produit contenu non visible
  - Colis non effondrés : arêtes des colis d'équerre.

4.2 Analyse de la chaîne

Etape : Réception

Analyse des dangers	Causes	PCM	Mesures préventives	Critères de surveillance
Contamination	Matière première soles achetées contaminées	Non	• Sélection des fournisseurs sur résultats bactériologiques et audit (cahier des charges)	Contrôle des matières premières : température de transport des soles
Multiplication	Méthodes de travail Attente longue des soles hors des chambres froides	Non	• Entrée directe des soles dans les chambres froides sans attente • Absence de croisements avec d'autres produits	Contrôle de la température
Multiplication	Environnement Température des chambres froides	Non	• chambre de stockage des soles au dessus de 4 °C • Herméticité du quai d'embarquement	
	Matériel			
Contamination	Personnel Défaut d'hygiène du personnel et des manipulations	Non	• Plan d'hygiène du personnel : tenue vestimentaire propre et adaptée, nettoyage régulier des mains Accès contrôlé des pers. extérieures	

Etape : collecte et glaçage des carcasses

Analyse des dangers	Causes	PCM	Mesures préventives	Critères de surveillance
Contamination Multiplication	*Produits* Macération dans l'eau -Temps d'attente trop long-Glaçage insuffisant	Non	Respect des proportions optimales de glaçage – Bonne répartition de la glace	Température carcasse < 7 °C
Multiplication	Environnement Température des salles de travail	Non	Disposer d'un enregistreur de T° et effectuer des relevés	Température salle 16 °C
Contamination Survie	Matériel Mauvaise application du plan de nettoyage-desinfection		Programme de nettoyage et désinfection approprié Personnel formé qualifié	Prélèvements de surface
Contamination	Personnel Défaut d'hygiène du personnel et des manipulations	Non	Formation et sensibilisation : Contrôle médical à l'embauche – Respect des règles d'hygiène et des bonnes pratiques de fabrication	Prélèvements de main

Etape : étêtage et éviscération

Analyse des dangers	Causes	PCM	Mesures préventives	Critères de surveillance
Contamination Multiplication	*Produits* Contamination du produit par des viscères	Oui	Maîtrise des techniques d'éviscération, élimination complète des viscères, célérité des opérations	Absence de viscères et de restes de peaux Contrôle visuel

Etape : lavage des carcasses

Analyse des dangers	Causes	PCM	Mesures préventives	Critères de surveillance
Contamination Multiplication	*Produits* Lavage inefficace utilisation d'eau de mauvaise qualité	Non	Renouvellement des bains de lavage toutes les 30 mn	Température eau < 10 °C

Etape : extrusion des carcasses

Analyse des dangers	Causes	PCM	Mesures préventives	Critères de surveillance
Contamination Multiplication	*Produits* Contamination croisée Présence d'arête, de restes de peau, de nageoire	Oui	réduction des temps d'attente, réglage des tamis et de la vitesse du tapis	Température produit < 3,3 °C – < 1 arête/kg Absence de restes de peaux et de nageoire

5. CONCLUSION

La pulpe de sole tropicale crue congelée en bloc est un produit dont l'élaboration est relativement simple, en dehors de l'étêtage – éviscération et de l'extrusion qui demeurent des étapes de majoration des risques de contamination par rupture de la cavité abdominale de la sole.

Cette étude menée à Sénégal-Pêche, a permis d'apprécier de façon objective la qualité de ce produit très peu connu au Sénégal. Une meilleure promotion de ce produit passe par la maîtrise de sa qualité bactériologique. Le seul recours efficace et viable reste bien entendu l'application du système HACCP.

6. PERSPECTIVES

- Mettre en place un guide pour la définition d'un plan d'autocontrôle pour les fabrications de pulpe de sole
- Étudier l'impact économique de la fabrication de tels produits
- Mettre en place la technologie (charcuterie de poisson) qui donne plus de valeur ajoutée aux pulpes de sole (fabrication de bâtonnets de sole, cœur de sole,…..)
- Élargir l'étude à d'autres fabrications afin de répondre aux besoins d'expertise microbiologique des industriels
- Envisager des techniques de valorisation des co-produits obtenus après fabrication de la pulpe de sole (têtes, viscères, carcasses, peaux, etc.…)

7. ANNEX

Photo : Bloc de pulpe de sole tropicale congelée 7,5 kg

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DESIGN AND CONSTRUCTION OF AFSMO – 150, AN IMPROVED FISH SMOKING OVEN

by

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Abstract

AFSMO – 150, an improved fish-smoking oven was developed at the Food Research Institute of the Council for Scientific and Industrial Research (CSIR) of Ghana under the Agro-Processing Programme of the Agricultural Services Subsector Investment Project (AgSSIP). The total cost of construction of the oven was ¢2 500 000 (approximately US$280). It exhibited various advantages over the popular chorkor smoker because of its cost effectiveness and efficiency. The design eliminated the laborious interchanging of tray positions, reduced heat loss and eliminated tar deposition on the fish. AFSMO-150 (AgSSIP/FRI Smoking Oven) is an enclosed rectangular-shaped structure composed of three basic units of two firing sections, a cooking/smoking chamber and a chimney. It could be fired by either firewood, Liquefied Petroleum Gas (LPG) or a combination of the two.

Test run of the oven with firewood fuel on mackerel showed temperature distribution with highest temperature difference of 29 °C at 90th minute and maximum temperature of 195 °C at 110th minute of operation; a smoking capacity of 150 kg of fresh fish per batch at 3 hours, fuel consumption of 39.5 kg of firewood (i.e. unit fuel consumption rate of 0.33 kg of firewood/kg of smoked fish); 80.6 percent yield with 19.4 percent moisture loss. Microbiological analyses indicated a final fish product devoid of faecal coliforms, spoilage and food poisoning micro-organisms – hence a product safe for human consumption.

Résumé

AFSMO-150, un four amélioré de fumage du poisson, a été développé à l'Institut de recherche alimentaire du «Conseil pour la recherche scientifique et industrielle au Ghana (CSIR)» dans le cadre du Programme pour l'industrie agro-alimentaire du projet d'investissement pour le sous-secteur des services agricoles (AgSSIP). Le coût total de construction du four était de 2 500 000¢ (280$EU environ). Celui-ci a montré beaucoup d'avantages par rapport au très populaire four chorkor du fait de son coût et son efficacité. Le prototype a éliminé le laborieux changement des positions des claies, a réduit la perte de chaleur, et a éliminé les dépôts de goudron sur le poisson. AFSMO-150 (four pour fumage AgSSIP/FRI) est une structure fermée à forme rectangulaire composée de trois unités de base ayant deux sections pour l'allumage, une chambre de cuisson/fumage, et une cheminée. Il peut être allumé soit par du bois combustible soit avec du Gaz Pétrole Liquéfié (LPG) ou par une combinaison des deux.

Des essais effectués avec le four à l'emploi de bois combustible pour le maquereau ont démontré une distribution de température avec une différence maximum de 29 °C à la 90ème minute et une température maximum de 195 °C à la 110ème minute d'opération ; une capacité de fumage de 150 kg de poisson frais par lot toutes les 3 heures, une consommation de 39,5 kg de bois combustible (i.e. unité de ratio de consommation de combustible de 0,33 kg de bois combustible/kg de poisson fumé); 80,6 pour cent, de rendement avec 19,4 pour cent, de perte d'humidité. Les analyses microbiologiques indiquent que le produit final de poisson est dépourvu de coliformes fécaux, de microorganismes pathogènes d'altération; le produit est donc salubre pour la consommation humaine.

1. INTRODUCTION

Smoking is the most widely used fish preservative method in Ghana among other traditional methods, such as sundrying, salting and fermenting. Thus about 70 percent of catch by artisanal fishermen are smoked using various types of ovens, such as the round/rectangular mud or metal ovens. The chorkor smoking oven was thus developed as an improvement over these aforementioned ovens (UNICEF, 1983) because it was thought to be cost effective. However, there were aspects of its operation that needed improvement. These included the laborious interchanging of tray positions during smoking to prevent the charring of the lower layers of fish closest to the fire source. In the process, a substantial amount of heat energy is expended during the operation of interchanging the trays. Also direct application of heat during smoking tended to increase the deposition of tar on the smoked product.

The objective of this project was therefore to develop an improved oven over the chorkor type that eliminated the interchanging of tray positions during smoking, reduced heat loss and made fish smoking less laborious. The improved oven also targeted the reduction/elimination of tar deposits usually associated with processed fish.

2. MATERIALS AND METHODS

2.1 Design features

The new design was created with the concept of eliminating the laborious process of interchanging tray positions during smoking with its associated heat loss and elimination of tar deposits on smoked fish products. The firing chambers were therefore located at the two sides of the smoking chamber where the trays were stacked. The curved nature of the sidewalls of the oven, coupled with the central position of the shelf structure that carried the trays in relationship to the firing chamber and the exhaust, guaranteed uniform smoking in the oven.

The height of the exhaust/chimney was such that smoke was always directed above the immediate surroundings of the smoking area, thus preventing the processors from smoke inhalation and pollution. Figure 1 shows the front, side elevation and the plan of the oven.

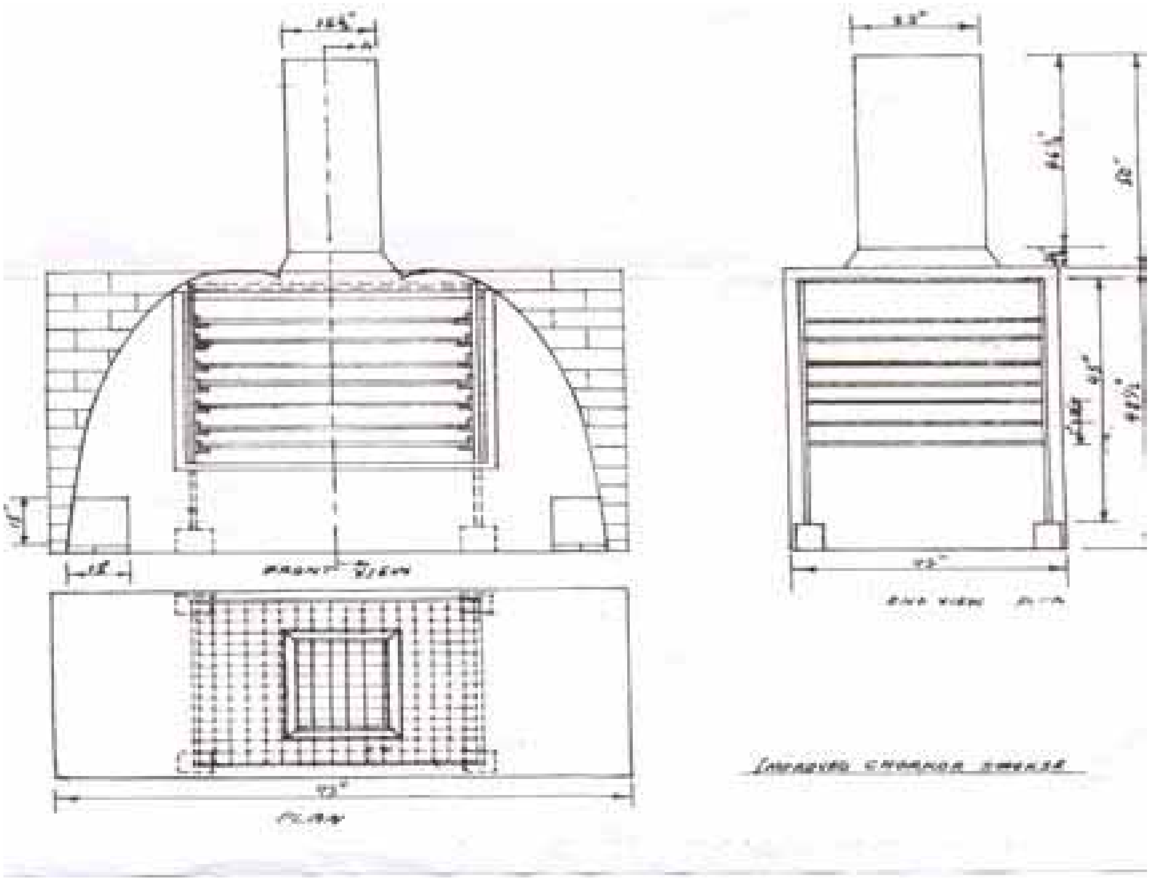

Figure 1: Front, side elevation and plan of the AFSMO-150

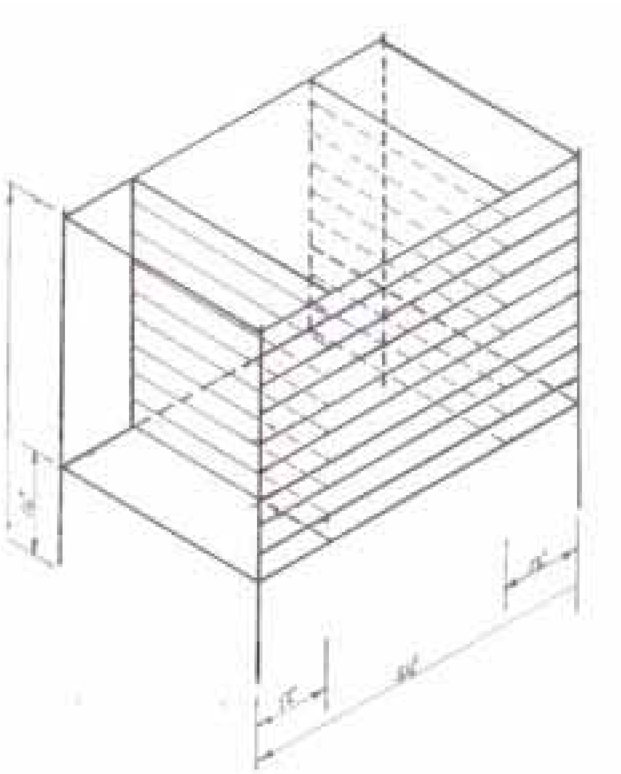

Figure 2: Shelf

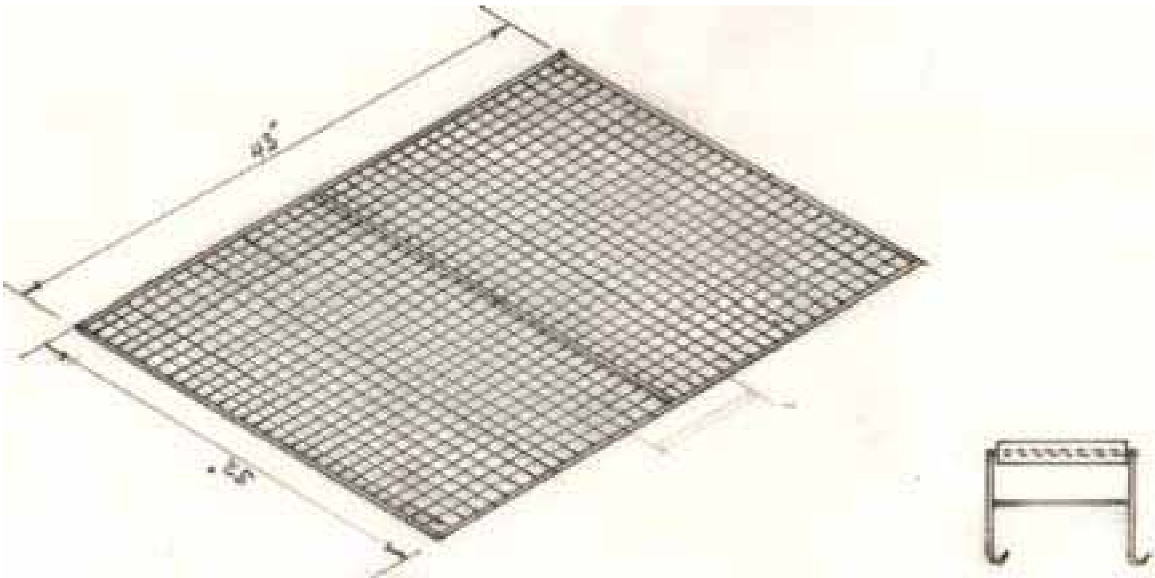

Figure 3: Tray and hook

The shelf was made from 5/8" steel rods and designed to allow easy "push-in and pull-out" of trays. The trays were made from 5/8" steel rod frames and 3 mm welded mesh. A hook with wooden handle was constructed to allow for pulling out the trays in sequence after the smoking process. Drawings of the shelf, tray and hook are as presented in Figures 2 and 3. The structural frame of the oven is as shown in Figure 4.

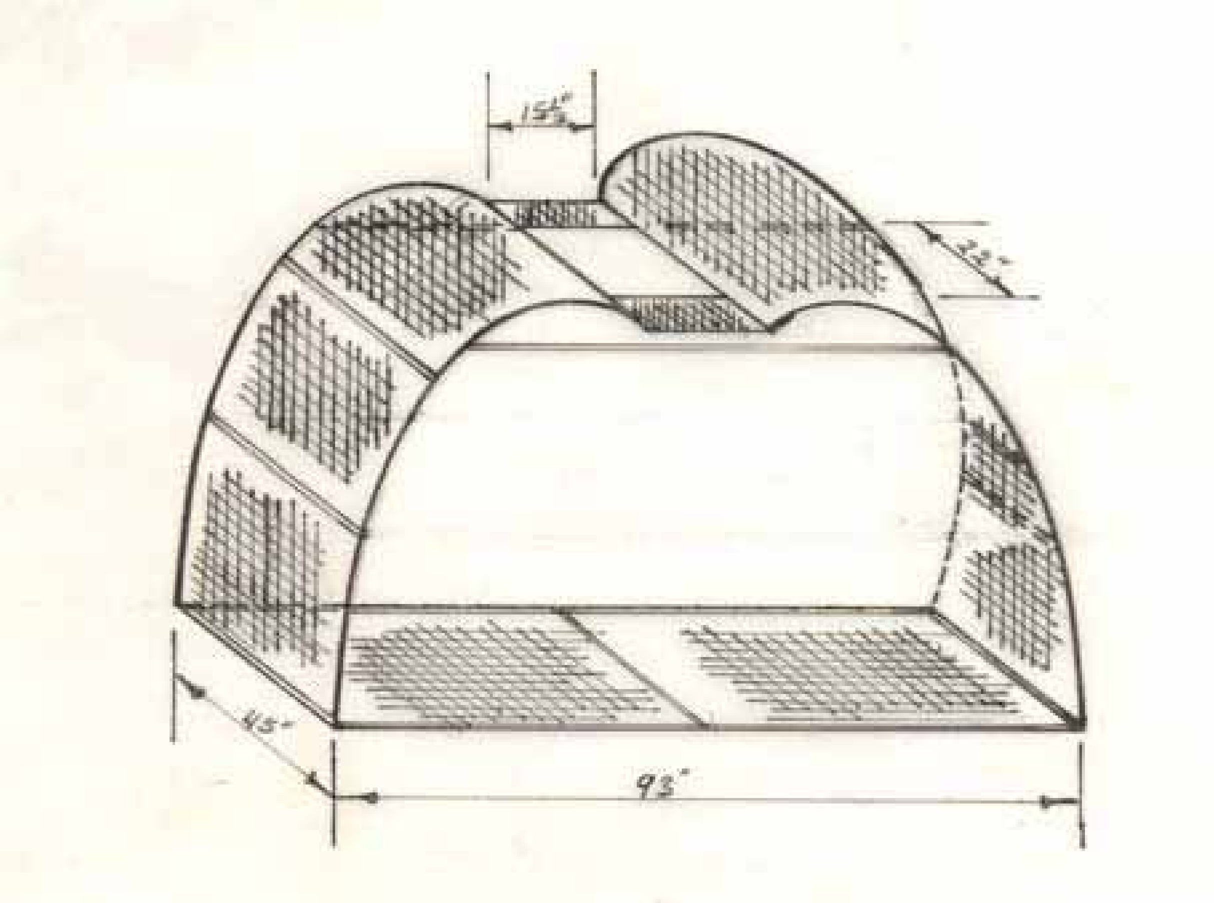

Figure 4: Structural frame of the improved oven

3. TEST RUN OF OVEN

The performance characteristics of the oven were determined by test running of the oven by smoking mackerel on firewood fuel. The mackerel was obtained in good frozen condition from a cold store facility at the Tema Fishing Harbour while the firewood was the traditional "Osha" obtained from Shiashi market near Okponglo in Accra.

3.1 Temperature distribution test

Test on temperature distribution in the oven was conducted to ascertain the uniformity of heat distribution. Three temperature probes were inserted in the oven from the back and positioned on the top, middle and bottom trays. Temperature readings were recorded every 10 minutes.

3.2 The smoking process

The fish was allowed to thaw, washed, drained of water, weighed and spread as uniformly as possible on the ten trays with each tray carrying 10 percent of the total quantity of fish to be smoked, i.e. 15 kg of the mackerel. Firewood for the smoking process was weighed, and about five or six sticks were arranged in each of the stoke holes and lit. The trays were then slid onto the shelves and the door closed. Three stages of smoking process were employed. The first stage (slow firing) covered a period of about 30 minutes during which the fire was manipulated such that temperature in the oven increased slowly and steadily but did not exceed 100 °C to prevent case hardening. The second stage (increased firing) lasted for about 2 hours during which the temperature was raised to record a maximum of about 195 °C. The third stage (cooling) was characterized by partial withdrawal of the firewood from the stoke holes to allow the fish to slowly reduce its temperature for about 30 minutes. After the third stage, the firewood was completely withdrawn and the door was opened for the fish to cool to room temperature. The trays were then pulled out of the shelves and the smoked fish weighed. The remaining firewood was also weighed and recorded.

Samples were taken from the top, middle and the bottom trays for microbiological analysis, chemical and texture analyses.

4. RESULTS AND DISCUSSIONS

Table 1 and Figure 5 show the temperature recordings at the top, middle and bottom trays during smoking. A maximum temperature difference of 29 ^{o}C representing 15 percent of the maximum working temperature of 195 ^{o}C was obtained and it fell within the smoking temperature range.

Table 1: Temperature (^{o}C) profile in oven

Time (minutes)	Temperature Top	Temperature Middle	Temperature Bottom	Temperature difference
0	30	30	30	0
10	61	58	55	6
20	70	70	67	3
30	87	82	77	10
40	95	92	89	6
50	102	98	95	7
60	133	128	116	17
70	160	142	134	33
80	143	135	127	16
90	171	152	149	29
100	190	186	175	15
110	195	184	179	16
120	165	150	148	17
130	150	135	132	18
140	159	146	144	15
150	126	123	110	16
160	117	110	105	12
170	89	84	78	11
180	77	72	69	8

Table 2 shows data recorded before, during and after the fish smoking process. It can be deduced from the results that the oven has a smoking capacity of 150 kg per batch of 3 hours and firewood consumption of 39.5 kg.

Results of the microbiological analyses (Table 3) indicated that aerobic plate counts at 30 °C ranged between 3.0 x 10^{1} and 2.6 x 10^{3} cfu/g. The Ghana Standards Board Microbiological Standards (GSBMS) for food samples (1988) and the International Commission on Microbiological Specifications for Foods (ICMSF, 1982) indicated a limit of acceptability as less than 1.0 x 10^{6} cfu/g for the total viable count in any food to be safe for consumption. Such counts recorded in the smoked fish were therefore within the limits of acceptability.

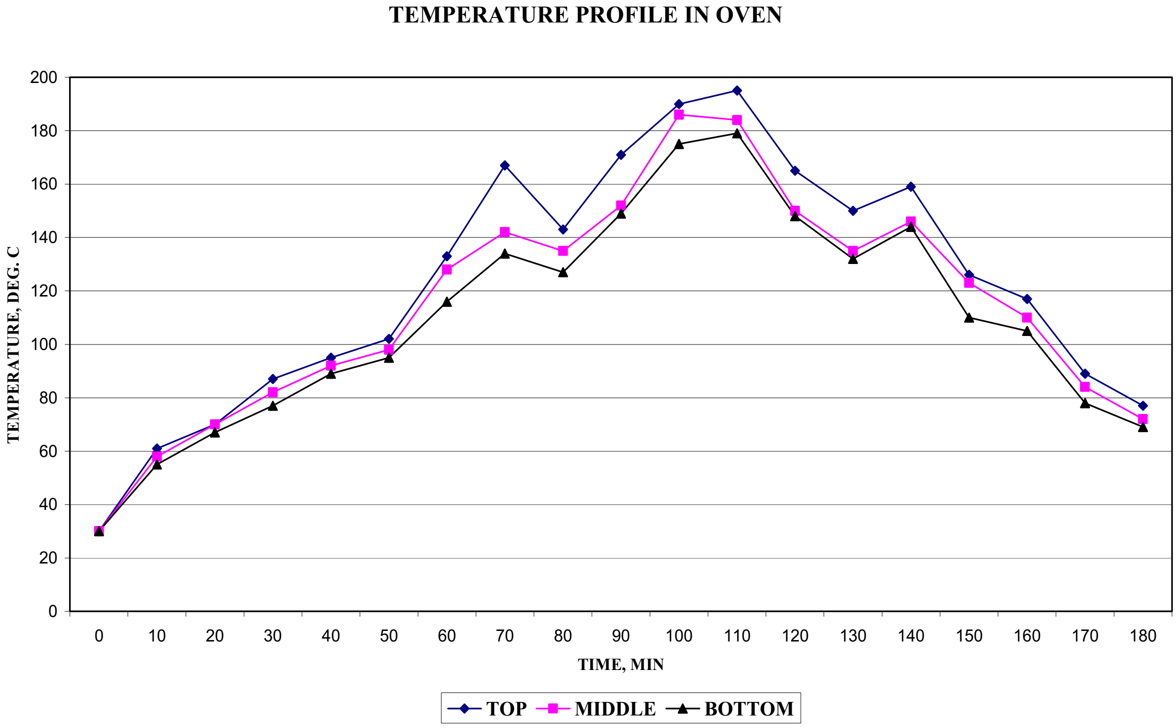

Figure 5: Temperature profile in oven during smoking of mackerel

Table 2: Fish smoking data

Type of fish	Mackerel
Type of firewood	"Osha"
Weight of firewood before smoking, kg	46.0
Weight of firewood after smoking, kg	7.5
Weight of firewood used, kg	39.5
Process time, hr	3.0
Consumption rate of firewood, kg/hr	13.2
Cost of wood per kg	¢952.38
Cost of firewood used	¢37,620
Weight of fresh fish, kg	150.0
Weight of smoked fish, kg	120.9
Weight of loss, kg	29.1
Weight loss, percent	19.4
Yield, percent	80.6
Firewood consumption rate, kg/kg smoked fish	0.33
Firewood consumption rate, kg wood/kg fresh fish	0.26
Unit energy cost of smoking, ¢/kg smoked fish	¢314.28
Unit energy cost of smoking, ¢/kg fresh fish	¢247.19

Mould and yeast counts were between 0 and 9.0 x 10^2 cfu/g in the smoked mackerel (Table 3). The ICMSF (1982) and GSBMS (1988) has a specification of less than 1.0 x 10^4 cfu/g, which indicated that the smoked fish met the specified standard requirement for safe food.

Table 3: Population of micro-organisms in smoked fish processed with improved smoker

Coliforms were absent in all the samples (Table 3), and further indications showed that *Escherichia coli* (*E. coli*) were also not detected. While ICMSF (1982) specified the levels of *E. coli* to be less than 1.0 x 10^1 cfu/g, the GSBMS (1988) indicated levels of zero cfu/g. The non-detection of these food poisoning organisms indicated that the fish was safe for consumption.

Smoked fish batch	Aerobic microorganisms at 30°C (cfu/g)	Moulds and yeasts (cfu/g)	Coliform organisms (cfu/g)	*E. coli* (cfu/g)	*Salmonella* species (/25g)	*Bacillus cereus* (cfu/g)	*Staphylococcus aureus* (cfu/g)	Dominant flora
1	1.3 x 10^3	8.0 x 10^1	0	0	Absent	0	0	*Mucor* spp., yeasts, Gram +ve rods
2	2.6 x 10^3	9.0 x 10^2	0	0	Absent	0	0	Yeasts, Gram +ve rods
3	7.7 x 10^2	6.0 x 10^1	0	0	Absent	0	0	Gram +ve rods and yeasts
4	3.0 x 10^1	0	0	0	Absent	0	0	Gram +ve rods

Salmonella species were not detected in 25 grams of any of the samples (Table 3). Both ICMSF (1982) and GSBMS (1988) stipulated levels of zero cfu/g of these organisms in the food to be considered safe for human consumption.

Staphylococcus aureus and *Bacillus cereus* were absent in the smoked fish samples (Table 3). For *S. aureus*, both ICMSF (1982) and GSBMS (1988) indicated safe levels of less than 1.0 x 10^2 cfu/g and zero cfu/g respectively; while *Bacillus cereus* levels should not exceed 1.0 x 10^4 cfu/g. Dominant flora observed were Gram-positive rods, yeasts and *Mucor* species.

The absence of faecal coliforms, spoilage and food poisoning micro-organisms in the smoked fish showed that it was microbiologically safe for human consumption and would not pose any health hazard when consumed.

3. CONCLUSION

A 150 kg capacity smoking oven AFSMO – 150 has been designed, constructed and tested at the Food Research Institute (FRI) of the Council for Scientific and Industrial Research (CSIR). The oven is working satisfactorily and has actually eliminated the process of interchanging trays during smoking with the chorkor smoker, thus reducing the amount of labour expended. Series of trials are being conducted to determine the tar deposits on the products, i.e. polycyclic aromatic hydrocarbons (PAH) content, texture and shelf-life properties of smoked fish with AFSMO-150.

The total cost of construction of the AFSMO-150 is ¢2 500 000 (US$280).

UTILIZATION OF FISH WASTE FOR MUSHROOM CULTIVATION

by

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Abstract

Fresh fish waste (FFW) and cooked fish wastes (CFW) mixed with sawdust from *Tryplochyton scleroxylon* wood species (*Wawa*) were matured in compost heaps for 30 days. Control compost from rice bran (CRB) was also prepared. Higher temperatures were recorded from compost heaps prepared from both FFW (38–52 °C) and CFW (37–52 °C) than from CRB (33–45 °C), with reduction in composting time, generation of large numbers of micro-organisms in the fish-based compost heaps. Mycelial colonization of compost bags and subsequent growth of oyster mushrooms (*Pleurotus* species) were faster in fish-based substrates (FFW and CFW) as compared to CRB. *P. eous* and *P. oestreatus* exhibited a more uniform spread of mycelia in the compost bags than *P. eous* hybrid. However, *P. eous* hybrid produced the fastest rate of mycelial growth, completely colonizing the substrate within 26 days. Growth of each species of mushroom investigated was independent of the substrate in which it was grown. Irrespective of the substrate used to grow the mushroom, the pattern of utilization and growth remained the same. Oyster mushrooms grown on fish-based substrates produced bigger and firmer fruiting bodies.

Keywords: Fish waste, slow release nitrogen, oyster mushroom, *Pleurotus* species.

Résumé

Des déchets de poisson frais [1] et de poisson cuit [2], mélangés de sciure de bois *Tryplochyton scleroxylon* (*Wawa*) ont été maturés en compost pour 30 jours. Du compost de contrôle avec du son de riz [3] a été aussi préparé. Les températures les plus élevées ont été enregistrées avec les tas de compost préparés avec FFW (38–52 °C) et CFW (37–52 °C) plutôt qu'avec CRB (33–45 °C); avec une réduction du temps de formation du compost, une génération de nombreux microorganismes dans le compost préparé avec du poisson. La colonisation de mycètes dans les sacs de compost et la croissance de pleurotes en huîtres qui en a résulté (*Pleurotus* sp.), ont été plus rapides dans les substrats à base de poisson (FFW and CFW) que dans les substrats CRB. *P. eous* et *P. oestreatus* ont montré une diffusion uniforme de mycètes dans les sacs de compost par rapport à l'hybride *P. eous*. Toutefois, l'hybride *P. eous* a eu un taux plus rapide de croissance de mycètes, en colonisant complètement le substrat en 26 jours. La croissance de chaque espèce de champignon expérimentée s'est avérée indépendante du substrat dans lequel il se reproduisait. Malgré la différence de substrats utilisés pour la croissance des champignons, le mode d'utilisation et de croissance restait le même. La croissance des pleurotes en huître sur des substrats contenant du poisson a produit des carpophores (organes portant des fruits) plus grands et fermes.

Mots clefs: Déchets de poisson, azote à libération lente, pleurote en huître, espèces de *Pleurotus*

1. INTRODUCTION

Artisanal fishing activities are carried out by residents along the coastal regions of Ghana with generated fish waste not adequately disposed of. This therefore results in gross environmental hazard causing foul odour because of the fast decomposition of the proteinaceous material under the prevailing high temperature and humidity. This is further compounded when the decomposed waste serves as a potential source of health hazard to inhabitants in the vicinity. Additionally, domestic animals that roam the rubbish dumps may spread the contaminants to homes and humans.

[1] Déchets de poisson frais – Fresh fish waste (FFW).
[2] Déchets de poisson cuit – Cooked fish wastes (CFW).
[3] Compost de son de riz – Compost from rice bran (CRB).

Other disposal methods for fish waste include dumping into the sea or along the shores. Surface dumping of such waste especially during the rainy season has resulted in increased attendance at our health centres because of rampant illnesses partly caused by contaminants or pathogens, especially in flood prone areas. More environmentally friendly methods include using the waste as feed in piggeries and/or in other animal feed industries.

Large volumes of lignocellulose agricultural residues (fish waste, vegetable materials) are generated annually through agricultural and food processing industries (Buswell, 1991). In Ghana, these are either disposed of by burning or dumping in landfills, thus posing hazard to the environment and human health, and which would otherwise be used in the cultivation of edible and medicinal mushrooms. Residues – such as peelings from cassava, straw and stover from wild grasses, rice, maize, millet, sawdust, by-products of cotton, oil palm by-products – have all been utilized as potential substrates for mushroom cultivation. The application of appropriate bioconversion technology, such as slow release of nutrients for mushroom cultivation, would reduce the waste profitably. Moreover, environmental awareness has grown to such a proportion that enforcement of pollution control laws has become more effective. Waste recycling and supplementation techniques in the production of mushrooms, especially *Pleurotus* species that survive on a wide range of substrates, would be beneficial to ensuring pollution control.

It is estimated that the weight of by-products from 12 major crops grown in Ghana, including cocoa, oil palm, cassava and maize, amount to more than 9 million tonnes annually (Sawyerr, 1994). When only one-fourth of this amount is utilized in growing mushrooms, about 1.2 million tonnes of fresh mushrooms can be harvested within two months assuming a biological efficiency of 50 percent. This is enough to provide 18 million people each with over 1.1 kg of mushrooms daily.

Mushroom is an important food in the diet of Ghanaians. Depending on the variety, they contain high quality protein with levels ranging from 21 to 40 percent dry weight. They also contain vitamins B1, B2, B6, B12, C, D and rich in minerals essential for human health. Dry mushrooms can be powdered and used in infant food preparations for increased nutritional value. Protein energy malnutrition has been identified as one of the biggest nutritional problems of the vulnerable group. Such diseases as Kwashiorkor, marasmus and anaemia are becoming widespread because protein is lacking in the daily dietary intake of the average Ghanaian. To combat the crisis, the Food and Agricultural Organization (FAO) has recommended the use of mushrooms as a potential food source especially since mushrooms have the capacity to convert agricultural wastes into high protein food (Chang and Hayes, 1978). Nutritional analysis (Fauzia Hafiz *et al*., 2003) showed that mushrooms are a more valuable source of protein than either cattle or fish on dry weight basis, and are good sources of almost all the essential amino acids when compared with most vegetables and fruits (Mattila *et al*., 2002).

The cultivation of mushrooms in Ghana is basically the Plastic Bag Method, with the use of decomposed sawdust from cereals (rice or millet) to produce *Pleurotus* species of mushrooms. It involves an initial composting of the substrate, bagging, sterilization, inoculation with mushroom spawn, incubation, cropping and harvesting of the fruiting bodies (Obodai *et al*., 2002). Nevertheless, fish waste has not been used as slow release nitrogen organic fertilizer for mushrooms or field plants.

The use of fish waste as slow release nitrogen organic fertilizer for mushroom production is novel in Ghana. The study therefore aims at reducing environmental pollution and odour by utilizing raw and cooked fish waste to produce edible and medicinal mushrooms from sawdust of *Tryplochyton scleroxylon* wood species; in addition, to disseminate technology and create jobs for the youth and reduce unemployment in fishing communities along the coastal regions of Ghana.

2. MATERIALS AND METHODS

Fish waste was obtained from Pioneer Food Cannery, a fish processing industry at Tema in Ghana, and conveyed to the Food Research Institute for analyses. The samples consisted of fresh fish waste (FFW) and cooked fish waste (CFW). A control treatment with rice bran (CRB) normally employed for mushroom cultivation was used. Sawdust from *Tryplochyton scleroxylon* wood species (*Wawa*) was used to compost three heaps respectively for FFW, CFW and CRB.

For composting the control heap (CRB), 300.0 kg fresh sawdust was mixed with 21.0 kg rice bran and 2.1 kg quicklime. Water was added to increase the moisture content to 65.0 percent from the initial value of 30 percent. The contents were thoroughly mixed several times before heaping. The heap was left to ferment for 30 days during which it was turned every 4 days. Temperature readings were monitored daily. The fish waste was ground in a mill and respective heaps prepared (FFW and CFW) and similarly treated as for the control.

The matured compost was bagged in heat-resistant transparent polyethylene sachets, with each containing 1.0 kg of compressed substrate. The open end of each bag was passed through PVC pipe of dimension 2.0 cm thick and 2.5 cm long, which served as a bottleneck into which cotton wool was inserted. A rubber band was used to tie the overlapping polyethylene over the pipe to hold it upright and securely in place. These bags were respectively labelled FFW (fresh fish waste), CFW (cooked fish waste) and CRB (control rice bran).

The compost bags were placed on wooden racks (49.0 cm long x 10.0 cm high) in a metal drum filled up to one-fifth its volume with water. The container was tightly sealed and the bags sterilized for 3 hours. The bags were then transferred to a sterile room to cool to room temperature.

The pH of the bags was measured with a pH meter (PHM 92). The moisture content was obtained by difference between the calculated percentage of fresh and dry weights of the sampled compost bags. Equal numbers of sterile bags from the different treatments were then aseptically inoculated with three different varieties of oyster mushroom spawns (*Pleurotus* species), namely *P. eous* (EM1), hybrid of *P. eous* (P21) and *P. oestreatus* (P34). The bags were subsequently incubated for 5 weeks under ambient temperature during which mycelial growth in each bag was measured at 3-day intervals. This was done by marking and measuring the length of the progression of mycelial growth at three different foci on each bag.

3. RESULTS AND DISCUSSIONS

Supplementation of substrate with fish waste for mushroom production was observed to cause a rise in the temperature during incubation of the bags at spawning. This was the result of the increase in the nutrient content (carbohydrates and nitrogen), such that resident bacteria and competitive moulds in the substrate increased in numbers to cause the high temperature. Lelley and Janben (1993) observed that a rise in temperature of between 40 and 60 °C might kill the mycelium in less than 24 hours. Although high temperatures were recorded in this study, the death of the mushroom mycelia was not observed. This might be because of the use of delayed release supplements (fish waste) providing nutrients that were released in stages and subsequently utilized for mushroom growth.

Figure 1 shows the temperature generated in the compost heaps prepared with fresh untreated (FFW) and cooked (CFW) fish waste as compared with the control heap of rice bran (CRB). High temperatures were generated in the compost heaps prepared with fish waste. This indicated that there might have been greater activity of fermenting micro-organisms that accelerated the composting process in FFW and CFW as compared with CRB. For the 30 days during which composting was carried out, the temperature ranges for FFW and CFW were between 38 and 52 °C and between 37 and 52 °C respectively (Table 1). For FFW, the maximum temperature occurred on the third day while for CFW it was on the eighth day of fermentation. This indicated that there was early rise in temperature in the compost prepared with fresh fish than in any of the other heaps. Thus decomposition of the substrates when fresh fish was incorporated was achieved faster for the release of nutrients than when cooked fish was used. For CRB, lower temperature range of 33–45 °C was obtained. During the 30-day period of composting, the heaps were turned seven times (Table 1).

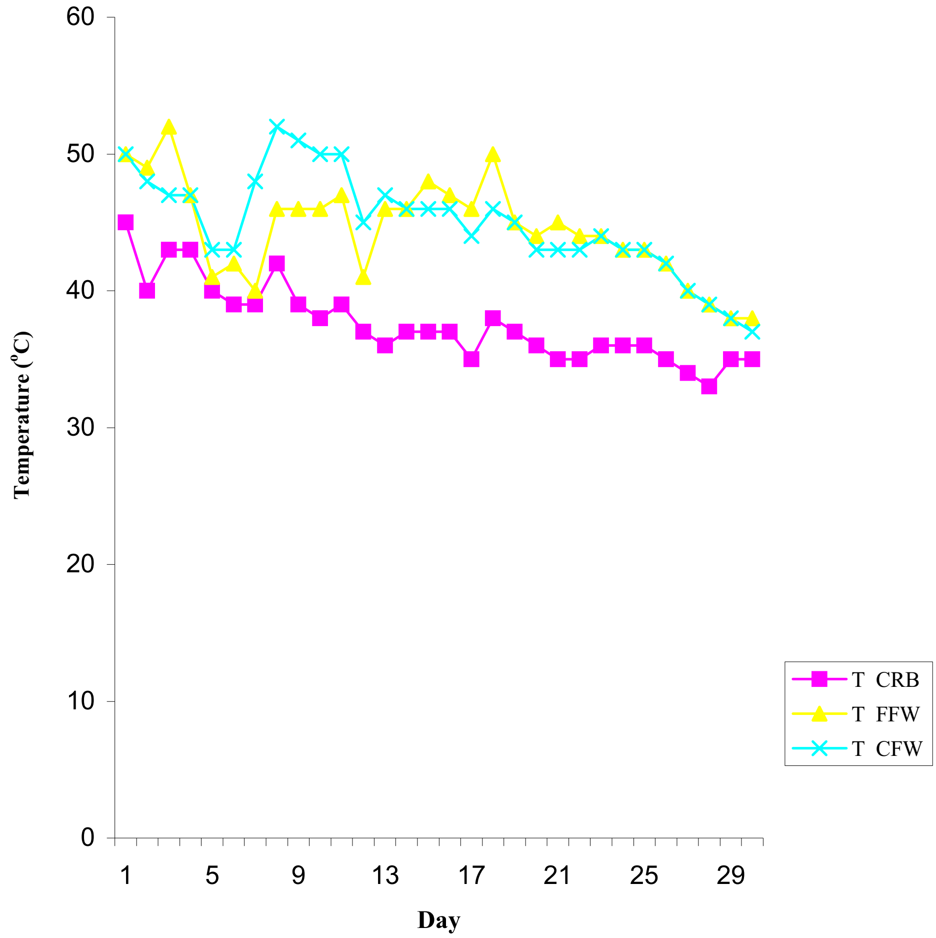

Figure 1: **Temperature of fermenting compost for mushroom growth**

T CRB: Temperature of compost with fish waste mixed with rice bran (control).
T FFW: Temperature of compost with fresh (untreated) fish waste.
T CFW: Temperature of compost with cooked fish waste.

Table 1. Temperature readings in compost heaps for mushroom cultivation

Day	Temperature (^{o}C)			Action
	CRB	FFW	CFW	
1	45	50	50	
2	40	49	48	
3	43	52	47	
4	43	47	47	1st turn
5	40	41	43	
6	39	42	43	
7	39	40	48	
8	42	46	52	2nd turn
9	39	46	51	
10	38	46	50	
11	39	47	50	
12	37	41	45	3rd turn
13	36	46	47	
14	37	46	46	
15	37	48	46	
16	37	47	46	4th turn
17	35	46	44	
18	38	50	46	
19	37	45	45	
20	36	44	43	5th turn
21	35	45	43	
22	35	44	43	
23	36	44	44	6th turn
24	36	43	43	
25	36	43	43	
26	35	42	42	
27	34	40	40	7th turn
28	33	39	39	
29	35	38	38	
30	35	38	37	

CRB: Temperature of compost with fish waste mixed with rice bran (control).
FFW: Temperature of compost with fresh (untreated) fish waste.
CFW: Temperature of compost with cooked fish waste.

Figures 2 and 3 are respectively the fresh and cooked fish waste used in the compost preparation for the cultivation of mushrooms. The preparation of the compost heap (Figure 4) was carried out as earlier indicated and turned (Figure 5) several times within the maturation period to ensure aeration.

Figure 2: Fresh fish waste

Figure 3: Cooked fish waste

Figure 4: Preparation of compost heap using fresh fish waste

Figure 5: Turning of the compost heap

The following figures show mycelial growth of *Pleurotus* species in compost bags of: rice bran/sawdust (Figure 6a), fresh fish waste/sawdust (Figure 6b), and cooked fish waste/sawdust mixture (Figure 6c).

Figure 6a: ***Pleurotus*** **species growing in rice bran/sawdust mixture**

Figure 6b: ***Pleurotus*** **species growing in fresh fish waste/sawdust mixture**

Figure 6c: ***Pleurotus*** **species growing in cooked fish waste/sawdust mixture**

Freshly prepared compost bags of cooked fish waste/sawdust, fresh fish waste/sawdust and rice bran/sawdust mixtures that have not been inoculated with mushroom spawn is shown in Figure 7a. Mycelia growth of *Pleurotus eous* colonizing fresh fish waste/sawdust, cooked fish waste/sawdust and rice bran/sawdust mixture is shown in Figure 7b.

Figure 7a: Compost bags of cooked fish waste/sawdust (left), fresh fish waste/sawdust (middle) and rice bran/ sawdustmixture (right) without mushroom spawn

Figure 7b: Mycelia of *Pleurotus eous* colonizing fresh fish waste/sawdust (left), cooked fish waste/sawdust (middle) and rice bran/sawdust mixture (right)

Figure 8 shows mycelial growth of *Pleurotus* species in compost bags of a mixture of rice bran and sawdust. *P. eous* (Figure 8a) and *P. oestreatus* (Figure 8c) exhibited a more uniform spread of mycelia in the compost bags than *P. eous* hybrid (Figure 8b). Generally *Pleurotus eous* hybrid showed a typical plateau from day 26 to 38 (Figure 8b) during which the nutrients may have been depleted. This indicated that maximum growth of this species would be achieved in the compost bags at day 26, during which full maturity would have been achieved. Between days 26 and 38, mycelial growth was observed to be static, indicated by the uniform horizontal area of the curve shown by all the compost bags investigated.

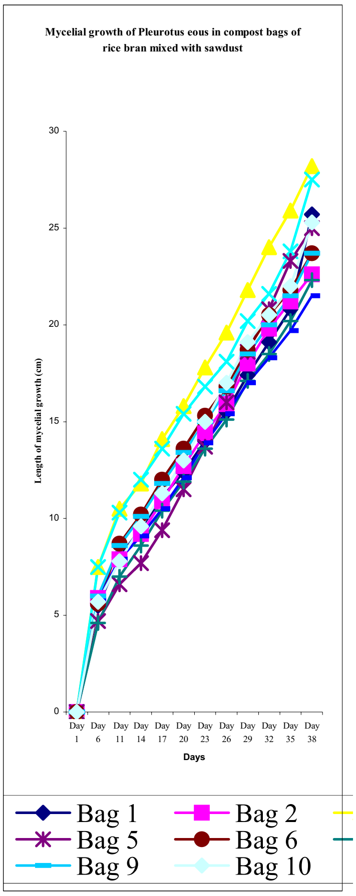

Figure 8a

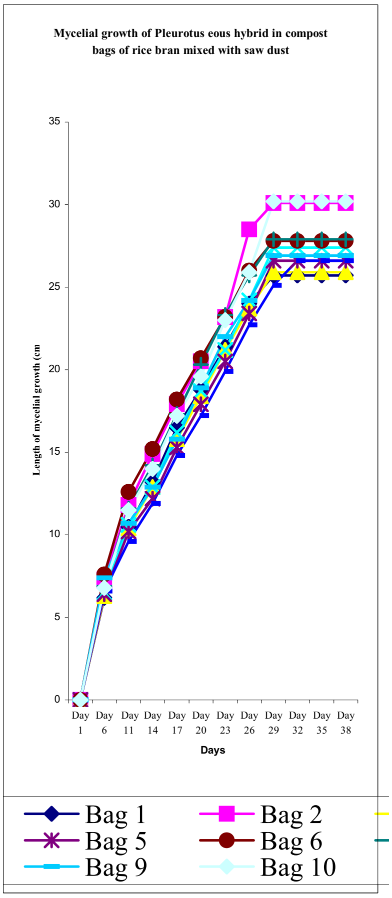

Figure 8b

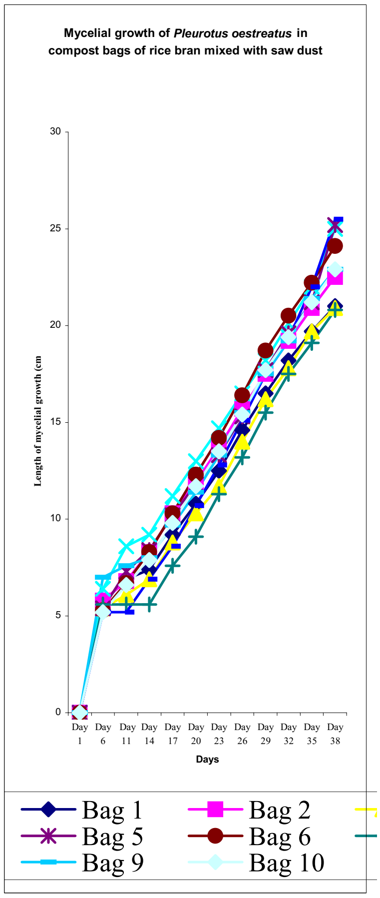

Figure 8c

Figure 8: Mycelial growth of *Pleurotus* species in compost bags of rice bran-sawdust mixture

Figure 9 shows mycelial growth of *Pleurotus* species in compost bags of fresh fish waste and sawdust mixture. Similar uniform growth pattern of the mycelia was observed in this substrate for both *P. eous* (Figure 9a) and *P. oestreatus* (Figure 9c). As earlier observed in compost bags of rice bran/sawdust mixture, the growth of *P. eous* hybrid (Figure 9b) in fresh fish waste/sawdust mixture showed stagnation in spread of the mycelial in the compost bags generally beginning at day 29 till day 38 (Figure 9b).

Figure 10 shows the mycelial growth of *Pleurotus* species in compost bags of cooked fish waste and sawdust mixture. Similar growth patterns were observed for *P. eous* (Figure 10a) and *P. oestreatus* (Figure 10c) using cooked fish waste/sawdust mixture. The growth of *P. eous* hybrid (Figure 10b) followed a similar pattern as observed for the other substrates used. Stagnation of the mycelia started at day 26 (Figure 10b).

Generally, comparative analysis of the growth of the three types of oyster mushroom showed that *P. eous* hybrid exhibited the fastest mycelial growth, completely colonizing the substrate during the period of growth. However, during the first week of colonization, substrates with rice bran/sawdust mixture showed earliest signs of mycelial growth.

Each species of mushroom investigated showed a peculiar pattern that was independent of the substrate in which it was grown. Thus it would be concluded that irrespective of the substrate used to grow the mushroom, the pattern of utilization and growth remained the same.

Figures 8a, 9a, and 10a showed that the growth of *Pleurotus eous* in three different substrates of ricebran/sawdust, fresh fish waste/sawdust and cooked fish waste/sawdust mixture exhibited a similar pattern. Likewise, that of *P. eous* hybrid (Figures 8b, 9b, 10b) and *P. oestreatus* (Figures 8c, 9c and 10c) in the aforementioned substrates

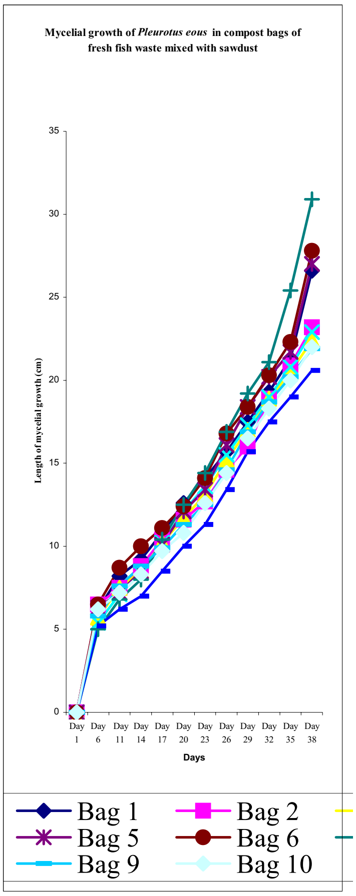

Figure 9a

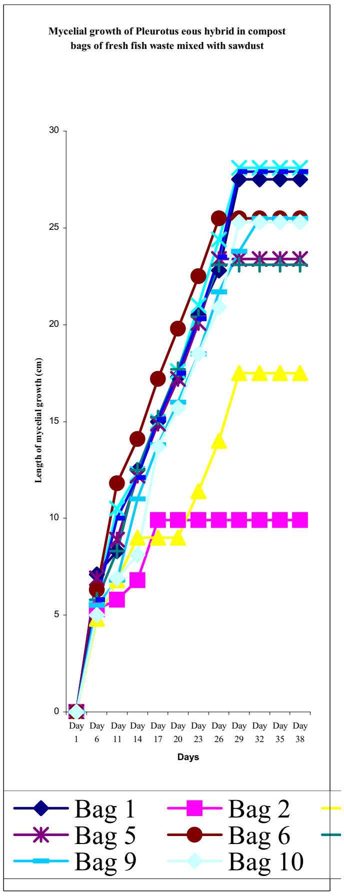

Figure 9b

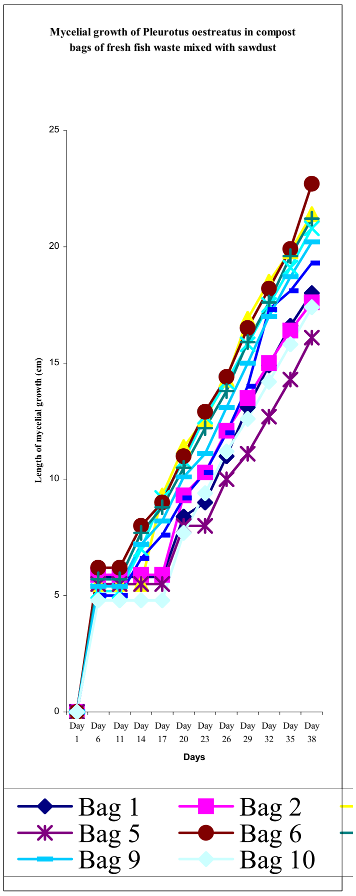

Figure 9c

Figure 9: Mycelial growth of *Pleurotus* species in compost bags of fresh fish waste-sawdust mixture

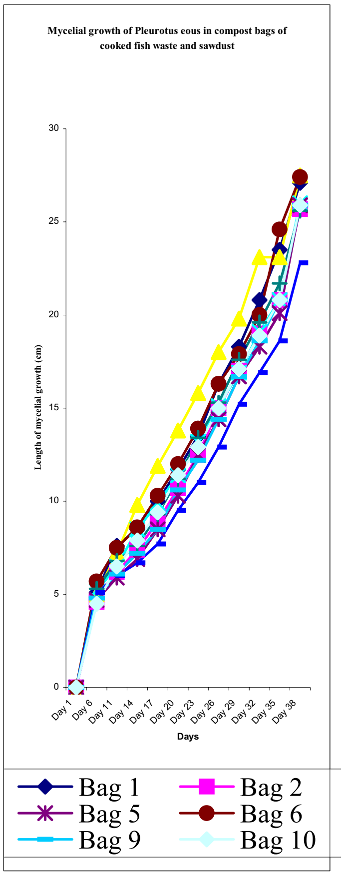

Figure 10a

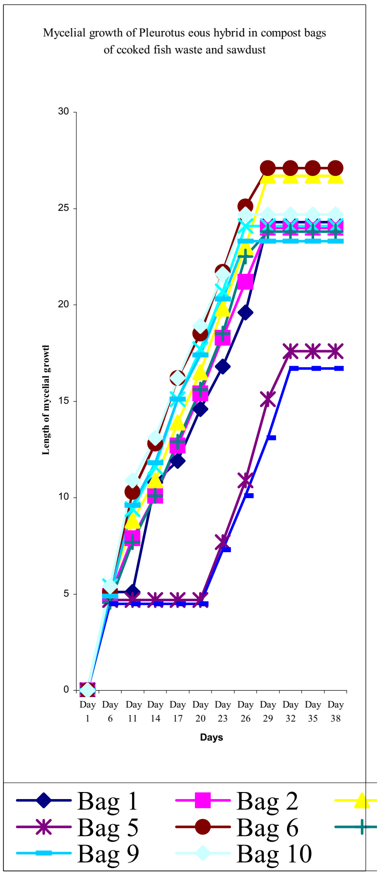

Figure 10b

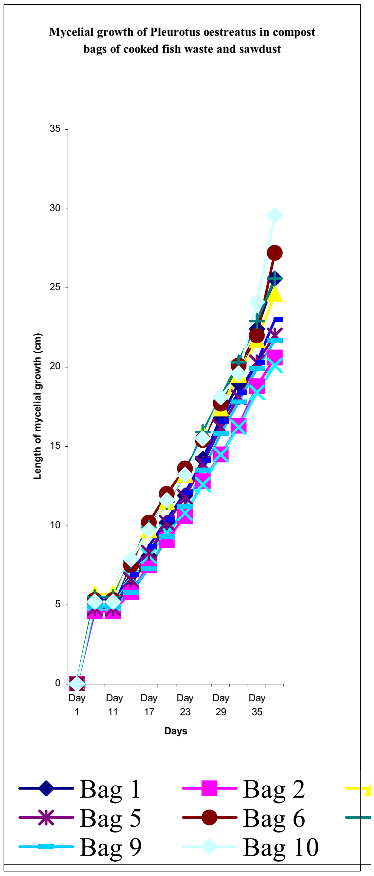

Figure 10c

Figure 10: Mycelial growth of *Pleurotus* species in compost bags of cooked fish waste-sawdust mixture

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IMPROVEMENT OF *Brycinus leuciscus* OIL EXTRACTION TECHNOLOGY

by

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Abstract

*Brycinus leuciscus (*or Tineni in local language), the Alestes genus of the family of the Characidae, is a highly fatty fish less utilized. Extraction of its oil for frying and for the preparation of the sauce constitutes the main mean of adding value to it. The traditional technology, however, gives a bad oil quality, of limited shelf-life. This project, whose general objective is to improve the oil quality of *Brycinus leuciscus*, tries to address these shortcomings.

Comparative trials of extraction techniques have been conducted on fresh and fermented products. From the analysis, average rate of fat resulted as being of 30 percent and average water content of 52 percent. Average yields of oil for the two extraction methods (fresh and fermented) are within the same ranges and vary from 18 to 22 percent, contrary to the opinions of fish processors who are convinced that fermentation gives higher yields than extraction from fresh product.

As for oil extracted from fermented fish, initial acidity is higher than 2 percent and chemical quality is rapidly degrading during storage, together with sensorial properties: colour has changed to yellowish brown, smell becomes nauseous and taste rancid in less than 6 months.

Initial rate has increased during conservation (2 years), but still remains low when compared with Codex standards. Organoleptic properties are better with a golden colour, good taste and smell. Results of this research are presently exploited by fish processors who have unanimously adopted the technique. More research is under way to:

- determine the chemical composition of the oil in fatty acids, mineral elements and other attributes that can be utilized in other areas than frying oil;
- study on packaging;
- elaborate quality standards for oils derived from *Brycinus leuciscus.*

Résumé

Brycinus leuciscus, (ou Tinéni en langue locale) genre Alestes de la famille des Characidae, est une espèce très grasse et peu utilisée. L'extraction de son huile pour la friture et la préparation de la sauce constitue le principal moyen de valorisation. Toutefois, la technologie traditionnelle donne une huile de mauvaise qualité et de conservabilité limitée. Le présent projet, dont l'objectif général est d'améliorer la qualité de l'huile de ***Brycinus leuciscus***, s'inscrit dans ce cadre.

Les essais comparatifs d'extraction ont été effectués sur l'espèce à l'état frais et à l'état fermenté. Il ressort de l'analyse des résultats que le taux moyen de matière grasse est de 30 pour cent et la teneur moyenne en eau 52 pour cent. Les rendements moyens d'huile pour les deux méthodes d'extraction (frais et fermenté) sont du même ordre de grandeur et varient entre 18 et 22 pour cent, contrairement aux suppositions des transformatrices de poisson, selon lesquelles, la fermentation donne un rendement en huile plus élevé que celui de l'extraction à l'état frais.

Pour l'huile extraite du poisson fermenté, l'acidité initiale est supérieure à 2 pour cent et la qualité chimique s'est dégradée rapidement au cours de la conservation, de même que les propriétés sensorielles: la couleur est devenue jaune brun, l'odeur nauséabonde et le goût rance en moins de 6 mois.

Le taux initial a augmenté au cours de la conservation (2 ans), mais demeure toujours inférieure à norme du Codex. Les propriétés organoleptiques sont meilleures avec une couleur toujours jaune or, un goût agréable et une bonne odeur. Les résultats de cette recherche sont actuellement exploités par les transformatrices de poisson qui ont unanimement adopté la technique. Les travaux sont en cours pour:

- la détermination de la composition chimique de l'huile en acides gras, en éléments minéraux et autres attributs utilisables dans des domaines outre l'huile de friture;
- l'étude sur les emballages;
- l'élaboration de normes de qualité pour l'huile de *Brycinus leuciscus.*

1. INTRODUCTION

De tous les poissons de la zone d'inondation du fleuve Niger, *Brycinus leuciscus* est l'espèce la plus abondante (Daget, 1952). C'est un characidae de petite taille, du genre Alestes (maximum 100 mm de longueur standard).

Son aire de répartition comprend les bassins de la Gambie, du Sénégal, du Niger et de la Bénoué. La pêche de l'espèce est très limitée et s'effectue de novembre à février. *Brycinus Leuciscus* a une courte durée de vie. Le nombre d'individus atteignant la deuxième année est relativement faible (Niaré, Benech, 1993).

Brycinus leuciscus fait l'objet de pêche spéciale avec des filets très spécifiques, de faible maille. Très grasse, l'huile extraite constitue la principale matière grasse utilisée dans les préparations culinaires des zones productrices. L'huile est très prisée dans le Delta Central du Niger et représente une spéculation importante pour les communautés de pêcheurs (Quensière, 1994).

La technique traditionnelle d'extraction à partir du poisson fermenté, le conditionnement dans des barriques métalliques et les mauvaises conditions de conservation influencent négativement la qualité de l'huile: une odeur caractéristique du fermenté, un goût de rancidité oxydante et une courte durée de conservation.

Pour lever ces contraintes, le projet de recherche intitulé « Amélioration de la technologie d'extraction d'huile de *Brycinus Leuciscus* a été exécuté de 1999 à 2001, sur demande des utilisateurs des résultats de recherche du Centre Régional de Recherche Agronomique de Mopti.

Des résultats de cette recherche, il ressort une bonne qualité chimique et organoleptique, avec la méthode améliorée d'extraction d'huile à partir du poisson frais; l'utilisation d'emballages en plastique pour le conditionnement ; la conservation à l'abri de l'air, de la lumière et de la chaleur.

Les principales recommandations ont été : la poursuite de l'étude par la détermination de la composition chimique et biochimique de l'huile, en vue d'une diversification de son utilisation; l'effet du mode d'extraction sur le rendement et la qualité et l'amélioration de la qualité de l'huile de *Brycinus Leuciscus.* C'est dans ce cadre que la présente recherche a été exécutée.

L'objectif général de cette recherche est d'améliorer la qualité de l'huile de *Brycinus leuciscus* pour une large consommation, une diversification de son utilisation pour une valorisation de cette espèce sous utilisée.

Les objectifs spécifiques assignés sont :

- déterminer le rendement en huile par les deux méthodes d'extraction;
- déterminer la qualité chimique et organoleptique de l'huile extraite à partir du poisson frais et du poisson fermenté ;
- déterminer la composition chimique en acides gras et autres propriétés de l'huile de *Brycinus leuciscus*.

2. MATÉRIEL ET MÉTHODES

2.1 Extraction d'huile dans le campement permanent de Mopti Hindé

Les travaux ont été réalisés dans le campement permanent de Mopti Hindé, situé à 3 Km en aval de Mopti sur le fleuve Niger, suivant un protocole de recherche sur les deux méthodes d'extraction : état frais et état fermenté 24 heures. Le poisson comme matière 1ère a été acheté auprès des pêcheurs dudit campement.

Les déterminations ont porté sur la matière grasse de l'espèce, la teneur en eau, le rendement d'huile, la qualité chimique initiale (acidité), les propriétés organoleptiques (flaveur : odeur et goût ; apparence : couleur) et l'évolution des caractéristiques chimiques au cours de la conservation.

Les activités de terrain se sont déroulées de décembre 2002 à février 2003 et de décembre 2003 à février 2004. L'extraction a été effectuée sur un échantillon de 5 kg de poisson frais et 5 kg de poisson fermenté.

Pour la fermentation, le poisson séjournait dans une marmite pendant 24 heures. Il était ensuite additionné d'eau. Pour l'extraction à l'état frais, le poisson était directement additionné d'eau.

Dans les deux cas, il était chauffé jusqu'à 70° – 80° C ; aspergé d'eau par moment, pour maintenir cette fourchette de température. A la fin de l'extraction, l'huile qui surnage est récupérée dans une autre marmite, évaporée, filtrée à l'aide d'un tamis nylon et pesée. Cinq extractions ont été effectuées sur le poisson frais et fermenté et cinq échantillons d'huile ont été obtenus par méthode d'extraction et par campagne.

Les différents échantillons d'huile ont été conditionnés dans des bidons en plastique et étiquetés.
Les bidons ont été ensuite conservés dans des cartons placés dans une armoire en bois, à la température ambiante.

2.2 Analyses physico-chimiques de *Brycinus leuciscus* et des échantillons d'huile

Elles ont porté sur la matière grasse et la teneur en eau de l'espèce, le rendement d'extraction à partir du poisson frais et du poisson fermenté, l'humidité et l'acidité initiale des échantillons d'huile.

L'évolution de l'acidité et des propriétés organoleptiques des échantillons d'huile en fonction de la durée de conservation, était déterminée tous les six mois. Les déterminations ont été effectuées suivant le protocole d'analyse des matières grasses de l'Union Internationale de Chimie.

2.2.1 Le rendement d'extraction : il a été déterminé à partir du poids initial du poisson utilisé.

2.2.2 La matière grasse a été déterminée par la méthode d'extraction avec l'hexane.

2.2.3 L'indice d'acide a été déterminé par titrage avec l'éthanol à 95 pour cent d'hydroxyde de potassium. La prise d'essais était de 2,5 g d'huile.

2.2.4 L'acidité a été déterminée à partir de l'indice d'acide. Elle est exprimée en pourcentage d'acide oléique et sa valeur représente la moitié de l'indice d'acide.

2.2.5 L'humidité a été déterminée par la méthode de dessiccation, dans une étuve à 105°C pendant 24 heures.

Les analyses ont été effectuées en trois répétitions et les résultats obtenus sont les moyennes.

Les données observées ont été analysées par la méthode de l'analyse de variances (SAS 12), incluant l'effet des facteurs rendement, méthode d'extraction, caractéristiques physico-chimiques.

2.3 Analyses sensorielles

Un jury de dégustation de dix personnes a été constitué pour apprécier les caractéristiques sensorielles de l'huile: couleur, odeur et goût. L'échelle de notation était la suivante:

Pour la couleur
Jaune clair = 5
Jaune or = 4
Brun = 3
Sombre = 2

Pour le goût et l'odeur :
Très bon = 5
Bon = 4
Passable = 3
Mauvais = 2

3. RÉSULTATS OBTENUS

3.1 Matière grasse et teneur en eau de *Brycinus leuciscus*

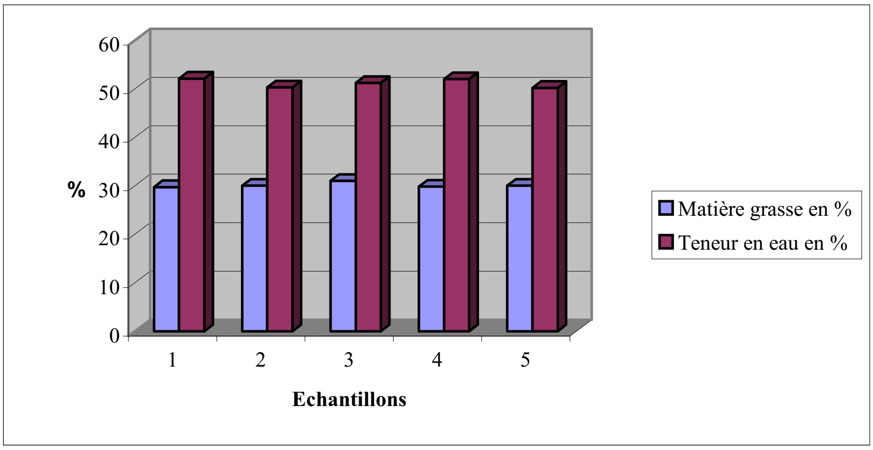

Figure 1 : Matière grasse et teneur en eau de *Brycinus leuciscus*

La matière grasse moyenne de *Brycinus leuciscus* est de l'ordre de 30 pour cent et la teneur moyenne en eau 52 pour cent.

3.2 Caractéristiques physico-chimiques de l'huile de *Brycinus leuciscus*

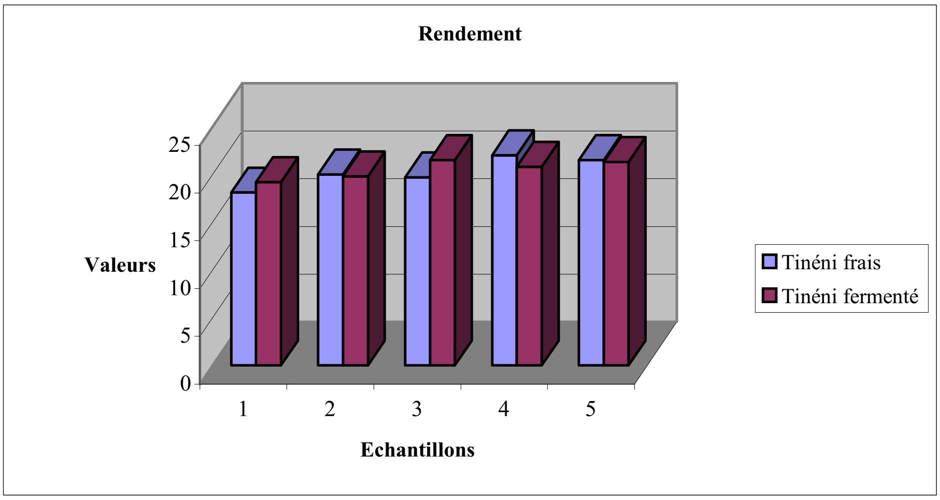

Figure 2: Rendement d'extraction de l'huile

Le rendement moyen d'extraction pour les deux méthodes varie de 18 à 22 pour cent.

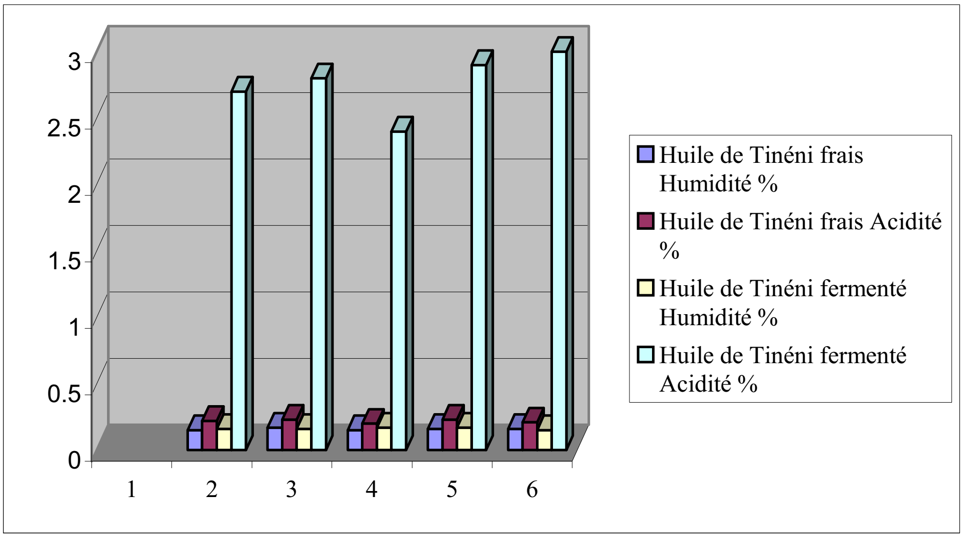

Figure 3 : Humidité et acidité initiale des échantillons d'huile de *Brycinus leuciscus*

L'acidité initiale est inférieure à 1 pour cent, pour tous les échantillons d'huile de *Brycinus leuciscus* frais et supérieure à 2 pour cent; pour l'huile de *Brycinus leuciscus* fermenté. L'humidité pour les deux types d'huile est inférieure à 1 pour cent.

3.3 Evolution de la qualité au cours de la conservation

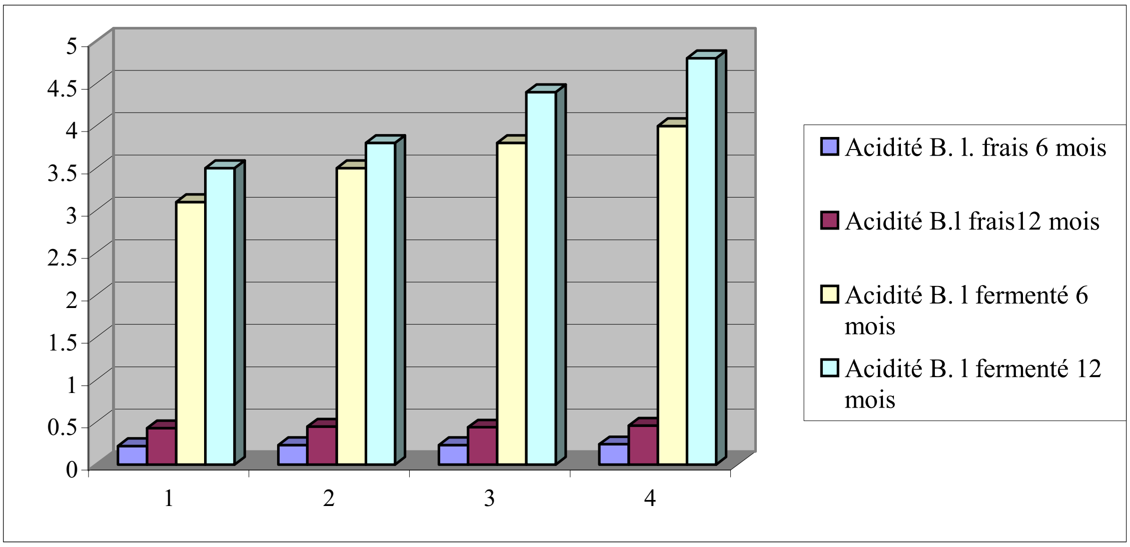

Figure 4 : Acidité au cours de la conservation

L'acidité pour tous les échantillons d'huile de *Brycinus leuciscus* frais reste inférieure à 1 pour cent.

Elle varie de 3 à 4 pour cent pour l'huile de *Brycinus leuciscus* fermenté conservée 6 mois et de 3,7 à 4,7 pour cent pour 12 mois.

3.4 Caractéristiques organoleptiques de l'huile de *Brycinus leuciscus*

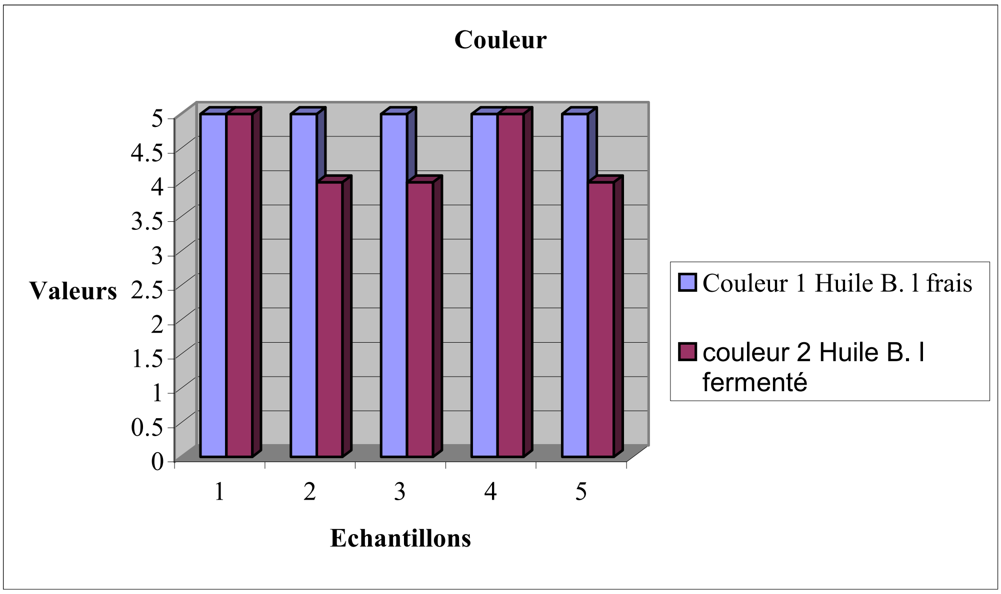

Figure 5 : Couleur des échantillons d'huile

La couleur pour l'huile de *Brycinus leuciscus* frais a été très bien appréciée. L'huile de *Brycinus leuciscus* fermenté a été notée en moyenne « Bon ».

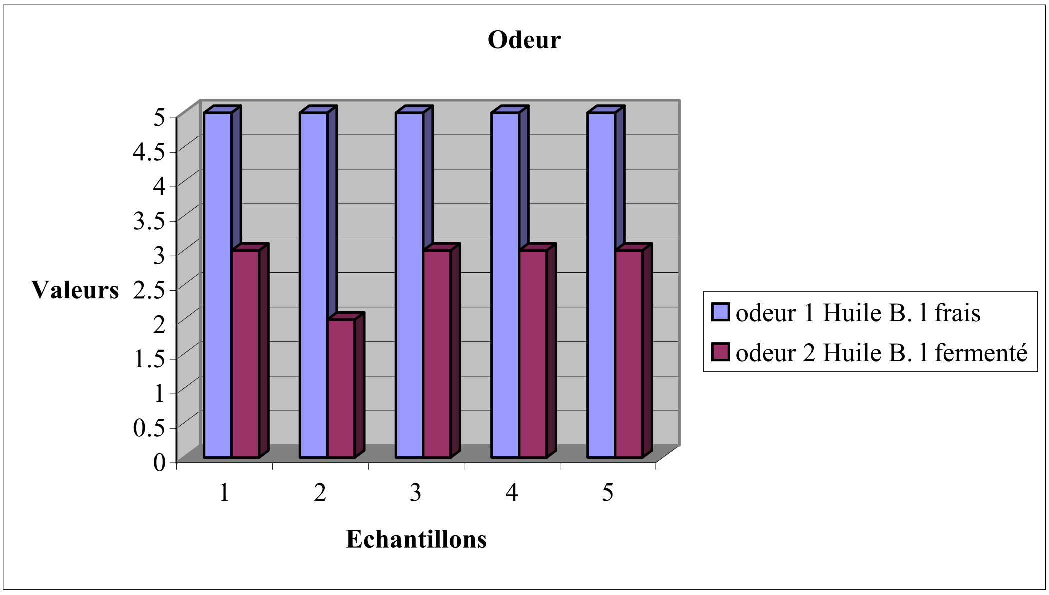

Figure 6 : Odeur des échantillons d'huile

L'odeur pour l'huile de *Brycinus leuciscus* frais a été très bien appréciée.

L'odeur de l'huile de *Brycinus leuciscus* fermenté est passable.

Le goût pour l'huile de *Brycinus leuciscus* frais a été noté très bon et celui du fermenté passable.

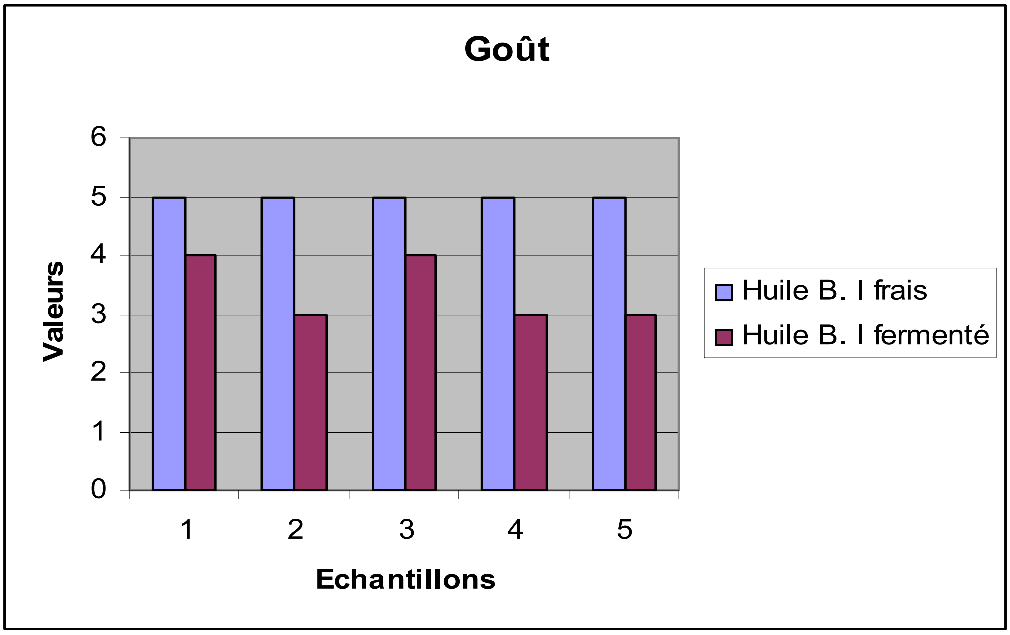

Figure 7 : Goût des échantillons d'huile

4. DISCUSSION

La teneur en matière grasse de *Brycinus leuciscus* est supérieure à celle des poissons gras. La matière grasse du poisson dépend non seulement de l'espèce, mais aussi de sa taille, son habitat et de son cycle sexuel (Bal, 1980). Pour certaines espèces, le taux fluctue de 3 – 4 jusqu'à 14 -16 pour cent. Chez la majorité des poissons d'eau douce, il n'est que de 5 à 8 pour cent. Ainsi, les espèces sont classés en quatre catégories, suivant le taux de matière grasse : les poissons maigres, de moins de 3 pour cent ; moyennement gras, avec des taux supérieurs à 3 mais inférieurs à 8 pour cent et les poissons gras, de plus de 8 pour cent. Les espèces dont la matière grasse peut atteindre 27 et même 35 pour cent sont classées dans la catégorie exceptionnelle, extra-gras. *Brycinus leuciscus*, avec un taux moyen de matière grasse de 30 pour cent, rentre dans cette dernière catégorie.

Les rendements d'huile par les deux méthodes d'extraction sont du même grandeur et varient de 18 à 22 pour cent. En effet, il n'y a pas de différences significatives, contrairement aux offirmations des transformatrices de Mopti Hindé, selon lesquelles, la fermentation donne un rendement en huile plus élevé que celui de l'extraction à l'état frais. La fermentation facilite la libération de la graisse, mais provoque une hydrolyse des triglycérides et une accumulation d'acides gras insaturés. Directement proportionnelle à la température, elle favorise l'oxydation des acides gras insaturés et la production de peroxyde ; ce qui influence négativement la qualité de l'huile et n'augmente guère le taux d'huile contenu dans le poisson.

Les taux initiaux d'acidité des échantillons d'huile de *Brycinus leuciscus* frais sont inférieurs à 1 pour cent. La qualité de l'huile est jugée meilleure, selon la norme du Codex Alimentarius (2 pour cent). Les taux initiaux d'acidité ont augmenté au cours de la conservation pendant un an, mais demeurent toujours inférieures à 1 pour cent.

Les taux initiaux d'acidité sont supérieurs à 3 pour cent pour *Brycinus leuciscus* fermenté. La qualité de l'huile s'est dégradée rapidement au cours de la conservation, à cause du taux élevé d'acides gras libres, provoqué par la fermentation : L'huile est trouble, la couleur est devenue jaune brun et l'odeur nauséabonde.

Les résultats obtenus permettent de constater une différence significative entre l'odeur et le goût des échantillons d'huile de *Brycinus leuciscus* frais et fermenté.

La qualité d'un produit alimentaire est une notion subjective, puisque le principal instrument d'évaluation est le consommateur (Cheftel, 1990). Les caractéristiques principales impliquées dans le terme « qualité » pour le cas de l'huile de *Brycinus leuciscus* sont :

1. les propriétés organoleptiques :

- l'apparence : la couleur qui relève de la vision;
- la flaveur : l'arôme et la saveur, qui relèvent de l'odorat et du goût;

2. la salubrité : c'est à dire l'absence d'action toxique, de microorganismes pathogènes.
3. la valeur nutritionnelle : la composition en termes de teneur en calories, acides gras indispensables, vitamine, sels minéraux et oligo-éléments.
4. la stabilité : l'aptitude de l'huile à ne pas s'altérer rapidement.

La qualité de l'huile est donc influencée par la valeur intrinsèque de *Brycinus leuciscus*, les diverses réactions favorables ou défavorables qui ont lieu après la capture; les effets des traitements technologiques (fermentation, chauffage); les conditions et la durée de l'entreposage. Tenant compte de ces informations, l'huile de *Brycinus leuciscus* fermenté n'est pas stable dans la mesure où elle s'est vite oxydée. C'est pourquoi, l'appréciation a été négative surtout pour les critères odeur et goût; acceptable pour la couleur.

La couleur a été bien appréciée pour l'huile de *Brycinus* frais. La couleur joue un rôle important dans l'évaluation de la qualité d'un aliment. En effet, elle est souvent liée à la maturité, la présence d'impuretés, la mise en œuvre appropriée ou défectueuse d'un traitement technologique, de mauvaises conditions d'entreposage, un début de détérioration par les microorganismes.

Le principal problème posé par l'oxydation des lipides réside dans la formation de composés volatils d'odeur désagréable. Ce qui peut limiter la durée de conservation (Cheftel, 1990). L'oxydation des acides gras insaturés dans l'huile entraîne en outre, des pertes de couleur et provoque une diminution de la valeur nutritionnelle. La présence de lipides oxydés peut entraîner l'oxydation secondaire de divers arômes (Cheftel, 1990). Dans l'oxydation des lipides, on distingue trois groupes de réactions:

a) les réactions d'initiation qui donnent lieu à la formation de radicaux libres à partir d'acides gras insaturés ou de peroxydes lipidiques (hydroperoxydes). Ces réactions peuvent être facilitées par les températures élevées et surtout par la lumière et les traces de certains métaux.
b) Les réactions de propagation qui se caractérisent par une accumulation de peroxydes lipidiques. Ces réactions constituent l'étape d'oxydation par l'oxygène gazeux des acides gras insaturés. Elles nécessitent l'intervention de radicaux libres, mais en créent autant qu'elles en consomment.
c) Les réactions d'arrêt, par lesquelles des radicaux libres s'associent pour donner des composés non radicalaires. Ces radicaux libres proviennent en grande partie de la décomposition des peroxydes lipidiques, substances très instables et réactives.

Parmi les composés non radicalaires qui se forment, ce sont les aldéhydes et les cétones de faible poids moléculaire qui sont responsables de l'odeur de rance. Certains de ces composés proviennent directement de la décomposition des peroxydes.

La vitesse d'oxydation est proportionnelle à la teneur en peroxydes. Les lipases peuvent également accélérer l'oxydation des graisses dans la mesure où les acides gras libres sont plus susceptibles d'oxydation que les triglycérides. L'oxydation des graisses est en outre accélérée par la lumière qui catalyse les réactions d'initiation et les métaux.

L'analyse des résultats confirme l'idée selon laquelle, l'oxydation des lipides entraîne la dégradation de la qualité chimique et des propriétés organoleptiques (Cheftel, 1990).

5. CONCLUSION

La matière grasse de *Brycinus leuciscus* très élevée, classe cette espèce dans la catégorie des poisson extra gras.

Il ressort de l'analyse de variances, qu'il n'y a pas de différence significative entre les rendements en l'huile obtenue par les deux méthodes d'extraction.

L'huile extraite de *Brycinus leuciscus* frais est de meilleure qualité et répond à la norme du Codex Alimentarius.

Conditionnée dans un emballage en plastique et hermétiquement fermé, l'huile de *Brycinus leuciscus* se conserve mieux à l'abri de la lumière et de l'air.

Les caractéristiques organoleptiques de l'huile extraite de *Brycinus leuciscus* frais sont satisfaisantes, avec une couleur jaune or et une bonne odeur.

Les résultats préliminaires de cette recherche sont applicables, si les conditions suivantes sont respectées:

- l'extraction de l'huile à partir de *Brycinus leuciscus* frais ;
- l'utilisation d'emballage plastique pour le conditionnement ;
- la conservation à l'abri de l'air, de la lumière et de la chaleur.

9. PERSPECTIVES

- les activités seront poursuivies pour la détermination de l'indice de peroxyde, l'indice de saponification, la composition en acides gras, en vitamines et en éléments minéraux. Les différents échantillons d'huile en conservation seront analysés avec le HPLC et le CPG couplé au niveau du Laboratoire de Nutrition Animale de Sotuba;
- l'étude en cours sur les emballages sera poursuivie;
- I'élaboration de normes de qualité pour l'huile de *Brycinus leuciscus*;
- l'élaboration d'un article scientifique sur l'huile de *Brycinus leuciscus*.

En vue d'une éventuelle utilisation à grande échelle, un inventaire du stock ichtyologique de l'espèce doit être conduit. Un projet sera élaboré et soumis pour financement (à rechercher).

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LOW-COST PROCESSING TECHNOLOGIES FOR MUKENE

(*Rastrineobola argentea*)

by

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Abstract

Low-cost fish processing technologies for Mukene (*Rastrineobola argentea*) were disseminated to a group of 15–20 vulnerable members of the fishing communities at Kisuku landing site along the shores of Lake Victoria in Masaka District, Uganda. The technologies included smoking, salting, fermentation, deep-frying, milling for both human consumption and animal feed, and improved sun-drying. The endeavour had two principle objectives, namely, create awareness about low-cost processing technologies and link processors with the market.

Generally, fishers were receptive to the ostensibly new technologies. Most of the products processed were readily acceptable to consumers locally and regionally. The time taken to process them was either less or equal to the time normally used by fishers. For example, the smoking process took 30 minutes to 1 hour depending on the quantity of fish per tray. Sun-drying Mukene, using old mosquito nets overlaid on wooden racks, took only 5 hours on average and it was faster than drying on either turplin or polythene sheeting that took 8 hours on a hot day. Salting, as expected, facilitated the drying process and enhanced the fermentation process. Deep-frying took only 15 minutes to achieve the desired golden colouration of the product. It was also observed that exposure of fish to salt and heat (solar) created a hostile environment for *Ligula intestinalis* a common parasite in Lake Victoria Mukene, which was observed crawling out after 15–30 minutes of exposure.

Preference for products varied across the board. The deep-fried product was more preferred than the fermented type. Consumers were willing to pay a premium price for high quality product regardless of the processing method. The commercial viability varied with processing technology. Whereas it was possible to break-even after five times of processing using such methods as improved sun-drying, salting, deep-frying, smoking and milling for human consumption, it was not possible to make a profit on animal feed while processing at artisanal level. In conclusion, commercialization of some Mukene products at cottage level would improve the livelihoods of vulnerable members of fishing communities through increased incomes. The use of low-cost processing technologies can reduce post-harvest losses drastically, widen processing options and offer a wide range of products from Mukene. However, there would be need for start-up capital for the majority of fishers who would venture into such enterprises.

Résumé

Des technologies de transformation du poisson à faible coût pour Mukene (*Rastrineobola argentea*) ont été disséminées à un groupe de 15–20 membres vulnérables des communautés de pêche du site de débarquement de Kisuku, au bord du Lac Victoria dans le District de Masaka-Uganda. Les technologies comprenaient le fumage, le salage, la fermentation, la friture, le broyage, pour la consommation humaine et animale ainsi que l'amélioration de la technique de séchage solaire. L'effort avait deux objectifs principaux à savoir, d'une part à sensibiliser sur les technologies de transformation à coût limité et d'autre part à mettre en contact les opérateurs avec le marché.

En général, les pêcheurs étaient réceptifs à l'acquisition de technologies apparemment nouvelles. La majorité des produits transformés sont aisément acceptés par les consommateurs locaux et régionaux. La durée de transformation était inférieure si non égale à celle normale des pêcheurs. Par exemple, le processus de fumage prend de 30 minutes à 1 heure, selon la quantité de poisson par claie. Le séchage de Mukene au soleil avec l'emploi d'un moustiquaire usagé placé sur des plateformes en bois surélevées prend seulement cinq heures en moyenne et se révèle plus rapide que le séchage sur bâche en terpauline ou sur des feuilles de polythène, qui demande huit heures en journée chaude. Le salage, comme prévu, facilite le séchage et stimule le processus de fermentation. La friture prend seulement 15 minutes pour atteindre la coloration dorée désirée du produit. Il a aussi été observé que l'exposition du poisson au sel et à la chaleur (solaire) a crée un environnement hostile pour *Ligula intestinalis,* un parasite très courant du Mukene du Lac Victoria, qui rampe hors du produit en 15–30 minutes d'exposition, selon les observations.

La préférence des différents produits est variable. Le produit frit est préféré par rapport au type fermenté. Les consommateurs étaient désireux de payer un prix plus élevé pour un produit de qualité supérieure, quelque soit la méthode de transformation. La viabilité commerciale varie avec la technologie de transformation. Alors qu'il est possible d'atteindre des bénéfices financiers après cinq transformations avec des méthodes telles que le séchage, le salage, le friture, le fumage et le broyage pour la consumation humaine, il n'est par contre pas possible d'atteindre des bénéfices avec la nourriture pour animaux avec la transformation artisanale. En conclusion, la commercialisation de certains produits à base de Mukene au niveau artisanal, pourrait améliorer le niveau de vie des couches vulnérables des communautés de pêcheurs grâce à l'augmentation de leurs revenus. L'emploi de technologies de transformation à faible coût peut réduire considérablement les pertes après capture, avec augmentation d'une multitude d'options de transformation, et un choix plus vaste de produits à base de Mukene. Toutefois il y aurait un besoin pour la majorité de ces pêcheurs, d'avoir accès à un capital initial pour pouvoir se lancer dans ce type d'entreprise.

1. INTRODUCTION

Mukene (*Rastrineobola argentea*) is a silvery sardine-like fish with an average length of 5 cm and average weight of 15 g. It contributed 41 percent of the total Lake Victoria fish catch estimated at 175 435 tonnes in 2000 (DFR, 2002) and the main stay for the domestic as well as regional markets. Traditionally Mukene is preserved by sun-drying on various surfaces including rocks, tiny stones spread on the ground, turplin sheets, bare ground and rarely on raised drying racks. Several reasons have been advanced for the choice of the preservation method. Abila and Jansen (1997) reckoned that its low value did not warrant large inputs while Namisi (2000) attributed it to its bony structure, size and available large quantities in Lake Victoria. Sun-drying method is weather dependent, and as such, during the rainy season most of the fish drying on bare ground or rock surfaces is either washed away or rots while on drying surface for lack of storage space. The Department of Fisheries Resources (DFR) estimated that 80 percent of all Mukene caught was processed for animal feed production and only 20 percent was fit for human consumption (DFR, 2002). The substantial losses that occur as a result of adverse weather condition have been estimated as varying between 50 and 90 percent according to various stakeholders in the sector (Dhatemwa and Masette, 2002). The losses that may be in terms of quality and quantity seem to occur along the whole supply chain from fishing ground to the market place (Masette, 2002).

Although sun-drying in the Mukene fishery is common, the handling method employed and the choice of the drying surface is usually determined by the type and requirements of the market. In Kampala, high quality Mukene dried off the ground is normally sold at a higher price than that dried on bare ground because the latter is usually contaminated with sand and other extraneous matter. Invariably, this latter lot is normally intended for animal feed production.

Smoking is an old form of food preservation method (Aitken *et al.,* 1982; Storey, 1982) with anti-oxidant properties (Masette, 1990) that imparts flavour to the product (Potter and Hotchkiss, 1995). There are two common types of smoking, namely; hot and cold. However, liquid smoke can also be used for flavour impartation in such products as bacon *Ibid*. Whereas cold smoking is common in developed countries as a cosmetic flavour enhancer, hot smoking is used both as a preservative and flavour enhancer method in developing countries. In Uganda and indeed the whole East Africa region, hot smoking is the commonest type, and it has been limited to large-sized fish, such as Nile perch *Lates niloticus* and *Bagrus* species. In West Africa, however, *Sardinella* species similar to Mukene in size and structure is smoked (Stroud, 1986). About three decades ago, FAO in collaboration with Ghana Food Research Institute promoted smoking of a sardine-like fish species using a chorkor kiln (UNCEF, 1984).

Fish fermentation has been the preserve of Southeast Asia (Clucas and Ward, 1996) where all kinds of species are fermented into sauces and pastes. However, around the Mediterranean, anchovies *Engraulis encrasicolus*, with the same size as Mukene, are also fermented. In 2001 while attending the Experts Consultative Workshop on Fish Technology in Africa that was held at Saly Mbour, Senegal, the author visited a place where trash fish was fermented to produce a sauce condiment. In Brazil, fermentation has been promoted as a way of preserving small pelagic species of fish, which has resulted in a stable product under ambient tropical temperatures (Clucas and Ward, 1996).

Milling of fish into flour has been the commonest technology for animal feed production using a hammer mill. However, Ssali (1985) hydrolysed Mukene into fine white powder using a freezer drier, which has not been adopted for commercialization because of lack of interest among potential entrepreneurs. In 1985, FAO organized a workshop in Mwanza, Tanzania, which the author attended, and Mukene was processed into flour fit for human consumption using an inexpensive mortal and pestle.
Deep-frying in Uganda is common in the Nile perch and Nile tilapia *Oreochromis niloticus* fishery where whole fish or chunks are deep-fried in Nile perch fat and presented as ready-to-eat product. Vegetable oil is rarely used because of the expense involved.

Apart from testing the viability of the smoking, frying and fermentation technologies in the Mukene fishery, the present study also conducted a cost-benefit analysis to find out whether adoption of technologies would financially benefit and ultimately improve the livelihoods of vulnerable fisher communities. In addition, it would also revert the current utilization trend such that 80 percent or more of Mukene processed benefits human consumers and only 20 percent or less goes for animal feed production.

Principal study objectives:

- Create awareness about low-cost processing technologies.
- Link Mukene processors with the market outlets.

Specific objectives:

- Improve artisanal processing technologies.
- Improve Mukene product quality.
- Develop value-added products from Mukene.
- Test the market for Mukene products.
- Carry out a basic cost-benefit analysis.
- Develop a training manual for frontline extension staff and processors

2. MATERIALS AND METHODS

The study was conducted at Kisuku landing site in Masaka District, Uganda. It involved 10–15 women involved in processing of Mukene for animal feed. Materials and methods varied with the processing technology.

3. RESULTS AND DISCUSSION

Generally, the fishers enthusiastically received all the technologies that were introduced to them. It was observed that one basin of raw material resulted into two basins of dried product. Apparently, in the Mukene fishery, measurement is done by volume and not by weight. It was observed that exposure of fish to salt and/or heat (solar) created a hostile environment for *Ligula intestinalis* a common parasite in Lake Victoria Mukene (FIRRI, 2002). It was observed that the parasite crawled out of the fish after 15–30 minutes of exposure. It was also observed that birds and chickens pecked out the dried parasite from the product on drying surfaces. As such, the final Mukene product exposed to salt or heat was technically free from parasitic contamination.

Table 1: Materials and methods used in the study

Processing technology	Materials required	Methodology
Smoking	Smoking trays, mud bricks, fish, smoke spreader, salt, vegetable oil, and packaging materials	A "Chorkor" kiln measuring 150 cm length, 70 cm width and 100 cm height, was constructed at 100 m mark from the shoreline. Four trays made from 10 mm wire mesh held together with a wooden frame were constructed to fit closely onto the kiln. Mukene, weighing 20 kg per shift per tray, was washed, dry salted using 1:20 ratio for 15 minutes, drip-dried for 1 hour on trays and finally loaded on trays for the smoking processing. The fuel wood was weighed before the commencement of the process. Low temperatures not exceeding 50 ^{o}C were maintained for 30 minutes to impart the smoky flavour then elevated to 80 ^{o}C for 1 hour. The smoked product was allowed to cool before packaging in 500 g poly bags.
Salting	Mukene, salt, potable water, salting vats or buckets, construction materials for drying racks (poles, nails), old mosquito nets	Raised drying racks measuring 3 m length x 2 m width x 1m height and made from locally available wooden poles were constructed a few metres from the shoreline. The racks were constructed and designed to slant at 45^{o} angle. Both sides of the rack were overlaid with old mosquito nets. Mukene weighing 40 kg was washed, dry salted using 1:20 ratio for 30 minutes and spread on both sides of the drying rack. Temperatures and the relative humidity were monitored throughout the drying process. Dried products were packed in gunny bags.
Sun drying	Same as above without salt	Same as above accept that the Mukene was not salted.
Deep frying	Drip-drying tray, fish, charcoal stove, charcoal washing salting vat, frying pan ladle, vegetable oil, salt, spices, sealer, muslin cloth and packaging material	Mukene weighing 20 kg was washed, dry salted using 1:20 ratio for 15 minutes, drip-dried for 1 hour on trays. While the Mukene was drip-drying a charcoal stove was lit and oil poured on frying pan to heat. When the oil was hot enough, 2 kg of semi-dried Mukene was gently lowered into the hot oil. The Mukene was turned gently until the colour changed to golden brown, then scooped out of the hot oil, drained and cooled. The remaining lot was similarly treated and finally packed in 250 g sachets.
Fermentation	Pot or bucket, salt, fish, polybag and packaging materials	Mukene weighing 40 kg was washed, dry salted using 1:20 ratio. Then the Mukene was emptied into a polybag, fastened by a single knot and put in an air-tight container (pot or bucket). After 5 days, the Mukene was taken out and sun-dried for 6 hours or 12 hours, depending on the weather conditions. Fermented products were packed in gunny bags for storage and marketing.
Milling for human consumption	Fish, mortar and pestle, muslin cloth, drying rack, carbohydrate or groundnut flour and packaging materials	A portion of the smoked Mukene was milled using a mortar and pestle then the flour was mixed with pounded groundnuts for smoky flavour enhancement. A second portion (20 kg) was cooked for 15 minutes, excess water squeezed out and the solids sun dried for 4–8 hours, depending on the weather. Dried Mukene was pounded into flour using a mortar and pestle. Then it was sieved before mixing with other flour items, such as maize, millet, beans and cassava for human consumption. The mixing ratio depended on type of complementary flour and consumer acceptability. Products were packed in 250 g packs.
Milling for animal feed	Fish, mortar and pestle, muslin cloth, drying rack	Using available cooking utensil, 20 kg of Mukene was cooked for 15 minutes, excess water squeezed out and the solids sun dried for 4–8 hours, depending on the weather. Dried Mukene was pounded into flour using a mortar and pestle. Then it was sieved before mixing with maize bran or rice husks. Products were packed in 500 g packs.

Table 2. Duration and weight losses for each processing technology

Type of technology	Processing time (Hrs)	Quantities processed per shift (Kg)	Percentage weight loss	*Remarks*
Smoking	3	80	50	Process steps included washing, brining, smoking and cooling
Salting	5	80	65	The drying rack had a capacity of 200 kg and it was a hot day
Sun-drying	7	80	66	Same as above
Deep-frying	2	2	40	Process steps included drip-drying, frying and cooling
Fermentation	4	20	50	Process time refers to drying time only. The quantities processed was determined by capacity of container
Milling for human consumption • Boiling method • Smoked	 6 4	 20 20	 60 50	The percentage weight loss refers to milled dry product
Milling for animal feed using the boiling method.	6	20	50	The quality of raw material was not as high as for the above products

Smoking in the Mukene fishery was readily accepted in spite of the relatively high cost of initial inputs (Table 3) considering that most Ugandans live on less than US$1 per day (UBOS, 2003). The actual smoking process took only 30 minutes to 1 hour depending on the quantities of fish per tray. This was in stark contrast to the smoking of large-sized fish, such as Tilapia, Nile perch and a host of other fish species in Uganda where it takes a minimum of 2 days to achieve the same results (Masette, 1990). In totality, all the process steps from washing to cooling took only 3 hours (Table 2), an indication that a processor can have a quick turnover. The market survey indicated that probably it might take a bit of time before consumers acquire the taste for smoked Mukene product. However, traders predicted that it would sell at UGX 5 000/= equivalent to US$2.50 per basin (basinful of product weighs about 5 kg). From experience, it was economically more viable to sell on retail basis in 100 g or 250 g containers than wholesale in gunny bags. Because smoking was introduced as an alternative method to traditional sun-drying during adverse weather conditions (rainy season), the expected selling price of UGX 5 000/= equivalent to US$2.50 was better than total loss. As demonstrated in Table 3, a processor could make a profit of UGX 93 300/= or US$47 after only four times of repeating the process. It may appear meagre, but it can make a difference in the livelihood of a processor at a typical landing site originally living on less than a dollar.

Sun-drying and salting technologies were familiar but the use of old mosquito fishing nets overlaid on raised racks was a new approach and the womenfolk appreciated it. As expected, salted fish dried much faster than unsalted fish. According to (Clucas and Ward, 1996) salting enhances water removal by the osmotic pressure, hence the fast drying rate. By using these relatively cheap old nets, the drying time was reduced from 8 hours, when the drying surface was on either turplin or polythene sheeting, to 4–6 hours on raised racks overlaid with nets depending on solar heat intensity. The market was willing to pay 40 percent higher for sun-dried product devoid of sand and other extraneous matter than low quality product laced with sand as it was also noted by Namisi (2000). At the marketplace, traders were willing to pay 40 percent higher for sun-dried product devoid of sand and other extraneous matter than low quality product laced with sand as it was also noted by Namisi (2000). At the marketplace, traders were willing to offer UGX 6 500/= or US$3 30 per basin for unsalted sun-dried Mukene than salted products at UGX 5 000 or US$2 50. The difference in price was attributed to the abundance and silvery appearance of the former with a marketable quality characteristic (Figure 1). Besides, Ugandan consumers preferred unsalted to salted fish.

Apparently, the salting process blurs the silvery appearance of fish surface as Connell (1995) also noted with salted cod. Owing to their quick turnover and affordable inputs (Table 3), both products had the potential to make a difference in the livelihood of fishers. However, in the rural setting the cost of salt would present a hindrance to the adoption of salting in the Mukene fishery unless there is a premium market for its products. Generally, Ugandans dislike eating salted fish but they can process for the ready market in the Democratic Republic of Congo (DRC). However, the current insecurity in DRC renders the market unavailable to potential salted Mukene traders. Besides, incidences of fish traders being robbed after their sales in DRC have been frequently reported, which further discourages the would-be traders.

Fermentation process was completely new in Uganda although it was common in Southeast Asia, Brazil, (Clucas and Ward, 1996) West Africa and Central Africa including DRC as observed by the author. Salt facilitated the fermentation process and hastened the subsequent drying step. On average, it took only 4 hours (Table 2). The participants reckoned that it would be an ideal technology for the Mukene fishery during the rain season, when there is only 2–4 hours of sunlight, which often leads to losses estimated at 80 percent during the rainy season (Masette, 2001). Because the product had been purposely processed for the DRC market, the local traders and processors were excited at the prospect of a new product with an extended shelf-life and unlimited market outlet. The local traders were willing to buy it for resale to DRC. However, the market in DRC preferred larger fish than Mukene. Nevertheless, they were willing to buy the study product at UGX 4 500 or US$2 27 per basin. Considering that fermentation was presented as an alternative method during adverse weather conditions disposing it at UGX 4 500/=, would be better than processing it for animal feed. As demonstrated in Table 3, a processor would make UGX 20 700/= or US$10.45 profit after only 4 times of processing.

Table 3: Summary of cost-benefit analysis for Mukene products

Type of product	Cost of production UGX		Revenue (R)	profit (P)	Remarks
	Initial (**I**)	Subsequent (**S**)			
Sun-dried	60 700	18 000	52 000	93 300	Economically viable with quick turnover
Smoked	143 000 143 000	28 000 28 000	80 000 52 000	93 000 -19 000	Has potential when retailed. Retail marketing Wholesale marketing.
Salted	65 700	24 000	40 000	22 300	Main market outlet in DRC
Deep-fried	79 000	33 100	64 000	77 700	Economically viable in affluent markets and when sold in small consumer packs
Fermented	63 700	20 000	36 000	20 300	Has potential market in DRC, especially in absence of the illegal immature Nile perch.
Product for human consumption:					
• Smoked Mukene with groundnuts	183 500	42 000	70 000	- 29 500	Not viable because of high groundnuts cost
• Plain smoked Mukene	147 500	7 200	64 000	86 900	Only viable when used as a condiment in traditional sauces
• Boiled and sun dried Mukene mixed with maize flour	143 300	83 800	118 080	77 620	Viable as a weaning food
Animal feed production					
• Plain Mukene	86 700	18 000	16 400	-74 100	Not profitable at all
• Mixture of Mukene and Maize bran or rice husks	86 700	38 200	57 400	28 300	Economically viable with a quick turnover

Figure 1: Sun-dried Mukene with silvery appearance

Deep-frying as a technology in fish preservation was more associated with whole tilapia and Nile perch carcasses than Mukene. As such, the participants were initially apprehensive but when they tasted the first sample they abandoned the other methods that were concurrently being conducted! They compared it to the traditionally high valued grasshopper-like delicacy called "*Nsenene*". Overall, the process took 2 hours from start to finish (Table 2). The actual frying process took only 10–15 minutes to achieve the desired and appealing golden colouration of the product (Figure 2).

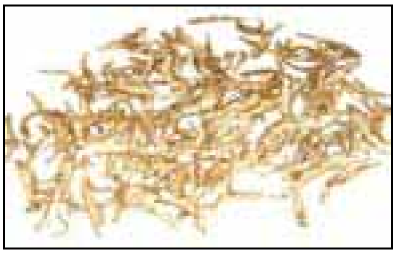

Figure 2: Golden brown deep-fried Mukene

Marketing trials conducted away from the landing site indicated that the product was readily acceptable at the drinking places. Because fried Mukene was a new product with a high level of acceptance, it was marketed in 250 g sachets at UGX 500/= at Kisuku and UGX 4 000 in Kampala. The processor could make a living from fried Mukene after only 4 times of processing (Table 3). In all probability, this product offered better business opportunities than the other improved products introduced in this study. However, the cost of vegetable oil and packaging materials were prohibitive and reduced the profit margins substantially. Probably, use of oil rendered from Nile perch industrial by-products may offer a profitable alternative.

Processing for human consumption was not a new concept as such, except that fishers lacked confidence to do it. Traditionally groundnut paste is added to smoked fish and eaten with "*matooke*", local name for cooking bananas. So the fascination of the process was the smoking, pounding of the Mukene into fine flour and subsequent mixing in the groundnut paste and not the milling process *per se*. The boiling of Mukene, then drying and subsequently pounding was also appreciated because they had not seen it before. Essentially, both processes were straightforward except that the pounding or milling operation was labour-intensive but manageable. After marketing trials, it was evident that the best option was to sell plain-pounded smoked Mukene in 250 g consumer packs instead of mixes. The sachet could be sold at UGX 750–1 000/= and used as a condiment in other sauces. On the contrary, it was economically feasible to mix boiled, sun-dried and pounded Mukene with maize flour to produce a weaning food for children living with HIV/AIDS. Packaging the mix in 250 g consumer packs would have a competitive edge over the 1 kg pack. Similar packs consisting of soya/Mukene mix are sold at UGX 1000/= in Kampala and used for children's porridge. Even at a cost of UGX 1 200 per kg, the processor would make substantial profits (Table 3).

Processing Mukene for animal feed was treated as a last resort in the present study. Fishmeal production is an important enterprise in areas of the world where surplus catches were a problem (Clucas and Ward,

1996) but in Uganda where the per capita consumption is less than 10 kg per annum (DFR, 2002) processing of Mukene into animal feed is an expensive luxury. Although the fishers participated in the production of animal feed, they were not interested because they were already supplying raw materials to the nearby animal feed manufacturing plants in urban centres. The cost-benefit analysis revealed that processing of plain animal feed was not a viable commercial enterprise but there was little profit of UGX 28 300 after 5 times of processing. This was possible because the cost of maize bran or rice husks was negligible but transportation cost from supply centres to landing site was a factor for consideration.

3. CONCLUSION

Generally, fishers were receptive to the ostensibly new technologies that were fairly affordable. It was possible to process Mukene using methods traditionally associated with large-sized fish species, namely smoking and fermentation. Most of the products processed were readily acceptable to consumers locally and regionally. The deep-fried product was more preferred than the fermented type. Consumers were willing to pay a premium price for high quality product regardless of the processing method. The commercial viability varied with processing technology. Whereas it was possible to break-even after 5 times of processing using such technologies, such as improved sun-drying on raised racks, salting, deep-frying, smoking and milling for human consumption, it was not possible to make a profit on plain Mukene animal feed at artisanal level.

Value-addition as a proposition for poverty alleviation in Uganda may be a viable enterprise in the Mukene fishery, especially among the low-income earners, most of whom reside at landing sites. Use of low processing technologies, would play a pivotal role in the determination of profit margins. Commercialization of some Mukene products at cottage level would improve the livelihoods of vulnerable members of fishing communities through increased incomes. In the long run, the use of low- cost processing technologies could also reduce post-harvest losses drastically, widen processing options and offer a wide range of products from Mukene. Nevertheless technologies that require substantial financial initial input would require outside intervention or “seed money” to initiate the enterprise.

4. RECOMMENDATIONS

- Microfinance institutions should extend their services to fish processors and offer “seed money” or initial capital at affordable interest rates.
- Processors should be encouraged to plant trees as fuel source/construction structures.
- Fishers should be re-organized into co-operatives or associations to ease funding of fish processing equipment.
- Relevant infrastructure should be developed at landing sites to ensure production of high quality value-added Mukene products.
- Other income generating activities should be introduced at landing sites to provide an alternative to Mukene processing, especially during lean seasons.
- These low-cost processing technologies should be further improved prior to dissemination at other landing sites around Lake Victoria and other lakes. The pH during fermentation should be determined as a reference for modification

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ESSAIS DE VALORISATION DE L'OMBRINE (A*rgyrosomus regius*) BY PAR MULTI-TRANSFORMATION

par

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ISTPM, Morocco

Abstract

The fish industry in Morocco is of particular importance; however its main characteristics are that it is export-oriented, focussed on a limited number of species and does not use much the utilization channel. More than 45 percent of the catches are meant for consumption in fresh or frozen form, and 55 percent of the exports are fresh or frozen products. Thus we propose to study a species, *Argyrosomus regius,* known locally as croacker – which is currently exploited (fresh and frozen) – in order to assess the species suitability to processing and, hence, determine the level at which it could be of interest to the processing industry. Currently the catch statistics show that this species is abundant in the southern zone of the Moroccan fisheries and that it has seasonal variability leading to fluctuation in price per kilo from 10 to 60 DH (1 to 6 Euro) but averages 15 to 30 DH/kg. It is characterized by its abundant flesh, which is much appreciated by national as well as foreign consumers.

The technological criteria of reference to encourage industrial processing are, first, the very low yield in fresh form because the flesh filets represent only 45 to 50 percent of the total mass. The visceral mass is well developed (20–22 percent) and contain utilizable organs (eggs, stomach, liver and pyloric appendices), the head and the central bone (30–33 percent) have enough recoverable flesh. Because of the size of the species, a minimum of 50 cm up to 140 cm, its skin can be considered for the production of fish leather. In the present study we were interested in the utilization of the flesh in several processes (smoked, sausages, fishburger, etc), the utilization of the head and the bones for the preparation of a concentrated bouillon as base for soups or sauces and, finally, the precious organs of the viscera are used for Japanese-like fermentation (shiokara).

To assess the suitability for processing we took into account the yield for each of the processing methods, the potential price of the subsequent products and the acceptability of the product by the consumer. The results of processing showed an increase in the utilization yield of around 80 to 90 percent. The sensory evaluation and the assessment of the potential price were conducted thanks to a poll in Agadir City (Morocco), including shopping malls, restaurants and personnel from institutions, as well as a professional panel involved in the fishery industry sector.

Résumé

L'industrie de pêche au Maroc revêt un intérêt particulier ; cependant ses principales caractéristiques est qu'elle est orientée sur l'exportation vers l'export concentrée sur un nombre d'espèces limitées et n'utilise pas beaucoup la chaîne de valorisation : plus de 45 pour cent des captures sont destinés à la consommation en frais ou à la congélation et 55 pour cent des exportations sont des produit frais et congelés. Ainsi nous proposons l'étude d'une espèce : *Argyrosomus regius* plus connue localement par courbine ou ombrine qui, justement entre dans ce cadre d'exploitation actuellement (frais et congelé), pour voir son aptitude à la transformation et de là, déterminer à quel degré elle est intéressante pour l'industrie de transformation. Actuellement les statistiques des captures montrent que cette espèce est abondante dans la zone Sud des pêcheries marocaines et qu'elle connaît une variabilité saisonnière induisant une variation du prix au kilo allant de 10 à 60 DH soit (1 à 6 Euros) mais en moyenne 15 à 30 DH/kg. Elle est caractérisée par une abondance de la chair très appreciée par les consommateurs aussi bien étrangers que nationaux.

Les critères technologiques sur lesquels on se base, qui inciteraient à une transformation industrielle sont tout d'abord un rendement au frais très faible puisque les filets de chair ne représentent que 45 à 50 pour cent par rapport à la masse totale ; la masse viscérale est très développée (20 à 22 pour cent) et contient des organes valorisables (œufs, estomac, foie et appendices pyloriques), la tête et l'arête centrale (30 à 33 pour cent) contiennent assez de chair récupérable. Du fait de la taille de l'espèce du minimum 50 cm et pouvant dépasser 140 cm on pourrait penser à utiliser sa peau pour la production de cuir de poisson. Dans la présente étude, nous nous sommes intéressés à la valorisation de la chair par différents procédés (fumé, saucisses, fish burger…), la valorisation de la tête, et les arêtes par la préparation d'un bouillon concentré servant de base à des soupes ou sauces et finalement les organes « nobles » des viscères sont utilisés pour la fermentation (shiokara) à la façon japonaise.

Pour estimer l'aptitude à la valorisation nous nous sommes basés sur le rendement pour chacune des transformations, le prix potentiel des produits issus de ces transformations et l'acceptabilité du produit par le consommateur. Les résultats de transformations ont montré une augmentation du rendement à l'utilisation d'environ 80 à 90 pour cent. L'évaluation sensorielle et celle du prix potentiellement praticable a été réalisée grâce à un sondage dans la ville d'Agadir (Maroc) incluant grandes surfaces, restaurateurs et personnel des institutions ainsi qu'un panel de professionnels oeuvrant dans le secteur de l'industrie de la pêche.

1. INTRODUCTION

La consommation du poisson frais au Maroc est relativement faible. En 2003, elle a représenté environ le cinquième des captures [(1)] ; l'excédent de l'offre est exporté essentiellement sous deux formes : conserves et semi conserves pour les poissons pélagiques (sardines, maquereaux et anchois) et en frais ou congelé pour le poisson blanc. Il existe donc un potentiel important de poisson blanc pouvant être destiné à la valorisation. D'autant plus que toutes les espèces de poisson blanc ne sont pas à forte côte. Il y a un manque à gagner certain du fait de la commercialisation en frais du poisson blanc à moyenne valeur commerciale. Par ailleurs, la présence, sur le marché marocain, de produits transformés pourrait améliorer davantage la consommation des produits de la pêche si elle est bien exploitée. Si, actuellement, les conserves et semi conserves de sardines et maquereaux sont les plus vendus parmi les produits de la pêche transformés au Maroc, ils n'ont pas, aux yeux des marocains, une grande considération : seuls les populations à faible revenu en consomment beaucoup. Toutefois, le poisson blanc transformé par de nouvelles préparations et à prix compétitif pourrait attirer une clientèle plus large. Ce mouvement commence à se faire sentir au Maroc, puisqu'une société à Tan-Tan a mis au point en fin 2004, des préparations à base de poisson blanc dans la gamme des surgelés (croquettes, burger, et boulettes). Ceux-ci sont commercialisés dans les grandes surfaces des principales villes à des prix très concurrentiels par rapport aux produits d'importation. Dernièrement, une autre société sur Casablanca s'est lancée, dans la même gamme de produits mais à base de sardine cette fois. Cela prédit d'un intérêt grandissant pour la valorisation de la part des industriels au Maroc.

L'espèce *Argyrosomus regius,* plus connue par courbine ou ombrine ou encore zalmza [(2)] au Maroc est très prisée pour sa chair qui rentre dans la préparation de tagines de poisson ou encore pour la confection de brochettes. Dans les régions du Sud, la tête est récupérée pour faire du couscous. Le choix d'étudier cette espèce pour son aptitude à la transformation se justifie par son abondance - 5 pour cent des captures de la pêche côtière en poisson blanc, statistiques 2004 [(6)] - au Sud des côtes marocaines particulièrement au large de Tarfaya (Cap Jubi) ainsi que par sa grande taille pouvant atteindre 230 cm pour un poids de 103 kg (poids max. publié, www. Fishbase.org). Par ailleurs, sa valeur commerciale peut être considérée moyenne à basse. Selon les mareyeurs les prix peuvent arriver à 60DH/kg alors que l'estimation du prix au kilogramme à partir des statistiques de l'ONP pour l'année 2004 [(6)] donne une moyenne mensuelle de 12 à 14 DH/Kg et respectivement de 16.5 et 19.5DH/Kg pour les mois de Novembre et Décembre de la même année. Faire augmenter le taux d'utilisation du poisson pourrait être aussi un motif pour la valorisation puisque la consommation en frais n'exploite que la chair alors qu'il est possible d'envisager d'utiliser les viscères, la tête et l'arête centrale mais aussi la peau pour les espèces de grandes tailles de ce genre.

Objectifs de l'étude:

- Identifier l'espèce communément appelée courbine ou ombrine
- Mettre au point des produits permettant la valorisation de cette espèce
- Mesurer l'amélioration du rendement induit par l'utilisation intégrale du poisson
- Etudier l'acceptabilité des produits fabriqués par le marché local

2. MATÉRIELS ET MÉTHODES

Identification des espèces:
- Morphologie générale et caractères spéciaux particuliers à l'espèce grâce au guide des espèces [2] ,
- Longueur totale à l'ichtyomètre.

3. PROCÉDÉS DE TRANSFORMATION

Opérations de prétraitement
Après écaillage du poisson, les viscères et la tête sont écartés et gardés en vue de leur utilisation ultérieure (fabrication base de soupe). Le filetage est réalisé en veillant à ne pas s'ecarter de l'arête centrale pour récupérer le plus de chair possible. L'arête centrale enlevée est jointe à la tête pour la préparation de la base de soupe de poisson. Le pelage des filets est réalisé par une peleuse mécanique qui évite l'endommagement des filets. Puis les filets sont parés en enlevant les restes de chair de la partie ventrale. Ces dernièrs sont ajoutés aux têtes et arêtes centrales pour la base de soupe.

Fabrication du fish burger [3]
Les filets préparés et lavés sont découpés en morceaux et mis dans une machine à découper (modèle OMF -400B munie d'une soucoupe et à lame verticale) en ajoutant les ingrédients : graisse (7 pour cent), sel (2 pour cent), fécule (5 pour cent), oignon (10 pour cent), carottes (10 pour cent), piment (1,5 pour cent), gingembre (1,5 pour cent), persil (1,5 pour cent) et le poivre (0,75 pour cent) ; l'opération d'émincage se fait en même temps avec le hachage. Ensuite on procède à l'opération de mise en forme puis friture à l'huile végétale à 180 °C. Les fish burger sont emballés sous vide après refroidissement et entreposés à 2 °C.

Fabrication des saucisses [3]
Après filetage et lavage, les filets sont découpés et hachés dans le hachoir avec confection du mix en même temps. Les ingrédients du mix sont : sel (2 pour cent), fécule (5 pour cent), oignon (10 pour cent), carottes (10 pour cent), poivre (0,6 pour cent), piment (0,6 pour cent), gingembre (0,5 pour cent), persil (0,6 pour cent), ail (12 g).
Ensuite le hachis est mis sous peaux artificielles ; la saucisse est ficelée après remplissage ; puis les bouts de peau sont fermés avec les polyclips.
Finalement, les saucisses ont été cuites à l'eau chaude (80 °C pendant 40 minutes) puis refroidis rapidement par eau fraîche (eau + glace). L'entreposage s'est effectué à 2 °C.

Fabrication de filets fumés (Notes Travaux Pratiques)
Les filets d'ombrine sont salés et séchés avant d'être fumés. Le produit fumé à froid présente une texture molle, un goût et une odeur de fumée.
Le salage est effectué en saumure de 15 pour cent de sel et 0,5 pour cent de glutamate. Les filets sont placés à 0°C pour une nuit.
Après déssalage à l'eau fraîche, les filets sont étalés dans l'enceinte de fumage pour subir un séchage pendant une heure à température 27 °C puis lancement du fumage à 30 °C pendant 11 heures.
Une fois sortis du fumoir, les produits ont subit une opération de raidissage par légère congélation.
Après pesage du produit fumé, les filets sont découpés en morceaux fins puis emballés sous vide et conservés à 2 °C.

Fabrication de la soupe
Les têtes, arêtes centrales, et restes de chair des parties ventrales ont bouilli dans un cuiseur à gaz, en ajoutant la même quantité d'eau, pendant 6h30 minutes à une température de 90 °C. On a procédé à la filtration du bouillon grâce à un tamis métallique de maille de 1cm de diamètre. Le filtrat est mis dans la chambre froide à 0 °C en attente de préparation des ingrédients pour la soupe.
Les ingrédients ajoutés au filtrat sont : concentré de tomate (3 pour cent) ; sel (2 pour cent) ; ail (0,2 pour cent) ; oignon (5 pour cent) ; poivre (0,15 pour cent) ; glutamate (0,2 pour cent) ; vermicelle (2,5 pour cent).

La cuisson de la base et des ingrédients a été effectuée à température de 90 °C pendant 25 min divisée en deux phases (15 min +10 min). Le rajout de vermicelle s'est fait durant la deuxième phase.
La soupe est mise dans des boîtes métalliques après refroidissement. Les boîtes sont serties et mises dans l'autoclave pour stérilisation à 121 °C pendant une heure.

Production de shiokara [5] *(fermentation)*
La fermentation est une transformation des composés organiques en composés simples sous l'action des enzymes et microorganismes en présence de sel. Le sel permet d'inhiber le développement et la croissance des microorganismes responsables de la putréfaction. Les bactéries de putréfaction présentes au moment de la capture sont remplacées par une microflore halophile prédominante contenue initialement dans le sel.
L'estomac, les appendices pyloriques, les ovaires et le foie sont mis dans l'eau fraîche ainsi l'estomac doit être vidé et nettoye.
Les intestins, la rate et la vésicule biliaire ne doivent pas être utilisé car elles rendent le produit amer et lui octroient une mauvaise couleur.
Les organes utilisés pour la fermentation sont découpés par des couteaux puis salés au sel sec (25 pour cent) puis mis en maturation une semaine pendant 2 mois après; le liquide, surnageant doit être éliminé.

Valorisation de la peau
Afin de conserver la peau pour un tannage ultérieur, celle-ci a été traitéeau au sel sec et placée à 0 °C. Après un temps d'exsudation on parfait la conservation par un séchage de 4 heures à 27 °C.

Traitement des déchets
La seule source de déchet est le gâteau de filtration restant après filtration du bouillon. La détermination du poids du gâteau est essentielle pour l'estimation du rendement d'utilisation. Etant donné que le gâteau provient de la filtration du mélange -reste de poisson et eau-, son humidité résiduelle dépasse de loin la véritable valeur du poids net des déchets. Pour mieux évaluer ce poids, nous avons estimé qu'il est majoré par le poids du gâteau de filtration égoutté et minoré par le poids de ce gâteau ayant subi un séchage juste suffisant pour le décharger de son humidité excédentaire. Il est vrai que l'on ne peut pas être sûr d'avoir surpassé l'excédent d'eau, lorsqu'on essaie de décharger le gâteau de l'excédent d'eau, et que l'on soit rentré dans l'humidité normale du gâteau mais il est sûr que la valeur réelle du poids du gâteau serait plus proche du poids du gâteau égoutté partiellement séché que du gâteau de filtration uniquement égoutté.

4. ANALYSES PHYSICO-CHIMIQUE ET SENSORIELLE

Analyse sensorielle
L'analyse sensorielle des quatre pièces d'ombrine fraîche a consisté à déterminer l'indice de fraîcheur en se basant sur le barème de cotation de l'union européenne de la fraîcheur du poisson puis à les classer selon leur degré de fraîcheur.

Détermination de la composition
Les protéines sont déterminées par la méthode de distillation sur l'appareil de Kjeldhal après décomposition de la chair par chauffage à l'acide sulfurique (concentré). La matière grasse est extraite par l'éther pendant 8 heures dans l'appareil de Soxhlet puis récupérée, séchée et pesée (balance de précision). L'humidité est déterminée directement par simple lecture sur l'humidimètre à infra rouge (balance infra rouge) tandis que les minéraux sont déterminés après incinération de l'échantillon dans un creuset à 600 °C dans le four à moufle et pesage (balance de précision). Enfin, les glucides sont déduits à partir des autres teneurs par simple différence.

Détermination des ABVT
La détermination des ABVT a concerné la matière première ainsi que les produits finis : fumé, saucisse, soupe et Fish burger. L'analyse est effectuée en double et la méthode utilisée est celle de la distillation d'un extrait déprotéinisé par l'acide perchlorique.

Les échantillons sont préalablement hachés (hachoir à viande) puis passés dans un mixeur à grande vitesse (8000 à 45000 tr/min) puis filtrés dans un système à filtration rapide (filtres de diamètre 150 mm).

En ce qui concerne les réactifs, seuls les réactifs pour analyses sont utilisés. Toutes les solutions sont préparées avec de l'eau distillée. Ainsi ont été préparées une solution d'acide perchlorique à 6 g/100 ml, une solution de soude à 20 g/100 ml; une solution étalon d'acide chlorhydrique 0,05 N; une solution d'acide borique à 3 g/100 ml ; une solution de phénophtaléine à 1 g/100 ml d'éthanol à 95 pour cent.
La solution d'indicateur de Tashiro a été préparée en dissolvant 2 g de rouge de méthyle et 1g de bleue de méthylène dans 1000 ml d'éthanol à 95 pour cent. L'agent antimoussant utilisé était à base de silicone.

Analyse microbiologique
la détermination de la flore totale, les coliformes totaux et fécaux, les staphylocoques, les anaérobies sulfito-reducteurs et les salmonelles ont été effectuée sur la matière première ainsi que sur les produits finis : Fumé, saucisse, Fish burger, et soupe. Les échantillons à analyser ont été prélevés dans les sachets stériles.

Le dénombrement de la FMAT est effectué sur gélose profonde de PCA à 37 °C. Le dénombrement des coliformes est réalisé par la méthode (NPP) dans le bouillon lactosé bilié au vert brillant (BLBVB). Le dénombrement des staphylocoques à coagulase positive est effectué sur milieu de Baird Parker enrichi au jaune d'œuf et au tellurite, à 37°C et après le test à la coagulase (Plasma EDTA). La recherche de salmonelle est effectuée en quatre étapes : pré enrichissement en eau peptonée tamponnée, à 37 °C, enrichissement sur milieu Rapaport-Vassiliadis à 43°C, isolement en deux milieux (gélose Hektoen Entérique) et gélose Salmonella-Shigella à 37°C, et identification en milieu de gélose inclinée TSI (Triglucide-Fer) à 37 °C. Le dénombrement des anaérobies sulfito-réducteur est effectué dans des tubes de gélose regeneré TSN de Marshall (Tryptone, Sulfite, néomycine) en surfusion (46 °C) à 46°C.

5. TESTS DE DÉGUSTATION

Les tests de dégustation ont été réalisés à deux niveaux. Un niveau panel professionnel et un niveau consommateur. Le premier test avait pour objectif de valider les produits fabriqués, il était donc constitué de personnes ayant une connaissance des produits de la pêche. Nous avons fait appel d'une part à quatre cadres de l'ISTPM - deux ingénieur–formateur du département des industries de la pêche, un docteur en océanographie et un cadre administratif, et d'autre part à trois chercheurs du Centre de Valorisation des Produits de la Mer d'Agadir (INRH) dont un ingénieur chercheur, responsable développement de produit, et deux experts japonais en mission dans ce centre.
Le deuxième test visait l'acceptabilité du produit par le consommateur. Les deux tests consistaient en la dégustation d'échantillons des produits fabriqués et le remplissage d'un questionnaire. Il y avait trois séries de questions :
i) Questions d'information sur l'enquête : profession, nationalité, sexe, appréciation des produits de la mer et préparations culinaires préférées, fréquence de consommation des produits de la pêche.
ii) Appréciation des critères organoleptiques (goût, couleur, odeur, aspect) avec cinq niveaux de choix
iii) Acceptation d'achat du produit et choix d'un prix (prix psychologique) dans une gamme de prix proposés.

6. RÉSULTATS ET DISCUSSION

6.1 Identification des espèces étudiées

Morphologie générale

La forme générale sur la photo 01 montre l'appartenance à la famille des sciaenidae

Longueur totale

Les longueurs totales respectives des 4 pièces étudiées étaient de 165 cm 120 cm 110 cm et 125 cm. Or parmi les huit espèces identifiées dans le guide des poissons au Maroc [(2)] seul le Maigre (*Argyrosomus regius*) et le Teraglin (*Atractoscion aequidaens*) peuvent avoir des tailles supérieures à 1m encore que la taille maximale de *Atratoscion aequidaens* est au maximum de 120 cm. La même source indique que la taille maximale de *Argyrosomus regius* est au moins de 140 cm**.**

Caractères spéciaux

La présence de couleur jaune orangé [(2)] à l'intérieur de la bouche est exclusivement un critère identifiant *Argyrosomus regius*. Sur toutes les pièces étudiées, ce critère était présent (Photo 02). Il nous a donc été possible de conclure de façon catégorique que les pièces étudiées étaient bien des spécimens de l'espèce *Argyrosomus regius*.

Tableau 1. Résultats des analyses chimiques et microbiologiques

Matière première	Test sensoriel de fraîcheur		ABVT (mg N /100 g)	FMAT (ufc /g)	Staphylococcus aureus (ufc /g)	Coliformes NPP /g		Anaérobies SR	Salmonelles
	Indice de fraîcheur	Catégorie de fraîcheur				CT	CF		
Pièce 1	2,22	A	4,4	$2,1\ 10^5$	$3.\ 10^3$	0	0	abs	abs
Pièce 2	2,11	A	12 ,0	$2,9\ 10^5$	$12.\ 10^3$	3	0	abs	abs
Pièce 3	2	A	13,4	$3,1\ 10^5$	$2.\ 10^3$	<1	0	abs	abs
Pièce 4	2,22	A	12,3	$2,2\ 10^5$	$6.\ 10^3$	0	0	abs	abs
moyenne	2,14	A	10,53	$2,6\ 10^5$	$5,8\ 10^3$	<2	0	abs	abs

Fraîcheur de la matière première

La matière première est relativement fraîche. Les résultats de l'indice de fraîcheur et de l'ABVT sont confirmés par les résultats microbiologiques. En effet, une valeur de la FMAT de l'ordre de 10^5 est normale pour un poisson à l'état frais comme il est rapporté par Sainclivier [(7)]. Il rapporte aussi que les coliformes ne sont pas éliminés par une basse température. Donc leur quasi absence dans nos échantillons montre que ceux-ci ont été bien traités depuis leur capture. Une flore staphylococcique de 10^3 est quasi normale vues les conditions de débarquement et de commercialisation. Les staphylocoques survivent même jusqu'à huit mois dans des crevettes congelées à l'azote liquide et conservées à -18°C [(7)]. Nous pouvons donc conclure que la matière première est relativement assez fraîche pour pouvoir être transformée.

Composition de la matière première
La détermination de la composition globale de l'espèce *Argyrosomus regius* vivant dans les côtes marocaines est d'un intérêt particulier car il n'existe pas de table de composition des espèces pêchées dans nos eaux territoriales. Les travaux se font par extrapolation à partir de table de compositions étrangères. Par ailleurs, cette composition nous permet de classer l'espèce *Argyrosomus regius* comme un poisson maigre, vue la faible quantité de matière grasse de 1,2 pour cent. Déjà, ce résultat peut nous orienter quant aux techniques de transformations à choisir pour la valorisation de la chair.

Tableau 2. Composition de la matière première

Poisson	Humidité pour cent		Matière Grasse pour cent		Protéines pour cent		Cendres pour cent		Glucides pour cent	
	Hs	Hh	MGs	MGh	Ps	Ph	Cs	Ch	Gs	Gh
P1	61,10	80,50	1,7	0,8	33	16,50	2,15	1,08	2,05	1,02
P2	60,20	80,00	1,9	1,0	34, 3	17,15	2,00	1,00	1,60	0,80
P3	59,00	79,50	3,5	1,7	-	-	3 ,85	1 ,94	-	-
P4	61,00	80,50	2,2	1,1	34	17,00	2,60	1, 30	0,20	0,10
moyenne	60,33	80,13	2,3	1,2	33,8	16,9	2,65	1,33	1,28	0,64

Ainsi pour le fumage, il est d'habitude de fumer à froid les poissons maigres et de fumer à chaud ou à froid les poissons gras [(4)]. Pour la fabrication de saucisses ou de fish burger, il est préférable de rajouter du gras pour retrouver la texture normale des saucisses qui plait aux consommateurs connaisseurs des saucisses.

Détermination du poids total moyen et poids relatifs des différentes parties du poisson
Nous notons d'après le tableau 3 que les filets ne représentent que 46 pour cent de la masse totale du poisson. La tête et l'arête centrale constituent à elles deux 37,4 pour cent de l'ensemble du poisson. Le reste est environ également ventilé entre les viscères, la peau et la chair de la partie ventrale. Ceci confirme l'idée que tout essai de transformation de ce poisson ou toute exploitation à travers la filière industrielle devrait envisager une utilisation des différentes parties autres que les filets. Mais aussi, on devrait choisir une technique de transformation du filet lui conférant une valeur ajoutée justifiant son utilisation

Produits fabriqués
En ce qui concerne le fumé nous avons obtenu de la pièce 1, deux filets fumés pesant respectivement chacun 1,92 et 1,78 kg. Nous avons défini le rendement de transformation comme le rapport entre le poids du produit fini et le poids brut. Pour les filets fumés cela donne (1,92+1,78) / 11,45, soit 32 pour cent,. Les pièces 2 et 3 ont donné respectivement 3,95 et 3,945 kg de saucisses soit 64 et 62 unités (d'environ 60g chacune) ce qui donne un rendement de transformation par rapport au poids brut de 28 pour cent; la pièce 4 nous a permis de fabriqué 148 pièces de fish burger pour un poids de 5,56 kg soit un rendement de transformation de 33 pour cent. La récupération des têtes, arêtes centrales, les restes de chair dans le bouillon de cuisson nous a permis de produire 32,10 kg de filtrat qui a servi à la fabrication de 20,94 kg de soupe de poisson (rendement de transformation de 39 pour cent), soit l'équivalent de 53 boîtes type: 1/2 H 40. Les pertes en filtrat sont dûes à la manipulation et à l'évaporation pendant la cuisson de la soupe.
La production de shiokara s'est faite avec 3,55 kg de matière après avoir écarté les intestins, les vésicules biliaires et les rates ainsi que l'estomac d'une pièce ayant une mauvaise apparence.

Stabilité des produits
Du point de vue de la salubrité, les produits obtenus étaient de bonne qualité comme l'attestent les résultats des analyses microbiologiques figurant dans le tableau 4 ci-dessous; en effet la FMAT n'a pas dépassé les 10^4 ufc/g. Pour les filets fumés et la saucisse, la flore de staphylocoques s'est située au même niveau que pour la matière première c'est à dire10^3 ufc/g. Ceci est relativement acceptable sachant que ce sont des produits dont les durées de vie sont très limitées 15 à 30 jours à 2 °C. Par contre la flore staphylococcique est réduite pour le fish burger 10^2 ufc/g (effet de la friture 180 °C/ 10 min). Toutefois,

la présence de staphylocoques dans la soupe alors que celle-ci a subi une stérilisation parait douteux. En effet, dans un travail similaire (non publié) réalisé l'année précédente, nous avons soumis l'analyse des boîtes de conserve au laboratoire Régional d'Analyse et de Recherche Vétérinaire d'Agadir. Cette analyse avait révélé que les boîtes étaient stables après étuvage que ce soit à 37 °C, à 55 °C ou à température ambiante. Il faut aussi ajouter que ces dernières analyses avaient été effectuées six mois après la production. La forte teneur en ABVT de la soupe s'explique par le fait que lors de la cuisson les protéines et acides aminés se sont fortement dégradés.

Tableau 3. Poids des diverses parties des pièces d'ombrine

	Poids en kilogrammes									
	Poidsbrut	Poids après écaillage	Poids après étêtage etéviscération	Poids des filets: Filet1	Poids des filets: Filet 2	Poids de la tête	Poids des viscères	Poids de l'arête centrale	Poids Reste de chair partie ventrale	Poids totalpeaux
Pièce 1	11,45	11,25	7,75	3,15	3,05	2,80	0,85	1,25	0,70	0,95
Pièce 2	14,20	14,00	9,10	3,15	2,80	3,75	1,15	1,70	0,75	
Pièce 3	11,55	11,45	7,70	2,80	3,50	2,60	1,25	1,80	0,65	
Pièce 4	16,75	16,45	10,95	2,50	4,05	3,20	1,85	3,05	1,30	
Moyenne	13,5	13,3	8,9	2,9	3,35	3,1	1,3	1,95	0,9	0,95
Pour-cent au poids brut	100	98,5	65,8	21,5	24,8	22,9	9,5	14,5	6,3	7

La production de shiokara n'ayant pas été menée jusqu'au bout, son analyse n'a donc pas été possible. En effet après un mois de fermentation, nous avons présenté le fermentât à un expert japonais pour l'appréciation du produit. Celui-ci a jugé que le produit est très en retard dans la phase de fermentation. Il a estimé que les paramètres de travail, sel à 25 pour cent et température de 4 °C n'étaient pas adaptés pour la maturation. Le salage est, pour lui, trop fort et la température trop faible. Il a incriminé le retard de fermentation par rapport à la phase dans laquelle devrait être le substrat à ce stade (après un mois), au fait que les bactéries de maturation étaient sans doute inhibées par le sel. Il a proposé un taux de 15 pour cent de sel et une température ambiante pour de prochains essais.

Les peaux conservées par simple salage et préséchage selon le procédé décrit plus haut, ont gardé leur qualité pour pouvoir subir un tannage ultérieur. En effet, la simple manipulation de peaux conservées pendant un an par la même technique, a montré que celles-ci étaient toujours aptes à être transformées en cuir de poisson.

Estimation du rendement

Le rendement a été déduit en faisant le rapport entre le poids utilisé (différence entre poids brut et déchets) et le poids brut. Dans les déchets, on a comptabilisé le gâteau de filtration et les écailles. Le poids du gâteau après égouttage était de 13,25 kg.

Le calcul du rendement par majoration des déchets (13,25 kg) et leur minoration (4,60 kg) était compris entre 75 pour cent et 90 pour cent. Or, comme la valeur de 13,25 kg majore de façon excessive la véritable valeur (voir explication dans matériel et méthode), on peut avancer sans aucun doute que le rendement se situe entre 80 et 90 pour cent.
Ce qui est très satisfaisant par rapport au rendement de 45 ou 50 pour cent qu'engendre l'utilisation uniquement de filets. Encore faut-il mettre au point la technique de production de shiokara et pratiquer certains essais de tannage de la peau pour cette espèce afin de confirmer son utilisation pour la production de cuir.

Tableau 4. Analyse des produits finis

Produits finis	ABVT (mg N/100 g)	FMAT (ufc /g)	Staphylococcus aureus (ufc /g)	Coliformes NPP /g		Anaérobies SR	Salmonelles
				CT	CF		
Saucisse	34,7	$5\ 10^4$	$1\ 10^3$	0	0	abs	abs
fumé	25 ,3	$4\ 10^4$	$1,2\ 10^3$	1	0	abs	abs
Soupe	112	$1\ 10^5$	$4.\ 10^2$	0	0	abs	abs
Fish burger	32,5	$8\ 10^4$	100	0	0	abs	abs

Appréciation des produits
Il est à noter que les seuls produits qui ont été dégustés sont les saucisses, le fish burger et la soupe de poisson. Au cours de l'entreposage un incident de coupure d'électricité a entraîné une élévation de température qui a causé la perte des filets fumés. Par ailleurs le shiokara comme expliqué plus haut n'était pas encore prêt à la consommation au moment des tests.

Résultats de dégustation du panel professionnel
D'une façon générale, Les saucisses ont été appréciées au niveau de leur texture et de leur aspect. Les seules remarques portaient sur le goût pour lequel, certains membres du panel (2/6), estimaient qu'il devait être plus raffiné. Le goût du poisson étaient pour certains camouflé par les légumes et épices ; une personne a estimé que le taux de sel était élevé et que la couleur devait être changée. Toutefois la majorité du panel (5/7) était prête à acheter ce produit s'il se trouvait sur le marché à une gamme de prix entre 10 à 40DH/ kg selon les avis.
De même le fish burger a été approuvé par son goût et l'effet à la mastication. L'aspect a été jugé moyen à bon, notamment pour certains la forme était à retravailler. Quatre sur sept membres sont prêt à l'acheter en cas de commercialisation avec un prix psychologique situé entre 20 à 40 DH pour un paquet de six unités.
La dégustation de la soupe a entraîné des avis partagés quant à sa qualité. La majorité des membres du panel ont jugé son goût et son odeur comme étant moyen. Une personne a estimé qu'elle était, au contraire, très bonne. Particulièrement les experts japonais ont apprécié cette soupe probablement du fait de leurs habitudes de consommation. Si toutefois la majorité n'est pas prête à l'acheter, une personne a estimé que la soupe pouvait avoir un marché en soignant la présentation avec un prix psychologique entre 20 et 30DH/ boîte. Une autre proposition d'un expert japonais était de rajouter du gingembre pour améliorer le goût et l'odeur. Mais en général, la majorité a préféré ressentir le goût du poisson.

Résultats de la dégustation consommateur
Sur les trois grandes surfaces contactées seul un super marché a accepté de faire les dégustations. Les deux autres avaient des conditions très spéciales, notamment des autorisations et similaires qui avaient retardé les produits (arrivée à DLC). Nous avons donc effectué les dégustations dans l'unique supermarché qui nous a donné son accord.
Le dépouillement des questionnaires (voir matériel et méthode pour le modèle) a donné les résultats suivants!

88 individus ont pris part aux dégustations et ont rempli les questionnaires. Sur ces 88 personnes, 52,3 pour cent étaient des femmes et 47,7 pour cent des hommes. Les individus interrogés étaient des différentes nationalités avec une prédominance d’autochtones. Ainsi 86,4 pour cent étaient de marocains, 8 pour cent des français, 2,3 pour cent belges puis un italien un américain et un libyen.
La presque totalité des individus aimaient consommer le poisson (95 pour cent). Cependant leur fréquence de consommation est très variable. Cela va d'une fois par semaine jusqu’à tous les jours. Toutefois la majorité des individus avait une fréquence de consommation faible. En effet, l’effectif cumulé des individus consommant de 1 fois par semaine jusqu’à trois fois par semaine a représenté près de 80 pour cent. Les individus consommant quatre fois par semaine ne représentaient que 16 pour cent, alors que ceux dont la fréquence était de 5 fois par semaine représentaient 2,7 pour cent. Enfin une personne consommait du poisson tous les jours et une autre en consommait 6 fois par semaine.
Les individus appartenaient à des classes socio professionnelles différentes avec une plus grande représentativité des employés (35 pour cent) suivi par les profession libérales 21,6 pour cent puis des gérants ou cadres (12,5 pour cent) l’échantillon comportait six enseignant ainsi que 5 étudiants.

Qualité organoleptique
Les résultats des tests organoleptiques sont regroupés dans le tableau 5. Les remarques d’ordre général qui se dégagent à la lecture du tableau sont :
Pour la Saucisse 1, tous les critères ont été perçus positivement par la majorité des individus interrogés. En effet, la somme des pourcentages des individus ayant jugé le produit bon et très bon pour chacun de ces critères dépassait les deux tiers de la population enquêtée : 80 pour cent pour le goût et l’odeur et 67 pour cent pour l’aspect et la couleur. Alors qu’elle dépasse les 90 pour cent si on cumule les niveaux très bon, bon et moyen.
La tendance est la même à quelques points près, pour la saucisse 2 et le Fish burger.
Pour la soupe de poisson, les avis sont plus partagés. Le cumul des pourcentages de « « très bon « et « Bon » était de 57 pour cent pour le critère (aspect) et était de 63,5 pour cent pour les critères (gout, couleur et odeur. Cependant 20 pour cent trouve la soupe organoleptiquement mauvaise.
On peut donc conclure que les fish burger et la saucisse ont été jugés bon en général et que la soupe a été considérée moins bonne.

Acceptation d’achat et prix psychologiques
A la question « Accepteriez vous d’acheter ce produit sur le marché ? », les résultats enregistrés vont dans le même sens que la tendance notée pour les tests organoleptiques. Ainsi 91 pour cent des personnes sont prêtes à acheter les saucisses 1 ou 2, 93,3 pour cent sont prêts à acheter les fish burgers alors que seulement 73,5 pour cent sont prêt à acheter la soupe de poisson. Et dans tous les cas, l’acceptation d’achat des produits existe dans une proportion assez satisfaisante.

Les prix psychologiques proposés pour chacun des produits sont représentés dans le graphique ci-dessous (figure 1). On peut remarquer que pour chacun des produits la distribution des individus par rapport aux prix déclarés suit une distribution normale au moins pour les saucisses et la soupe. Cela paraît moins vrai pour le fish burger mais on peut considérer en général la tendance comme normale. On peut facilement estimer les prix psychologiques par le calcul des moyennes des distributions; ce qui a donné 4,10 DH/unité de la saucisse 1; 4,2 DH/unité de la saucisse 2; 15,20 DH/ paquet de six fish burger et 12,40 DH/ boîte de soupe de poisson.

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Tableau 5. Résultat de l'analyse sensorielle des produits finis

		TRES BON		BON		MOYEN		MAUVAIS		T.MAUVAIS		Total effectif	pour cent à l'échantillon
		effectif	pour cent	effectif	pour cent	effectif	pour cent	effectif	pour cent	effectif	pour cent		
Saucisse1	Goût	26	**32,1**	40	**49**	12	**14,8**	2	**2,4**	1	**1,2**	81	92
	Aspect	14	**17,5**	40	**50**	19	**23,8**	6	**7,5**	1	**1,2**	80	91
	Couleur	13	**16**	42	**51,8**	21	**26**	4	**4,9**	1	**1,2**	81	92
	Odeur	18	**23,4**	43	**55,8**	13	**17**	2	**2,6**	1	**1,3**	77	87,5
Saucisse 2	Goût	25	**31,6**	30	**37,9**	21	**26,6**	2	**2,5**	1	**1,3**	79	89,7
	Aspect	17	**21,8**	38	**48,7**	17	**22**	5	**6,4**	1	**1,3**	78	88,6
	Couleur	13	**16,5**	39	**49,4**	22	**28**	4	**5,1**	1	**1,3**	79	89,7
	Odeur	16	**21,1**	38	**50**	17	**22,4**	4	**5,3**	1	**1,3**	76	86
Fish burger	Goût	37	**48**	22	**28,6**	14	**18,2**	4	**5,2**	0	**0**	77	87,5
	Aspect	23	**30,3**	34	**44,7**	14	**18,4**	5	**6,6**	0	**0**	76	86
	Couleur	21	**27,6**	40	**52,6**	10	**13,2**	5	**6,6**	0	**0**	76	86
	Odeur	20	**26,7**	35	**46,7**	17	**22,7**	3	**4**	0	**0**	75	85
Soupe de poisson	Goût	9	**14**	32	**49,2**	13	**20**	10	**15,4**	1	**1,5**	65	74
	Aspect	7	**10,8**	31	**47,7**	13	**20**	14	**21,5**	0	**0**	65	74
	Couleur	5	**7,81**	36	**56,3**	17	**26,6**	6	**9,4**	0	**0**	64	73
	Odeur	9	**13,8**	32	**49,2**	15	**23**	9	**13,8**	0	**0**	65	74
	Couleur	5	**7,81**	36	**56,3**	17	**26,6**	6	**9,4**	0	**0**	64	73
	Odeur	9	**13,8**	32	**49,2**	15	**23**	9	**13,8**	0	**0**	65	74

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Pour estimer le gain réalisé par la valorisation et au bout du compte juger de la pertinence de la valorisation du point de vue de la rentabilité économique on peut calculer sur la base des rendement de chaque transformation et sur la base des prix psychologiques moyens les chiffres de vente réalisés par l'ensemble des transformations et les comparer à la vente du poisson frais. En partant du prix par kg des pièces achetées qui est de 30DH, et en partant du poids moyen de l'ombrine mentionné dans le tableau 3. Les simulations sont reportées dans le tableau 6.

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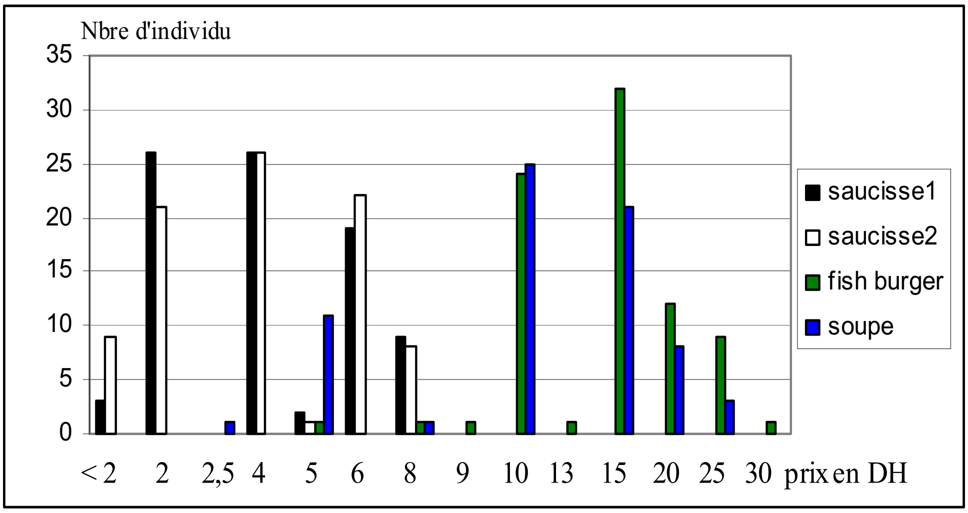

Figure1

Tableau 6. Estimation des gains par transformation

	Prix psychologique	Poids moyen du poisson (Pm)	Rendement De Transformation (R)	Poids du Produit transformé PT =Pm X R	Poids unité (Pu)	Nombre unités = PT/ Pu	Chiffre d'affaire réalisé
Saucisse 1 ou 2	4,10 DH/ unité	13,5	28 pour cent	3,78 kg	60 g	63	258,3 DH
Fishburger	15,2DH/ six unités		33 pour cent	4,46 kg	37 g	120	304
Soupe	12,4 DH/ boîte		39 pour cent	5,27 kg	395g	13	161,2

Un poisson de 13,5 kg engendrerait un chiffre d'affaire de 258,3 + 161,2 = 419,5 DH si les filets sont transformé en saucisse ou de (304 +161,2) = 465,2 DH si les filets sont transformés en fish burger sans compter le prix de vente des co-produits (peaux tannés et produits fermentés). Le poisson commercialisé en frais donnerait 13,5*30 = 405 DH.
La comparaison entre ces chiffres ignore le coût de l'énergie, de la main d'œuvre ainsi que des autres charges de gestion. Le seul intérêt de faire ce calcul est de montrer que la seule transformation des

filets rapporte le même prix que si le poisson était vendu en frais, ce qui laisse prédire qu'une utilisation totale du poisson et surtout en produisant des produits à haute valeur ajoutée comme le cuir, les hydrolysats etc… pourrait justifier la transformation.
Cependant il apparaît que, pour réaliser une rentabilité économique, il serait nécessaire de traiter une grande quantité de matière première afin de réaliser des gains substantiels (économie d'echelle). En effet l'exploitation des peaux et des produits fermentés ne donnerait un surplus significatif par rapport au gain réalisé par la vente en frais du poisson qu'à partir d'un grand tonnage traité car le rendement en peau et viscères est bas, comme on peut le voir à partir du tableau 2. Par ailleurs le coût d'investissement additionnel par rapport à un atelier de mareyage ne pourrait se justifiait qu'à partir d'une certaine quantité traitée à définir. Il est donc nécessaire de procéder à une étude plus approfondie avant de se prononcer sur la rentabilité économique d'une telle opération.

7. CONCLUSION ET RECOMMANDATIONS

L'espèce *Argyrosomus regius* présente effectivement un potentiel pour être valorisée. Son prix à la source est relativement bas. Une grande proportion reste inutilisée dans le cas de sa consommation en frais puisque les écarts représentent plus de 50 pour cent. Le rendement à l'utilisation est nettement amélioré par l'exploitation de ces écarts. Les produits fabriqués à partir de cette espèce trouvent une acceptation chez les consommateurs en général. Les produits qui n'ont pas été soumis aux tests de dégustation, devraient faire l'objet d'autres essais afin de mieux appréhender la taille du marché potentiel pour ces produits. Notamment des essais de tannage sur les peaux conservés par la technique décrite dans ce travail pourront confirmer l'aptitude à la transformation en cuir pour cette espèce. La rentabilité économique paraît être réalisable si l'ensemble du poisson est exploitée couplée à une production de masse. A ce niveau, une étude déterminant les conditions de rentabilité de tout projet d'exploitation industrielle devrait être menée.

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FOR A BETTER USE OF MARINE BY-PRODUCTS AND WASTES

by

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Abstract

On the estimated 90 millions tonnes of fish and shellfish produced each year, only one part is used for direct human consumption. Estimates of this direct use vary from 50 to 80 percent according to the type of species and the possibilities of processing. The remainder is used for the production of fishmeal/oil, including feed for aquaculture and other non-food uses. This under-utilization of marine living resources has to be considered along with their established over-exploitation. Therefore, the potential for exploiting more than that is presently treated very large and for taking advantage of the high added-value of the different types of molecules already present in fish by-products: enzymes, biologically active peptides, antioxidants, lipids, etc. The recovery of valuable quantities from fish processing waste, discards from white fish, oily fish and crustacean sources leads to a diverse range of useful by-products that may be enzymatically hydrolyzed to provide bio-active ingredients specifically suitable for the production of healthy fish for human consumption and thereby for human nutrition. This integrated project is centred on the production – by biotechnological treatment – of useful fish by-products, of extracts and functional molecules exhibiting nutritional and health enhancing properties. It targets overlapping domains of human nutrition and animal feed.

The main objective of this presentation is to contribute to the minimization of the adverse ecological and environmental impact of fishing activities (on shore) and, in compliance with the common fisheries policy, to promote a responsible and sustainable management of fisheries by developing and implementing efficient and integral waste management and processing practices to recycle and to reuse wastes produced by the fishing industry. In keeping with this objective, two goals will be pursued: first, to systematically assess the viability of management and processing practices on fishing discards, by-catch and wastes to recover and to produce valuable chemicals of interest to the food, feed, nutraceutical and pharmaceutical industries; second, to demonstrate the validity of such an approach by giving examples.

1. INTRODUCTION

In 2002, about 74 percent (65.5 million tonnes) of the estimated world's fish production, excluding China, was used for direct human consumption. The remaining 26 percent (23 million tonnes) was destined for non-food products, in particular the manufacture of fishmeal/oil. Seventy percent (62 million tonnes) of this production underwent some form of processing, and because fish is highly perishable, more than 90 percent of internationally traded fish and fish products are in processed form. Sixty-three percent (39 millions tonnes) of this processed fish was used for manufacturing products for direct human consumption and the rest (23 million tonnes) for non-food uses. Among these 37 percent of the initial fish body that are removed during processing, some are discarded (waste) and some are further used (by-products). In 2002, almost all the fish products used for non-food purposes came from natural stocks of small pelagics, which represented 37 percent of total capture fisheries. Most of these fishery products were used as raw material for the production of animal feed and other products. Ninety percent of world fish production (excluding China) destined for non-food purposes was reduced to fishmeal/oil, the remaining 10 percent was largely utilized as direct feed in aquaculture and for animals.

In its report in 2004, FAO has noticed a great by-catch reduction from 27 million tonnes in 1994 to 7.3 in 2004, which represents nowadays 8 percent of the total catch. Many factors have contributed to this decrease: the promotion of the Code of Conduct for Responsible Fisheries; scientific and fishermen concerns over the impact of unsustainable fishing practices; economic factors, such as the costs of sorting catches, ecolabelling requirements, quotas on by-catch species; improvements in fisheries management and improved enforcement of regulations. Therefore, if the catches are less and less discarded on board they are nowadays landed. Moreover, as marine products are more and more processed, the volume of the non-food part (wastes or by-products) is increasing.

The aim of this presentation is to demonstrate how benefits can be obtained from good management of this non-food part of the catch. In order to develop more sustainable fishery practices, wastes need to become by-products, and better uses of by-products need to be developed. Indeed, such biomasses contain great potential of added value, especially because of their valuable components, such as proteins and lipids. If fishmeal/oil are the traditional products derived from these materials, their production requires equipment that is not available worldwide. Moreover, the global prices of these resultant products are not very high (about US$0.6/kg) and very few benefits are, ultimately, collected by fishermen. This presentation will examine another strategy based on global and complete upgrade of this biomass by using simple technology and biotechnological treatments. The resulting sustainable process will be described into successive steps of processing, some of which could be easily transferred everywhere, even to a single fisherman, while other operations could lead to the development of small or medium industries. Thus, a larger amount of biomass could be upgraded, instead of becoming waste material, and the resulting benefits could be distributed to different actors, including the initial fishermen.

2. METHODOLOGY

The technological challenge is to develop processes and products with adequate physical and bioactive properties for use in feed; food and functional foods (nutraceuticals) without the negative effects of unpleasant flavours, lack of stability or processing functionality. The novelty of this project is both in utilization of new techniques and in the integrated approach used in the project (Figure 1).

The first part of this multistep process is based on the production of marine hydrolysates in order to solubilize a great part of this marine biomass. Such hydrolysates can be obtained by adding external enzymes, such as industrial proteases or by using internal enzymes leading to autolysates. The resulting "soup" will then be physically fractionated into three parts by centrifugation: sludge, aqueous and oily phases. Then each phase can be further fractionated in order to concentrate valuable components.

2.1 Liquefaction of the biomass – production of hydrolysates

This initial step can be conduced by different methods. From the most simple, which consists in supporting the internal enzymes to react with their substrate (the digestive protease for example), to the most sophisticated one, which is a controlled and regulated hydrolysis using external enzyme, pH and temperature controller.

The simplest procedure is the production of fish silage (autolysate) by enhancing the action of the internal enzyme, such as digestive proteases. Several different methods can be used to produce fish silage: (1) adding inorganic or organic acids to lower the pH to a point where it is stable; (2) addition of inorganic or organic acids to lower the pH to a point at which intrinsic enzymes will liquefy (which are normally most active around pH 4 and at temperatures between 35 and 40 °C) the protein prior to adding additional acid to stabilize the pH to a level that is suitable for storage; and (3) adding carbohydrates and allow fermentation to occur, so that enough acid is produced to stabilize the silage. Quality of substrate used to prepare the fish silage is directly related to the quality of the resultant fish silage. If silage is prepared from partially decomposed materials, then the histamine levels in the fish silage will reflex what was present initially.

To obtain a more standard product, the external enzyme, such as industrial food proteases, has to be used. The hydrolysis is initiated by adding the enzyme at the correct range of temperature (generally 40 to 60 °C) and stopped by a heat shock during short time (generally 80 °C during 15 minutes). The time length of the hydrolysis will depend on the enzyme and biomass selected. Solar technology could be used for getting the required calories instead of a traditional process.

The most elaborated hydrolysis is the one which is completely under control, which means pH, temperature and time regulations. This is what is currently done in technological plants dealing with such products that produce standard fish hydrolysates with the most added value.

2.2 Separation of phases

After hydrolysis, two or three phases are obtained. For non-fatty wastes (by-products), then only aqueous phase and sludge can be collected, while for fatty biomass an additional oily phase can be separated.

The easiest way to separate solid and liquid phase is to filtrate on sieves. In this way, the non-hydrolysed material (fish bones, non-soluble proteins, some lipids) is removed from the soluble part (peptides, soluble proteins, some lipids). This basic filtration is quite easy to conduce for lean "soup" but much more difficult for fatty "soup". In this case, a physical three-way decanter is generally used allowing the recovery of oily phase, aqueous phase and sludge. This equipment is quite expensive and the operation can only be conduced in industrial plants while basic filtration can be realized at the seashore or just near the landing and transformation zones of marine biomass.

2.3 Fractionation of phases

These latest procedures are the ones that can improve the quality and the added value of the products. They are not needed for every kind of biomass but can be very useful in some cases.

Remark: The sludge that contains the insoluble part cannot be fractionated but can be submitted to a new hydrolysis with other enzyme in order to solubilize additional matter.

At this stage, the level of fat will be quiet low because the oily phase had been separated previously. Thus, only the fractionation of aqueous phases will be presented here.

It is well known that molecular weight of protein hydrolysates influences their functional properties and that the extent of enzyme hydrolysis controls the molecular size distribution in a hydrolysate. Thus, ultrafiltration membrane system is necessary if a hydrolysate or a peptide fraction with desired molecular size and functional properties is to be produced. In this presentation, the resulting hydrolysates are characterized in a molecular weight point of view (by size exclusion chromatography). Then both static adsorption and concentration experiments are carried out in order to detect strong membrane organic matter interactions and to identify the ability of nanofiltration (NF) and ultrafiltration (UF) membranes to concentrate, purify and fractionate the peptide solutions from enzymes or unhydrolysed proteins. Then the processed hydrolysates will be passed through a series of selected filtration membranes with different molecular weight cut off in order to concentrate the most interesting part.

2.4 Bio-assays

Such resulting hydrolysates can be used for traditional purposes (feed, fish sauce, etc.), but also for new and promising applications, mainly as nutraceutical components. Thus, systematic processing of hydrolysates for the production of bioactive peptides can yield promising new compounds (fractions) that can be used in functional foods. Among the many bio-assays available, the influence of the resulting hydrolysates on the regulation of blood pressure (angiotensin converting enzyme), calcium metabolism (calcitonin activity), gut function (gastrin and cholecystokinin secretions) and on food safety stability (cytotoxicity, antiviral and antibacterial activities) will be presented.

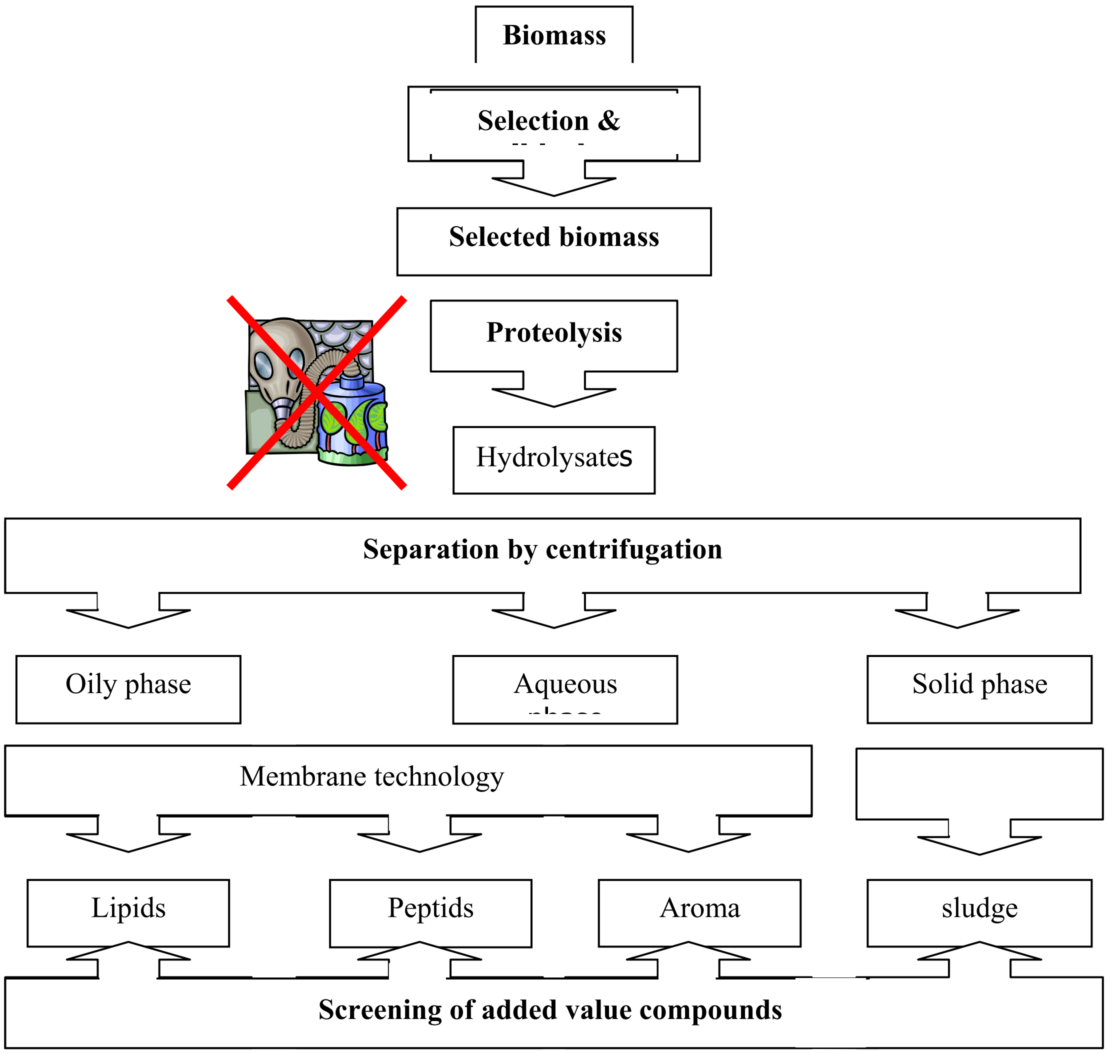

Figure 1: General methodology for upgrading marine by-products

3. RESULTS

3.1 Autolysates

Autolysates, usually called fish silages, have been traditionally used for a long time for feed. Indeed, the ensiling of fishery waste can be an easy and economical method of preserving fishery waste so that it can be fed at a later time. In some cases, particular autolysates are used as food. Indeed, nowadays in Asia and particularly southeast and China, people eat such products mainly as "fish sauce". Fish sauce is a condiment derived from fish that has been allowed to ferment. The term describes a wide range of products used in many different cultures at different times: *nước mắm* (Vietnam); *nam pla* (Thailand); *patis* (Philippines); *yúlù* (China), *shottsuru, ishiru* and *ikanago-jōyu* in Japan. However, such condiments were also eaten in Europe. Thus, a similar fish sauce was ubiquitous in Classical Roman cooking, where in Latin it is known as *garum* or *liquamen*, and also existed in many varieties, such as *oxygarum* (mixed with vinegar) and *meligarum* (mixed with honey). In English it was formerly known as *fishpickle*. The original Worcestershire sauce was a similar product, brought to England from India.

3.2 Feed

After hydrolysis (with or without external enzyme), the remaining insoluble part (sludge) is rich in minerals and insoluble proteins and sometimes also in complex lipids, called phospholipids. Such “biomass” is a good substrate for feed applications (notably aquaculture, porcine nutrition, poultry, etc.) that don’t need further sophisticated transformations, except drying and powdering.

The emphasis on piscivorous finfish and crustacean culture necessitates quality, high protein feeds based on fishmeal. This constrains the future expansion of the aquaculture industry and is also deleterious to both the fisheries and environment. Fish proteins, fish lipids, as sources of numerous and valuable biologically active substances, are now taken into consideration as components of functional foods and feeds. In aquaculture, these molecules can be added in specialized feeds for juvenile stages of production and in diets designed to minimize stress and also as potent feeding stimulants/attractants for species exhibiting difficult feeding behaviour. The probiotic, immuno modulatory and growth promoting factors present in these fractions will promote healthier fish with improved conformation and flesh quality. The latter is of considerable importance to the consumer and is currently driving the emphasis of research. One aim is to provide bioactive ingredient to plant-based protein feeds from marine processing wastes (particularly hydrolysates) for which the conventional fisheries sector guarantees a reliable supply of accessible and safe material.

The recovery of valuable fractions from fish processing waste, discards from white fish, oily fish and crustacean sources will lead to a diverse range of useful by-products that may be enzymatically hydrolysed to provide bio-active ingredients suited to specific requirements for the production of healthy fish for human consumption.

3.3 Nutraceutical ingredients

As far as marine products are concerned, positive relationships between nutrition and health demonstrate the virtues and benefits of fish-enriched diets. In particular, a series of dietary complements have been developed around enriched oils, growth activating fish hydrolysates, etc. The positive market aspect of “marine extracts” combined with the identification of new targeted biological activities support the market potential of this project. The emerging trends and new ingredients opportunities permit the selection of a panel of biological activities of direct interest to consumers. Some examples are:

- Calciotropic agents: The ageing global population considerably increases the occurrence of osteoporosis, a severe disabling disease.

- Digestive hormonal control: satiety and appetite.

- Anti-hypertensive activities: Hypertension is one of the major causes of cardiovascular disease. Looking for anti-hypertensive peptide in fish by-product hydrolysates and checking their ability to reduce the risk of disease is a paramount goal in matters of public health.

- Antioxidants: Antioxidants prevent injury to blood vessel membranes, defend against cancer-causing DNA damage, and help to lower the risk of cardiovascular disease and dementia, including Alzheimer's disease. Recent developments in the use of marine products (peptides, amino acids and fatty acids) to prevent free radical pathologies in humans are promising.

- Antibacterial activities: against pathogenic strains for preservation and food safety.

In addition to these hydrolysates, the oily phase is also of great interest. Indeed, it is well known that some fatty acids and notably the omega-3 are good for health in general and for the heart in particular. The hydrolysis process on fatty fish, leads to the separation of an oily phase from the sludge and the aqueous phase. If care is taken (not too high temperature, good separation procedure), then this fatty fraction is of a very good quality. Indeed, as opposed to classical fish oil production, this soft technology procedure does not involve high temperature and pro-oxidizing conditions. Thus, the resulting oil rich phase is devoid of trans-fatty acids and does not contain too much oxidized compounds. Therefore, the remaining refining procedure to fulfil the nutraceutical exigencies for such ingredients is not so important, and the final cost for getting the same end product quality is much less.

At least, food safety could be guaranteed by choosing wild organisms caught in non-polluted zones. Moreover, because enzymatic hydrolysis results in products that do not contain proteins in native form, the allergenicity and potential toxicity is therefore reduced.

In this context, products of marine origin may be of considerable value in providing adequate nutrition, health protection and improved product quality with positive implications for human health. Some of the characterized bioactive molecules are likely to possess an original structure, leading to further developments in pharmaceutical and associated fields.

3.4 Flavours

After purification and concentration steps by filtration membranes, the effluents (permeate) can be checked for their flavouring properties. Indeed, it is well known that flavour compounds are developed during processing of fish proteins, notably hydrolysis. For such upgrading of the effluents, additional assays have to be carried out; for example measurements of peptides and amino acids (bitter taste), influence of volatile compounds (contributing to the overall aroma) and sensory perception (for food applications).

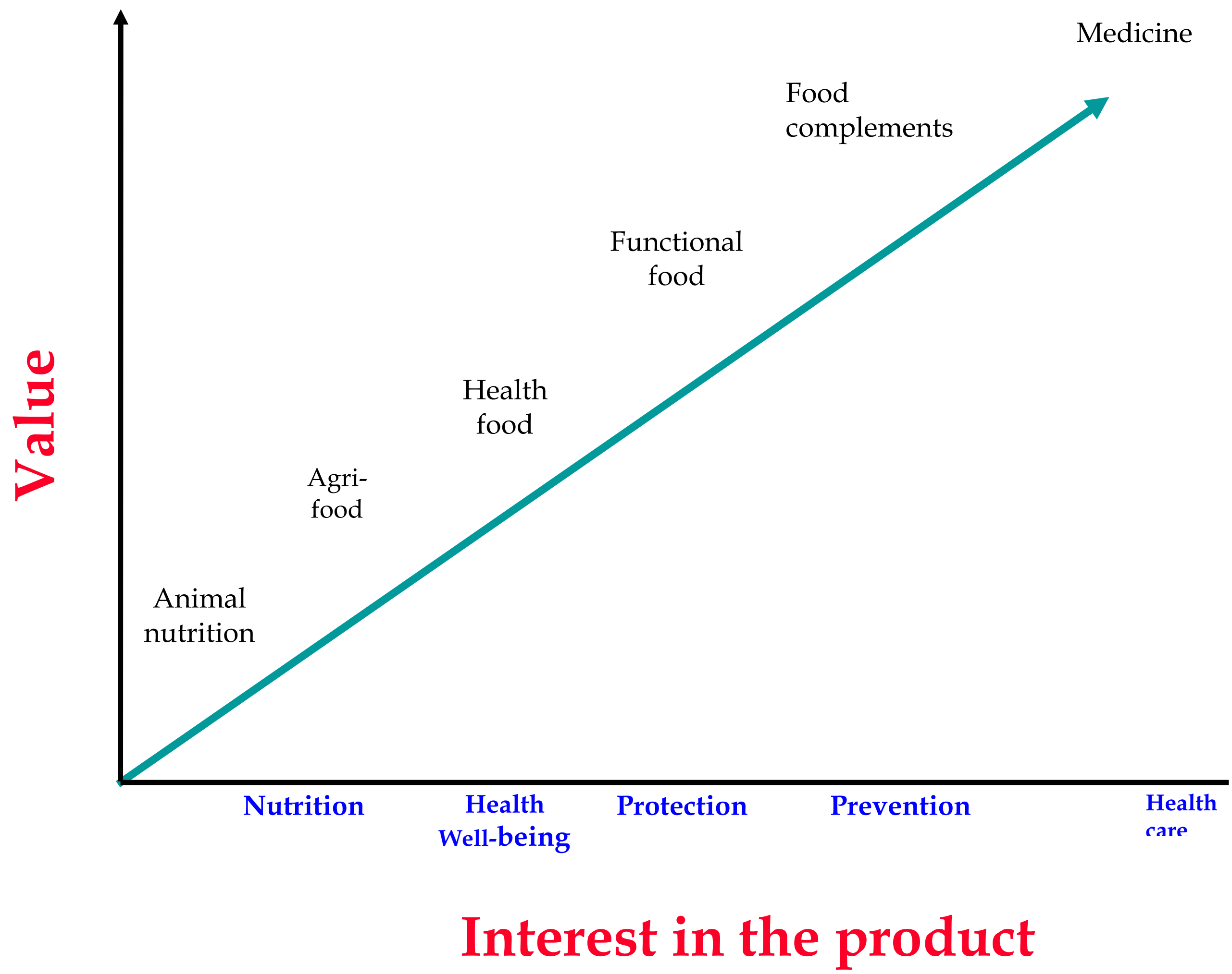

Figure 2 : Illustration of the relation between interest in the product and its unit market value

4. CONCLUSION AND PERSPECTIVES

The fisheries and aquaculture industries produce a large quantity of potentially valuable biological material that is currently wasted. With increasing pressure on traditional fishing activities, it is essential to maximize the return from the resource. New processes to extract and purify useful substances of industrial interest from these waste resources have been developed. Nowadays it is possible to exploit better while fishing less!

The tasks range from the selection of seafood by-products as raw material for upgrading, the mapping of compounds for feed, food or with health beneficial effects. The challenge would be – by the use of advanced minimal processing techniques – to obtain novel compounds or improve the functional (nutritional and health promoting) characteristics of some existing ones, with a catalogue of technological properties that give added value to these products and contribute to minimize wasting.

What can be exploited? Some examples

Agro-food, health-food and pet-food

High added value molecules can be exploited through the use of by-products obtained from raw materials. Thus, recovery of high added value molecules from marine by-products can be used to generate novel animal feed products, such as hydrolysates, fish meal or solubilized in the form of intended ensilages aimed at the pet food market. New methods of biotechnological treatments of the fished biomasses and marine by-products also allow for the production of molecules with high added value in human food (e.g. flavours, dyes, peptides, lipids, fatty acids, proteins).

Effluent treatment

Development of novel methods of effluent treatment from seafood processing plants: These methods not only treat the effluent but are also energy saving.

Fishery

Many fished species are not fully utilized. How to use them properly?
New biotechnological treatments of the fished biomass and marine by-products have been developed for the production of molecules with high added value (flavours, dyes, peptides, lipids, proteins). These substances have a specific potential in the fields of health, of human and animal nutrition and in many other areas.

Aquaculture, improving fish health

The marine resources can also be used in improving the health of fish in aquaculture through the control of viral infections, development of new vaccines and disease prevention.

In order to succeed in this reduction of marine resources wasting, everybody involved in fisheries has to be concerned and has to receive a positive feedback in exchange of his implication. For that, the most numerous processing techniques have to be transferred directly to fishermen or just near the landing zone. Such procedures must be soft, sustainable and quiet simple. The project I present fulfils these criteria.

In addition, I would like to note that based on this general strategy of upgrading “wastes”, a French network (SEApro) was created at the beginning of this year (Figure 3).

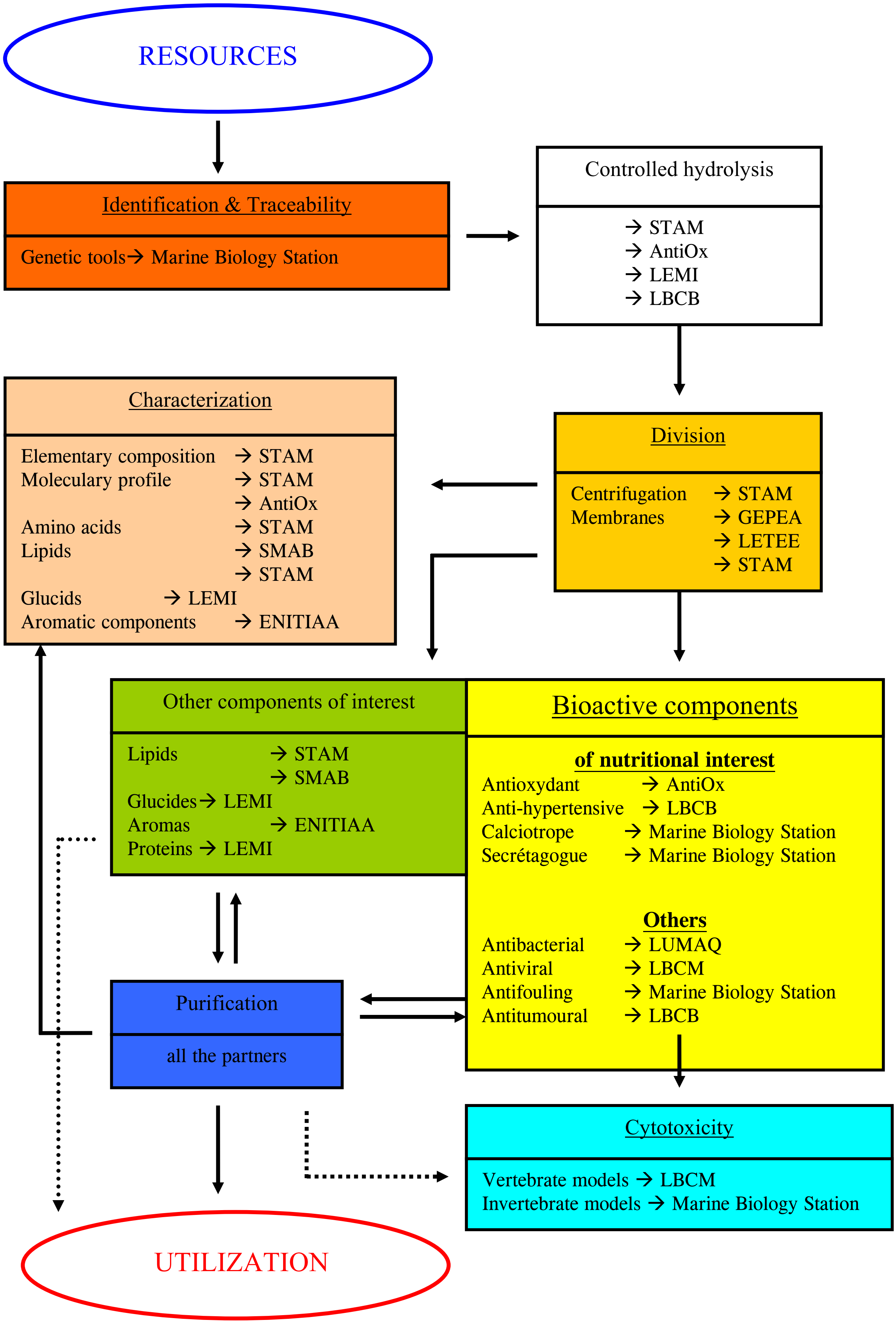

Figure 3: Diagram showing the research strategy and positioning of the partners

UTILIZATION OF FLESH FROM BONGA (*Ethmalosa fimbriata*) AS SALTED DRIED FISH CAKES

by

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Abstract

The composition and yield of mince prepared by passing gutted and dressed bonga (*Ethmalosa fimbriata*) through a flesh-bone separator were determined and compared with other clupeids, West African sardines (*Sardinella maderensis*) and shad (*Ilisha africana*), of economic importance. Food grade salt, NaCl (5 to 30 percent) was added to the mince to prepare salted cakes. Pre-heat treatment of freshly prepared salted cakes for 2 hours at 70 °C prior to solar drying was found to promote a rapid initial exudation of moisture from the mince, a factor that reduced total drying time and improved the appearance, flavour, odour and texture of the product with enhanced keeping quality. The dried cakes were assessed for peroxide and TBA values, bacterial counts and for sensory attributes immediately after preparation and after a 6-month storage period at 30±2 °C. The cakes were reconstituted by desalting in boiling water. Salted dried cakes prepared with different salt concentrations were found to be stable and have little sensory deterioration over the 6-month storage period, which is adequate to allow for the distribution of products at tropical ambient temperature.

Résumé

La composition et le rendement de hachis préparé en passant du bonga éviscéré et paré (*Ethmalosa fimbriata*) à travers un séparateur de chair et os sont déterminés et comparés à d'autres clupéidés d'importance économique, que sont les sardines ouest africaines (*Sardinella maderensis*) et (*Ilisha africana*). Du sel d'alimentation, NaCl (5 à 30 percent) a été ajouté au hachis pour préparer des gâteaux salés. Le préchauffage en 2 heures à 70 °C avant séchage solaire des gâteaux fraîchement préparés a montré une exsudation rapide de l'humidité du hachis, un facteur qui a réduit le temps total de séchage et amélioré l'apparence, la flaveur, l'odeur et la texture du produit avec une qualité améliorée. Les valeurs de peroxyde, TBA, bactériennes, attributs sensoriels immédiatement après préparation et après 6 mois d'entreposage à 30±2 °C des gâteaux ont été évalués. Les gâteaux étaient reconstitués par dé-salage dans l'eau bouillante. Les gâteaux salés séchés préparés avec différentes concentrations sont stables et ont une légère altération sensorielle au-delà d'une période d'entreposage de 6 mois, qui est adéquate pour permettre une distribution des produits à température ambiante tropicale.

1. INTRODUCTION

Salting of mince is an attractive alternative to traditional salting of whole fish. The quick salting of mince reported by various workers (Bligh, 1977; Young *et al*., 1979) for the production of salted fish cakes has resulted not only in a product of new appearance but also of better keeping quality than traditionally salted fish. A wide variety of products can be made from the coarse mince ranging from salted dried to frozen, spiced and canned fish cakes (Zain, 1980; Talberos and Young, 1982; Poulter, 1982).

In many developing countries where access to refrigeration storage is only in the upper income group, the development of quick salting process for the production of salted dried cakes is a welcome relief because the cakes require no refrigeration, even at tropical ambient temperatures (Del Valle, 1974). Factors responsible for the high keeping quality of such products are low moisture, high salt levels and low bacteria counts (Del Valle *et al.,* 1976).

The bonga (*Ethmalosa fimbriata* – Bowdich) is one resource whose utilization has a great potential. It is a coastal and estuarine clupeid that is found on the West African coast from Mauritania to Angola and contributes significantly to the promotion of food self-sufficiency in the sub-region (Jallow, 1994).

Bonga contributes between 11 and 86 percent of the small pelagic fish landings in these countries, with Nigeria having the highest contribution of 86 percent. Bonga is the most important pelagic fish in the artisanal fishery of the coastal states in Nigeria, accounting for between 20 and 30 percent of artisanal catches. However, bonga is a fish with lots of inter- and intra- muscular bones, seldom consumed in the fresh form but finds major utilization in the smoked form. In the smoked form, the yield of edible portion is 39 percent (Egwele *et al.*, 1986). This yield can be substantially increased through the process of flesh-bone separation of the fish to produce good quality mince thereby increasing the edible portion of the fish.

The objective of this work is to utilize the mince recovered from bonga for the production of quick-salted fish cakes using different proportions of salt and to present data on some properties of the salted dried fish cakes on storage.

2. MATERIALS AND METHODS

2.1 Fish samples

Bonga were caught in Nigeria waters on board the Nigerian Institute for Oceanography and Marine Research (NIOMR) research vessel, M.V. OKION. The fish were frozen on board at –30 ^{0}C and landed frozen after two weeks of fishing. The fish were then delivered to the Institute's cold store operating at –22 ^{0}C and kept at this temperature for subsequent use.

2.2 Production of mince

The mince was prepared from thawed, washed and gutted bonga. The processing method involved nobbing manually, washing to get rid of blood, pieces of gut, kidney tissue and swim bladder. Dressed bonga was then put through a Baader 694 (Lubeck, FRG) belt and drum type flesh-bone separator with a standard drum of 5 mm diameter orifices. The yield of the mince was determined and compared with other pelagic clupeids, West African sardines (*Sardinella maderensis*) and shad (*Ilisha africana*), both of which are of economic importance.

2.3 Production of salted cakes

Minced fish were thoroughly mixed with food grade salt (NaCl) (UNION DICON SALT PLC, Lagos, FRN) in various concentrations (5–30 percent, expressed as percent proportions of the weight of mince) using "*Leland*" double action mixer. The mixture was allowed to stand for 15 minutes before pressing out the excess liquor through a cheese cloth, using hand operated press. Cakes (60 g) were moulded using an *Accupat* food former. The moulded cakes were pre-heated in a hot air oven on a wire gauze for 2 hours at 70 ^{0}C prior to low temperature drying in NIOMR cabinet type natural convection solar drier at between 40 and 60 ^{0}C for 46 hours (effective sunshine time is actually 8 hours). For the 46 hours duration of drying, the outside temperature ranged between 30 and 34 ^{0}C (excluding night temperatures).

2.4 Storage Trials

Salted dried cakes packed in low-density polyethylene (LDPE) bags were stored in a cupboard at room temperature of 30±2 ^{0}C. Proximate composition, chemical indices of quality measurements, microbiological examination and sensory evaluation were carried out at zero months and after six months of storage.

2.5 Chemical analysis

Crude protein was determined by the Kjeldahl procedure using a nitrogen factor of 6.25 (Pearson, 1981). Total lipid was determined by the Bligh and Dyer (1959) method. Air oven drying at 103 ±2 ^{0}C was used to determine the moisture content and ashing was by incineration in a muffle furnace at 525 ^{0}C. Minced flesh of bonga was analysed for scales and bones content by determining the calcium content using precipitation of oxalate method (Pearson, 1981**)**. Peroxide Value (PV) and Thiobarbituric Acid

(TBA) numbers were determined by the methods of Lea (1952) and Tarladgis *et al.* (1960) respectively. Malonaldehyde (MA) standards were prepared as described by Sinnhuber and Yu (1977).

2.6 Microbiological analyses

Total Viable Count (TVC) to assess the general quality of the product was determined using serial dilution of macerated samples plated out on a standard plate count agar (SPCA) and incubated at 25 ^{0}C for 48 hours. This is the temperature suggested for the optimum growth of micro-organisms of marine origin present in fish (Del Valle *et al.*, 1973). *Staphylococci* count to indicate the level of hygiene employed during production processes was determined by plating on Baird-Parker medium. Incubation was at 37 ^{0}C for 24 hours. Any colony showing black spots with white zones was sub-cultured on a nutrient agar slope, and a coagulase test carried out on rabbit plasma for confirmation of *Staphylococcus aureus*.

2.7 Preparation and sensory evaluation of fish cakes

Salted fish cakes were desalted by soaking in freshwater (fish: water ratio of 1:10 by weight) for 30 minutes. The soak water was replaced with the same quantity of freshwater, heated to boiling and simmered for 15 minutes. (Young *et al.,* 1979). Desalted cakes were served hot to six assessors experienced in evaluating salted fish products and were asked to score the coded desalted fish cakes using 1–5 intensity scales for odour, colour, texture, saltiness, rancidity and fishy taste.

2.8 Statistical analysis

The data were analysed using one-way analysis of variance (ANOVA) and significance between means was determined using Duncan's (1955) multiple range test at $p< 0.05$ level. The software used was SPSS Inc. 1995.

3. RESULTS

3.1 Production, yield and composition of mince

Flesh-bone separation of mince was carried out using Baader 694 flesh-bone separator fixed with 5 mm drum orifice. Mean yields from triplicates and compositional data of bonga mince are presented in Table 1. The yield of mince from dressed bonga fish was found to be 66.27 percent. Comparison of yield of mince from bonga fish with other clupeids, the family to which bonga belongs, reveals some similarities. Yields of West African shad (*Ilisha africana*) and West African sardines (*Sardinella madarensis*) were found to be 63.00 and 64.85 percent respectively.

3.2 Microbiology of mechanically deboned mince

Total viable counts (TVC) and *Staphylococcus aureus* counts were carried out on whole, dressed bonga and mince produced through mechanical deboning operation (Table 2). The TVC of bonga decreased by a factor of 4 from 1.4 X 10^6 for whole ungutted fish to 3.5 X 10^5 after dressing and then increased by a factor of 3 to 9.7 X 10^5 after flesh-bone separation. *Staphylococcus aureus* was apparently present in both whole and dressed fish as well as in minced fish. *Staphylococcus aureus* increased progressively from whole fish through the process of dressing and peaking after mechanical deboning operation.

3.3 Effect of different salt levels on mince and cake formation

The addition of 5, 10, 15, 20, and 30 percent salt to bonga mince produced minces and cakes having different appearances and texture (Table 3). For salting ratios up to 15 percent, no exudate is lost from the mince, which gelatinizes and retains its Water Holding Capacity (WHC). At 20 percent salt/fish ratio, little exudate was noticed, and at 30 percent salt/fish ratio there was copious exudate, no gelatinization and the cake formation was slightly difficult. Pre-heat treatment at 70 ^{o}C for 2 hours of cakes with different levels of salt showed a rapid initial loss of weight.

3.4 Storage trials

Changes in moisture, PV, TBA and TVC of salted dried bonga cakes packed in low-density polyethylene (LDPE) bags at zero and after six months storage at tropical ambient temperature of

30±2 °C are presented in Table 4. Higher moisture was observed in 5, 10 and 15 percent salt concentration at zero and after 6-month storage compared to 20 and 30 percent salt concentrations. The peroxide value (PV) at zero month storage showed an increase with increasing salt concentration up to 15 percent and thereafter a decrease for the 20 and 30 percent salt concentrations. The trend exhibited after six months storage period however showed a gradual increase from 5 to 30 percent salt/fish ratios.

Thiobarbituric acid (TBA) values show a gradual increase with salt/fish ratios. The increase was however, more pronounced as from 15 percent salt concentration with highest values recorded for 20 and 30 percent salt/fish ratios respectively. The TBA values also increased with increasing PV and decreased with corresponding decrease in PV.

TVC decreased with storage time in all the cakes. There was a drastic reduction in the bacteria load from 5.1×10^5 cfu/g for unsalted mince to between 5.4×10^2 and 4.8×10^3 cfu/g at zero day salting. A further reduction to between 30 and 210 cfu/g was also recorded after six months of storage at 30 ±20 °C.

3.5 Sensory evaluation of cakes

Sensory evaluation of cakes with 5, 10, 15, 20 and 30 percent salt concentrations was assessed after drying and after six months storage period (Table 5).

4. DISCUSSION

4.1 Production, yield and composition of mince

Yield of mince varies with species and is a function of anatomical features of the species involved. The yield of bonga in this study falls within the range reported by Grantham (1981). The percentage loss was found to range between 8.73 and 10.20 percent. The percentage loss during flesh-bone separation depended on the efficiency of the scrapping, the nature of the flesh and the drip loss.

The proximate composition of mince from bonga (Table 1) was within the range reported for other fish species (Emokpae, 1986). Calcium contents of the mince as a measure of scales and bones were 0.47 percent and very close to the recommended upper limit of 0.5 percent (USDA, 1975). Bonga is a bony fish with intra- and inter-muscular bones and, as such, high level of calcium is expected. Patashnik *et al.* (1974) reported that the frequency of bone particles in minced fish is dependent on the drum size and species of fish. The presence of bones in minced fish can serve as a source of calcium especially for growing children, provided the bone particles are small and not sharp.

4.2 Microbiology of mechanically deboned mince

Flesh-bone separation increased the bacteria count (Table 2) by 3-fold because of increased surface area and smaller particles of flesh created as a result of the mincing process. Blackwood (1974) reported that by maintaining good standard of hygiene with a good quality starting raw material, the bacterial counts can be reduced by a factor of about 20.

The numbers of *Staphylococcus aureus*, although present in the fish, were however within the specified limit by ICMSF (1978) for fresh fish. The presence of *Staphylococcus aureus* is generally taken to mean post-handling contamination. Clucas and Ward (1996) observed that the skin of the processing personnel is an important source of this pathogen.

4.3 Effect of different salt levels on mince and cake formation

The process of pre-heat treatment in this investigation denatures the protein and releases bound water thereby reducing the drying time considerably. Young *et al.* (1979) observed that preheating produced a less moist and more porous product, reduced enzymic activity, and components likely to confer strong fishy tastes to the cakes are exuded. The characteristics of these cakes are influenced by whether protein denaturation occurred during salting and subsequent drying. Duerr and Dyer (1952) reported that cod muscle protein is denatured when a critical salt concentration, about 8 to 10 percent in the muscle is reached. Protein denaturation of bonga mince in this investigation occurred at salt concentrations of between 20 and 30 percent when little and copious drips were being observed respectively. The pre-heat treatment of these cakes also consequently resulted in easy removal from the wire gauze or tray after drying.

4.4 Storage trials

Higher moisture in 5, 10 and 15 percent salt concentration at zero and after 6-month storage compared to 20 and 30 percent salt concentrations can be explained from the point of view of protein denaturation and water holding capacity. Wet mince without salt has a high water-holding capacity, but at 20 percent salt concentration denaturation of protein starts to occur with little drip and therefore less water is retained after drying. At 30 percent salt concentration, complete denaturation may have occurred resulting in a faster drying rate and subsequently leading to low final moisture content of these particular cakes.

The overall result of PV shows that salt assisted in accelerating rancidity development in salted cakes. While it is possible to say that salt has acted as a pro-oxidant in all the cakes as a result of high peroxide values, the decrease observed in 20 and 30 percent salt concentrations may be explained from the point of view of peak formation. It is possible that at 20 and 30 percent salt concentrations the rate of lipid oxidation has been so rapid resulting in the termination stage of hydroperoxides formation. Peroxides are intermediate products of lipid oxidation and are themselves decomposed into aldehydes, ketones and short chain acids as oxidation progresses (Lundberg, 1962). This is why figures for the peroxide values were high for cakes after drying compared with cakes after six months storage period.

The TBA value is a measure of malonaldehyde, an end product of peroxide decomposition. Similar findings with other food systems have also been reported by various workers (Botta *et al*., 1973 and Labuza, 1981). This shows the complexity of food system containing many chemical constituents, which are likely to interact with products of lipid oxidation. Kwon *et al.* (1965) have suggested that the decrease observed in TBA may be the result of interaction between proteins and amino acids in the food system and malonadehydes or other aldehydes produced as a result of lipid autoxidation.

TVC decrease with storage time has been reported in similar work (Del Valle, 1973). The pre-heat treatment combined with high salt concentration must have caused a substantial reduction in bacteria load.

4.5 Sensory evaluation of cakes

All sensory attributes of colour, odour, saltiness, fishy taste and texture remained relatively stable during the six months storage period. The 5 and 10 percent salted cakes, however, developed a strong fish odour, other off-odours and tastes, and a dark brown colour, and were unacceptable. Rancidity scores at zero and after six months storage period were generally low for all the cakes and within the acceptable median score of ≤ 3.0. The taste panel rancidity scores were tested against PV and TBA values. There was a significant correlation ($p < 0.05$) of rancidity scores with PV and TBA numbers as previously reported by Cole and Keay (1976).

5. CONCLUSION

It is concluded that a value added food product can be produced from bonga, which is reasonably stable under ambient tropical storage conditions for up to 6 months, a time sufficient enough to distribute the product far and near consumer centres. The improved product from bonga has shown that the fish can be better utilized outside the traditional smoked form.

Table 1: Percentage yields, proximate composition and bone content (calcium) of mechanically deboned minced of bonga (*Ethmalosa fimbriata*) compared with sardines (*Sardinella maderensis*) and West African shad *(ilisha africana)*.

Parameters	Bonga	Sardines	Shad
Yield (%)	Bonga	Sardines	Shad
• Mince	65.27±0.86	64.85±0.74	63.00±0.78
• Residue	24.87±0.72	26.42±0.93	26.84±1.00
• Loss (by difference)	8.86±0.20	8.73±0.76	10.16±0.68
Proximate composition (%)			
• Moist	75.76±0.76	77.86±0.74	78.70±0.44
• Protein	19.94±1.12	19.75± 0.99	19.90±o.66
• Lipid	2.76±0.50	1.97±0.58	1.00±0.13
• Ash	2.25±0.26	1.80 ±0.32	1.70±0.83
Calcium (%) (as a measure of bones and scales)	0.47±0.02	-	-

Table 2: Bacteria counts of whole, headed and gutted bonga and minced fish

Parameter	Whole fish	Dressed fish	Mechanically deboned mince
Total Viable Count (TVC)	1.4×10^6	3.5×10^5	9.7×10^5
Staphylococcus aureus	1.0×10^2	1.6×10^2	2.5×10^2

Table 3: Observations on characteristics of bonga cakes prepared at different salt levels

Salt cake (%)	Salted wet mince	Dried cake
5	Gelatinous/fleshy, no drip, easy to form into cakes.	Dense, shrunken gel with leathery structure; dark brown coloration.
10	Gelatinous and fleshy with no drip, easy to form into cakes.	Firm and close texture; retain cake structure; dark brown colour.
15	Gelatinous and fleshy, no drip, easy to form into cakes	Rough, striated surfaces, retain cake structure; light brown colour.
20	Some drip, easy to form into cakes. Firm and gelatinous	Light brown colour; smooth and consistent surface; retain cake structure.
30	Copious drip. No gelatinization and difficult to mould into cakes. Need to press out liquor for proper cake formation.	Lighter colour with porous structure.

Table 4: Rancidity measurement and total viable counts of salted bonga during drying and storage at ambient temperature (30 ±2 ^{0}C)

Sample	Storage time (months)	Moisture (%)	PV MEq0_2/kg of lipid	TBA mg MA/kg of sample	TVC (cfu/g)
Mince		77.76±0.79	4.8±0.14	2.50±0.15	5.1x10^5
Dried salted cakes					
5 %	0	21.74±0.66	122.80±0.91	41.80±0.54	4.8x10^3
10 %		19.82±0.66	166.03±0.09	61.30±0.71	2.1x10^3
15 %		17.22±0.27	180.00±1.41	62.50±0.45	1.9x10^3
20 %		12.81±0.75	61.40±0.71	28.60±0.67	5.4x10^2
30 %		10.23±0.16	58.20±0.73	24.20±0.62	1.8x10^3
5 %		21.00±0.59	21.20±0.29	15.00±0.35	2.1x10^2
10 %		16.80±0.67	23.60±0.73	16.10±0.19	5.2x10^1
15 %	6	16.83±0.39	30.20±0.71	18.20±0.31	3.8x10^1
20 %		10.21±0.56	32.20±1.14	23.40±0.61	3.0x10^1
30 %		9.55±0.56	33.10±0.24	18.20±0.49	3.3x10^1

Table 5: Taste panel scores * + of dried salted cakes using different levels of salt concentrations

Parameter	0 month					6 months				
	5 %	10 %	15 %	20 %	30 %	5 %	10 %	15 %	20 %	30 %
Colour	4.0	3.8	3.0	3.0	3.0	4.6	4.0	3.2	3.2	3.0
Odour	3.2	3.0	2.6	3.0	2.6	4.2	3.8	3.0	2.8	2.4
Taste										
Salt	3.2	3.0	3.2	2.8	2.4	2.2	1.8	2.8	3.0	2.2
Rancidity	2.0	2.2	2.2	1.8	1.8	3.6	3.4	3.0	2.6	2.8
Fishy taste	3.0	2.8	2.4	2.6	2.8	2.6	2.8	2.2	3.0	2.4
Texture	3.2	3.0	2.6	2.4	2.8	2.4	3.0	2.4	2.8	2.2

*Score ranges:

Colour	1 = light	5 = dark brown
Odour	1 = no odour	5 = strong odour
Saltiness	1 = undersalted	5 = extremely salty
Rancidity	1 = not rancid	5 = extremely rancid
Fishy taste	1 = no fish taste	5 = very strong fishy taste
Texture	1 = soft	5 = granular

+Values shown are mean of six individual scores.

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