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SCOMBROTOXICOSIS IN AFRICAN FISHERIES-ITS IMPLICATIONS FOR INTERNATIONAL FISH TRADE: AN OVERVIEW

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ABSTRACT

Fisheries are important in many African countries because of their contribution to animal protein supplies, foreign exchange earnings and rural employment. An estimated 3 million people were directly employed annually in this sector in Africa in 2000-2004. Total fish production by African countries amounts to approximately 4 million tonnes annually. However, fish consumption has declined, from an average per capita supply of about 9 kg in 1990 to less than 7 kg in 2005. In Kenya, the per capita consumption was down to 5.2 kg in 2002 from 7.0 kg in 2001. The overall trade balance of the region continues to be positive (in monetary terms), even though the region has only a marginal role in international trade. The main future possibilities for increasing food-fish supplies in the region include productivity enhancement programmes in small water bodies, aquaculture development, better utilization of small pelagic and mesopelagic fish, relocation of foreign vessels to fish beyond the Exclusive Economic Zones, and greater catches of demersal fish in currently unexploited or underexploited fishing zones. Given the forecasts for modest growth in gross domestic product over the next few years, future prospects for further supply appear rather dim. Likely trends include further constraints on imports, increases in real fish prices, continued demand for mainly low-value species and the continuing export of most demersal production. At the same time, lower public subsidies will increase production costs and weaken competitiveness in export markets. The implications for food security and supplies as well as for foreign exchange earnings are difficult to quantify but might be a cause for concern in the future. To obtain any improvement in export or intra-African trade volumes requires increased production, investment in facilities and technology, as well as the adoption of food safety procedures aimed at processing for safety, value and quality. In a number of cases in the past, food safety concerns and scombroid fish poisoning have been a hindrance to export continuity and expansion. Because of the importance of trade for the social and economic development in African countries, the application of hazard analysis at critical control points in the fisheries sector, emphasis on public education, and the establishment of appropriate legislation to control scombrotoxicity and related fish-food hazards have the potential to enhance trade in fishery products from Africa in the international arena.

Key words: Fisheries, Africa, global trade, scombrotoxicosis

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INTRODUCTION-GLOBAL FISH SUPPLY

The total global fish supply for 2005 was 140 million tonnes with expected increases towards the end of the period 2006-2010 [1]. Worldwide, about 1 billion people rely on fish as their main source of animal proteins [2], with dependence on fish usually being higher in coastal than in inland areas. About 20% of the world's population derives at least 20% of its animal protein intake from fish, and some small island states depend on fish almost exclusively [3]. Cape Verde, Guinea Bissau, Morocco, Tunisia, Nigeria, Mozambique, South Africa and Angola, derive considerable economic and nutritional benefits from seafood exploitation [4]. In 2000-2004, Africa's fisheries sector employed 3-3.5 million people annually (about 4% of Africa's population) [4; 5].

Despite the relatively low consumption by weight in developing countries, fish contributes considerable calories per capita per day, but only in a few countries where a preference for fish has been developed and maintained as in Japan, Iceland and some small island states. Fish proteins are also essential and critical in the diet of some densely populated countries, where the total protein intake may be low (fish contributes ≥ 50% of total dietary proteins in Bangladesh, the Democratic People's Republic of Korea, the Republic of Congo, Ghana, Guinea, Indonesia, and Senegal), and is very important in the diets of other countries including Cambodia, Benin, Angola, the Republic of Korea and Japan) [6].

Of the 96.5 million tonnes available worldwide for consumption in 2005, four million tonnes were produced and consumed in Africa (giving a per capita supply of about 7 kg) [1]. In Kenya, total capture fish production for 2000 and 2001 was 215,518 and 165,160 metric tonnes [7], respectively, giving a per capita fish consumption of 7.0 and 5.2 kg, respectively. The total amount of fish consumed and the species composition of the food supply vary according to continent, region and country, reflecting the different levels of natural availability of the aquatic resource in adjacent waters, as well as diverse food traditions, tastes, supply, demand and income levels.

The developing countries' share of global trade in fishery products is generally increasing but many commodities except molluscan products tend to be of low monetary value. To compete effectively, Africa's fishery products exporters must meet the high standards of quality, hygiene and food safety set by importers. The application of food safety post-harvest processing procedures such as hazard analysis at critical control points (HACCP) to remedy shortcomings in seafood handling is necessary, especially where scombroid fish feature in commerce.

African fish supply

The areas where total catches have the highest potential for production increases are the eastern and western Indian Ocean and the western central Pacific [8]. These areas tend to have a lower incidence of fully exploited, overexploited, depleted or recovering fish stocks, and a prevalence of underexploited or moderately exploited stocks, although they also have the highest incidence of stocks whose state of

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exploitation is unknown or uncertain and for which overall production estimates are consequently less reliable [8]. Ethiopia, Djibouti, Somalia, Kenya, Seychelles, Tanzania, Mozambique and South Africa stand to benefit from greater exploitation of the western Indian Ocean. Inland aquatic resources in lakes Victoria, Chad, Tanganyika and Malawi continue to be under pressure from loss or degradation of habitat and overfishing or the use of inappropriate fishing gears [4]. Although freshwater fish species are reported to be the most threatened group of vertebrates harvested by humans, accurate data are difficult to collect, but work is under way to correct this situation, through international and national efforts [4]. In Kenya, the Ministry of Fisheries Development is improving the collection of information on fish stocks in the Indian Ocean portion that falls within Kenya's Exclusive Economic Zone, the inland lakes, small inland water bodies, rivers, etc. which had been neglected in the past [9].

A common problem in inland fisheries is the conflict between industrial and artisanal fleets. Some problems generated from the intense competition between these two user groups are evident in some of Africa's inland lakes including lakes Victoria and Tanganyika. Trawlers fiercely compete for the available catch with small artisanal craft often leading to the use of fish poisons and other unorthodox fishing methods to obtain the catch needed [9]. Large volumes of by-catch, which are often discarded, are a common result, although they are used for food when the normally desirable food fish species are not readily available. Furthermore, the artisanal sector is particularly vulnerable as it often depends on set gears that are incompatible with towed gears, such as industrial trawls. The solution is often to introduce zones that separate the gears (particularly when stocks do not move), although enforcement may be difficult. Another problem is loss of the export market as occurred in the recent past with Kenya and Uganda in their trade relationship with the European Union (EU) [9]. The EU imposed a ban on Nile perch fillets from Kenya and Uganda in 1996, 1998 and 2002 due to the poor state of hygiene in the landing beaches and insanitary handling and processing before export [9; 10]. These problems can be avoided by consistently improving the quality and food safety of exports through enforcement of codes of practice and good hygiene practices in the handling chain. The EU and the Kenyan Fisheries Department are currently harmonizing the use of EUROGAP as demanded by the EU and the application of the codes of practice elaborated by the Ministry of Fisheries Development [11] as well as the new hygiene and quality specifications provided in the Fish Quality Regulations, 2007 [12].

Although there has been a general decline in distant-water fishing, some African countries still allow long-range fleets from developed countries to exploit their offshore resources, despite their low economic gain from such arrangements [13]. Because of the need to share information on foreign fleets and to combat foreign fishing, regional management bodies are particularly valuable in dealing with fisheries that have a large foreign component. A successful cooperative effort is being implemented across national boundaries in West Africa in making decisions on fishery exploitation and management [14]. It aims to enhance fishers' decision-

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making by using the best homegrown methods for exploitation and management of resources without considerable help from the FAO and foreign governments.

Aquaculture

The total global aquaculture production was 43.5 million tonnes in 2005 [1]. Rural aquaculture is increasingly being recognized as a way to improve the livelihoods of poor people, and many governments and development agencies are attaching importance to the sector. It is therefore slowly being developed to improve the living standards of fishers and rural farmers in parts of Africa and as a way to avoid importation of scarce fishery products [1]. As in Asia, the introduction can take many forms including: traditional integrated systems where fish farming gets integrated with cropping; using extensive to semi-intensive modes of production in ponds, and, may be tanks, where the farmer can afford such systems; and teaching small-scale holders in coastal areas how to farm coastal seaweed and molluscs or fishers to become owner-operators of fish cages in both coastal and inland areas [15]. However, aquaculture still faces a number of problems, among them being access to technology and financial resources, its environmental impacts and diseases. Aquaculture not only has greater development potential than capture fisheries, which is declining, but is also an important tool for increasing food security and earning extra income.

In Kenya, aquaculture is subsistence in nature, although the Ministry of Fisheries Development is laying emphasis on commercialization. The potential for aquaculture development in the country is high, but is hampered by poor land tenure systems, lack of capital and technology [9]. The Government is enhancing expansion of the sector by training extension workers, holding farmers' training days, improving the output of fingerlings from government hatcheries, building aquaculture sub-centres equipped with fish rearing races and outgrow ponds, and collaborating with a number of other stakeholders, including the Lake Basin Development Authority and the Kenya Marine and Fisheries Research Institute. The major fish species reared include tilapia, catfish, the common carp, labeo, black bass and ornamental goldfish. In 2003, the national aquaculture fish production was 1,012 metric tonnes, a 5% increase from 962 metric tonnes in 2002 [9]. The production for 2004 and 2005 was a modest increase of 1035 and 1047 metric tons, respectively [11; 16].

INTERNATIONAL TRADE IN SEAFOOD

About 33% of live weight fish production for 1998 was exported, with developing countries accounting for almost 20% of exports [2]. Total fish and fishery products exports for the year were US$51 billion, a 3.8% decrease compared with 1997 [2]. Net export trade from developing countries increased from US$10 billion in 1990 to US$18 billion in 2000, corresponding to a real (corrected for inflation) growth of 45% [4]. In 1995, Africa produced 5% of the world's production of fishery products but supplied 0.2% of the fishery items in international trade [17]. To remedy this situation requires major investments in facilities and technology. More than 90% of global trade in fish and fishery products consists of processed products (excluding live and fresh whole fish) [4]. Frozen and chilled fish/fish products make up the majority of

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exports. Although live, fresh or chilled fish represents only a small share of world fish trade owing to its perishability, trade is growing, reflecting increased demand [4]. More than 77% of total world seafood export value is concentrated in the three areas of shrimp, tuna and groundfish, seafood categories that are often implicated in incidences of scombroid food poisoning [18; 19].

Emerging African economies that are capable of exporting considerable quantities of fishery products are assured of earning considerable revenue as long as they can meet food safety requirements and can compete effectively with similar products from other parts of the World. Although a choice has to be made between domestic and international export markets, it seems wise to develop both because the markets in developed countries are sometimes volatile, and world politics often unpredictably affects the functioning of markets. Intra-African trade can also use fishery products that international markets will not need or are currently met by European imports.

Although a sizable market for shrimp and other molluscs, tuna and small pelagics exists in North America, Japan and Europe, inclusion of components dealing with fishery products in international trade agreements would benefit Africa's fishery products exporters. However, the stringent standards of quality and safety required by the Center for Food Safety and Nutrition of the Food and Drug Administration (FDA) of the U.S.A. before fishery products are allowed into the U.S.A. will be an impediment Africa's fishery products exporters would have to overcome.

Many African countries are currently working hard to attract foreign investment but the pace of investment in the fisheries sector is slow, despite the incentives offered to would-be investors. The incentives include the unimpeded repatriation of profits, low domestic labor costs and low tariffs on fishery related imported technology [20]. An extra impediment to be overcome by African countries wanting to enter the seafood export markets includes improvement of catch handling through the application of post-harvest procedures acceptable to importing countries. Often, the Codex Alimentarius Commission assists adapt the necessary regulations to the prevailing situation in member countries [15].

FISH QUALITY AND FOOD SAFETY

Food safety remains important and has become increasingly stringent for exported products; in many cases, HACCP procedures must be applied by processors [21]. The distribution of marine fish to inland areas, distant from the coast, or to the export markets is a problem for many countries that depend on capture fisheries and have poor infrastructure. This is often a reason for developing good handling procedures as well as freshwater aquaculture facilities closer to markets.

In 1999, the Centers for Disease Control and Prevention (CDC) of the U.S. estimated there were 76 million cases of gastrointestinal illnesses; 325,000 serious illnesses resulting in hospitalization and 5,000 deaths from food-borne disease in the U.S. [22]. These data represent one of the best existing estimates of the impact of food-borne

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diseases on a developed country. The Infectious Diseases Unit of the Ministry of Health in Kenya reported that food and waterborne diseases represent 80% of preventable illnesses the health sector has to deal with every year, with more than 2 major cases of food and waterborne disease outbreaks reported annually [23]. Top among preventable and prevalent diseases are typhoid, dysentery and cholera. The symptoms of these illnesses are gastrointestinal in nature, including vomiting, diarrhoea and abdominal cramps, symptoms that are similar to those seen in scombroid fish poisoning (Table 1).

Food-derived illnesses can have several causes, including specific toxic substances, pathogenic micro-organisms and parasites that can develop and/or are conveyed by foods. Biotoxins may develop naturally in the environment, while others are human-generated contaminants. Some pathogenic micro-organisms, some being scombrotoxic, are part of the normal flora of fish while others are contaminants. Fish, similar to any other food, can cause health problems. It can be contaminated at any time from the moment of capture until it is eaten. Contamination may occur because pathogenic micro-organisms form part of the normal fish flora, or through toxic substances introduced through cross-contamination and recontamination or faulty handling and processing. The extent to which fish products are a source of food-borne diseases is a function of general food habits, the frequency of fish consumption and type of products and species consumed.

In 1997, the HACCP system was incorporated into Codex Alimentarius as a general guideline, making it the basic reference for international trade disputes under the World Trade Organization (WTO) and Agreements on the Application of Sanitary and Phytosanitary Measures [24]. However, the inclusion of the HACCP system as a general guideline for the Codex Alimentarius does not make all HACCP systems identical. The U.S. HACCP regulations apply to processors, while the EU regulations apply to the whole production chain, from handling fish on board fishing vessels to the retailing of fish. In both cases, the HACCP system is very closely linked to the individual food safety and hygiene regulation framework.

From the viewpoint of government and consumers, introduction of HACCP can be justified in economic terms owing to the possible reduction of illness or death caused by food poisoning, which implies a possible reduction in public and private health costs, insurance costs and lost workdays. From the producers' viewpoint, application of HACCP implies an investment. Some of the initial costs are linked to refitting plants, rearranging processing lines, buying new equipment, purchasing and installing measurement instruments, and training personnel and monitoring processing activities. From 1990-2000, both the fishing industry and the fish/food inspection services in many developing countries made very determined efforts to adapt processing and inspection methodologies that satisfied HACCP requirements. Among the countries that were successful and were authorized to export fish and fishery products to the EU in mid-1999, fifty operate in full accordance with the EU's HACCP-based regulations. Of these 50 countries, 37 are in Africa, Asia, the Pacific, Latin America and the Caribbean [2]. They received technical and financial assistance from the FAO and

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Denmark, who in 1995-1999 organized 44 workshops and trained more than 1,300 professionals from industry and government in HACCP principles [2; 4]. However, not all developing countries were able to make the necessary initial investments. Sometimes resources for this purpose were scarce or non-existent, and, as a result, some countries suffered a drastic reduction in the number of establishments authorized to export to EU markets. Cape Verde and Guinea-Bissau became extreme examples of this in mid 2000, when the EU banned all fish imports from them. A similar situation was witnessed in Kenya, Uganda and Tanzania in the recent past, although the ban has not been permanent [17]. However, despite lack of application of HACCP procedures in fishery products processing in some African countries, simple post-harvest handling procedures including gutting at sea, de-gilling and sometimes beheading contribute to the maintenance of good quality and a long shelf life in fishery products. In the marine fishery, a related health problem is the frequent breakout of illness associated with scombroid fish.

Aetiology of Scombrotoxicosis

Scombroid fish poisoning results from the consumption of spoiling scombroid or other marine fish, that contain hazardous levels of toxigenic biogenic amines, which may form on exposure of fish to abuse temperature [25]. Because 0-2^{o}C is the recommended temperature range for fresh fish storage, any storage temperature above 4^{o}C is regarded as abuse temperature [26]. Histamine, putrescine and cadaverine, are collectively considered likely causes of scombrotoxicosis, the syndrome resulting from the consumption of elevated levels of scombrotoxins [27]. Scombroid fish belong principally to 2 fish families-scombroideae and scombrososcideae. Spoiled fish of the families Scombroidae (tuna, mackerel and bonito) and Scombrososcideae (herring and marlins) are commonly implicated in incidents of histamine poisoning, which leads to the common usage of the term, "scombroid fish poisoning" to describe the illness. Table 2 gives fish species that are potentially scombroid or that have been implicated in scombrotoxicosis in the tropics. A considerable number are found in the marine catches of the major African fishing nations. Decarboxylation of amino acids to give biogenic amines occurs through the activity of amino acid decarboxylases, which are either naturally found in the food tissue, or are produced in the food by bacteria [28]. In the Kenyan marine fishery, scombroid fish include little mackerel, skipjack tuna, blue and black marlins and sardines. In a past study, 6 fish species from the Kenyan Indian Ocean coast that included parrotfish (*Callyodon gutatus*), rabbitfish (*Siganus oramin*), scavengerfish (*Lethrinus nebulosus),* skipjack tuna(*Euthynnus pelamis),* barracuda (*Sphyraena japonica*) and little mackerel *(Rastrelliger kanagurta)* were screened for potential scombrotoxicity [29]. However, the study showed that the iced tropical fish had much lower potential for scombrotoxicity under comparable handling conditions as temperate Atlantic mackerel. None formed >50 ppm histamine (the level that causes a human health hazard) even after subsequent exposure to 21±1^{o}C for up to 54 hr. Also, Ababouch *et al*. [30] showed the potential scombrotoxicity of sardines harvested off the coast of Morocco.

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In scombrotoxin poisoning episodes, histamine is normally found at >200 ppm in the incriminated food. Therefore, the level of histamine is the main guide that determines whether the food is capable of scombrotoxin poisoning or not. The symptoms of scombrotoxicosis are given in Table 2. The U.S. FDA has established 20 ppm of histamine as a defect action level, while 50 ppm is the hazard action level in tuna [26]. The defect action level signifies some mishandling of fish that is likely to lead to spoilage, while the hazard action level legally constitutes a known human health hazard. Although histamine >50 ppm in fish flesh is legally regarded as hazardous in the U.S. [26], levels must be greater than 100 ppm to be regarded as hazardous in the EU [31]. A number of commercially important tropical fish have been investigated for their ability to cause scombrotoxicosis. Chakrabarti [32] found that barracuda, jaw fish, two types of fresh water catfish, white baitfish, drift fish, scad, small mullet, mackerel and Indian mackerel had varying degrees of sensory acceptability after exposure to ambient tropical temperature over a 24-hr period. In mackerel, the histamine content was >200 ppm after 1 day of exposure to ambient temperature, implying it had a higher potential to increased histamine formation. Other tropical fish that have been confirmed to be potentially scombrotoxic include herring [33], yellowfin tuna [34], Pacific mackerel [35], tuna (*Thunnus thynnus*) [36], kahawai [37], the grouper (*Plecteropomus maculates*) [38], pacu (*Piaractus mesopotamicus*) [39], sailfish [40] and anchovies [41]. The ability of a food to develop high levels of toxigenic amines depends on the nature of microflora on the food, the proportion of the microflora that is scombrotoxic, environmental conditions of storage, prolificity for toxigenic amine formation by the scombrotoxic bacteria present, and the nature of handling to which the food is exposed. Tropical fish have been shown to have a predominantly mesophilic flora, while temperate fish have a predominance of psychrophilic microflora [42]. The proportion of scombrotoxic bacteria found on the fish as well as the effect of icing on the microflora also leads to formation of different levels of the toxigenic amines [43]. Icing is more effective in suppressing bacterial growth in tropical than in temperate fish [44], and, therefore, we expect less scombrotoxic amines to be formed in well iced tropical fish than in temperate fish treated similarly. Icing and/or freezing, are potential methods of preserving fish in international seafood trade in order to avoid losses and disruptions arising from potential scombrotoxicity. Freezing is a more effective procedure to arrest scombrotoxin formation in stored fish and fish products than ice storage.

Scombrotoxicosis and international fish trade

In tropical fisheries the two prevalent fish-related illnesses are scombrotoxicosis and ciguatera poisoning [45]. Ciguatera results from the consumption of some tropical reef fish that include the groupers, mackerel, herring, blue and black marlins, snappers, barracudas and goatfish [45]. Mackerel, herring, blue and black marlin and barracudas are also potentially scombrotoxic. In Kenya, the above mentioned fish, barracudas, dolphin fish and sardines, are a considerable percentage of the annual marine fish landings. Skipjack tuna, a scombroid fish, is a major Kenyan export. Although no cases of scombroid poisoning have been reported in Kenya, the presence of scombroid fish in the fishery cannot rule out the occurrence of incidents of scombroid poisoning among marine fish consumers. The illness is transient and

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therefore its attack is often not reported as the symptoms and effects pass 2-8 hr after the attack depending on dosage, the health status of the consumer, and the amount of incriminated fish product consumed [46].

Similar to other food-borne illnesses, scombrotoxicosis is of concern to consumers in the developed economies where the illness is known to affect a number of seafood consumers every year. Due to lack of reporting or ignorance about the illness in developing countries, estimates of its consequences are not known. In the U.S.A. according to the CDC, scombrotoxicosis is the most frequently reported chemical food-borne illness [47]. It is a transient illness that is self-resolving after attack, unless the dosage is very high. A patient who consumes fish with high scombrotoxin levels and is either immunocompromised, immunodeficient or has cardiac and respiratory health problems may require either medication or hospitalization. In 1988-1992, there were 152 illnesses in the United States reported as chemical intoxications [47]. Scombrotoxicosis accounted for 51% of these illnesses during this period, while ciguatera accounted for 38% of the intoxications and can therefore be said to be less prevalent among chemical illnesses in the U.S.A. Consumers of fishery products in every country with a marine based fishery are likely to experience scombrotoxicosis. Scombroid fish that are appropriately handled are normally safe. When well handled fish are involved in international trade, the resulting consumer confidence can be used to enhance trade in a wide range of fishery products. This can expand economic benefits to exporting countries resulting in increased production to satisfy the demand created in the importing markets.

Processing and handling procedures influence the quality, safety and value of fish products in the marketplace. Leitao *et al*. [39] and Mazorra-Manzano *et al*. [48] have shown that icing commercial fishery products results in a shelf life longer than 2 weeks. This is often true of tropical fish, which have been demonstrated to keep longer in ice than temperate fish [38]. Although lack of ice is a handicap in many tropical fisheries, its availability and greater use would boost maintenance of prime quality of catch in trade channels. The perceived high quality of such products ensures that fishmongers get good prices and the high margins to the fishmongers would most likely be passed onto the fishers through better prices. This in turn is likely to translate into increased production to meet the higher demand created by consumer satisfaction through high quality and safe fishery products in the trading chain. The U.S. Institute of Medicine [45] recommends the use of low temperature preservation to keep the incidence of scombrotoxicosis in check. Adoption and entrenchment of the widespread use of ice in African fisheries would improve the image of fishery products from Africa in international trade, opening up opportunities for the expansion of production to supply the demand created from improvements in the application of the safety measure. However, to benefit most from such a practice requires that certain legislative measures be put in place. These include legislating scombrotoxicosis as a notifiable disease, installing mechanisms for reporting the disease including training programmes for extension professionals, physicians and other medical personnel to be able to recognize the disease and provide the necessary

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support to keep it in check. These measures can spur further acceptance by importing countries of seafood products from Africa's marine fisheries.

CONCLUSION

Globally, fisheries make an important contribution to employment, food, commerce, and are an important dietary source of animal proteins. Poor handling is an impediment to the entry of Africa's fish products into the international trade arena. However, the Codex Alimentarius Commission and the FAO are assisting in the application of HACCP in order to improve the safety of seafood from African countries. Scombroid food poisoning is largely unknown in African fisheries, although it is an important concern in international seafood trade. Gutting may prolong the shelf life of scombrotoxic fish stored in ice. However, in stored scombrotoxic fish, all toxigenic amines increase with storage time, whether the fish are gutted, skin contaminated or not, as long as scombrotoxic bacteria are found in them. It is therefore important to use sanitary handling practices after catch to keep down the level of scombrotoxic bacteria that contaminate fish skin. Nevertheless, many tropical fish seem relatively "safe" with respect to scombrotoxicosis even after exposure to abuse temperature, despite the high environmental temperatures that are appropriate for the growth of mesophilic bacteria, some of which may be prolific histamine formers. Potentially scombrotoxic tropical fish that feature in international trade include skipjack tuna, mackerel, bonitos, marlins, anchovies, sardines, barracuda, scavengerfish, rabbitfish and mahi mahi.

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Table 1: Common symptoms of scombroid food poisoning

Cutaneous symptoms	Gastrointestinal symptoms	Neurological symptoms	Other symptoms
-Rash	-Nausea	-Facial and neck flushing	Hypotension
-Urticaria	-Vomiting	-Headache	-Bronchiospasm
-Edema	-Diarrhoea	-Palpitations	-Shock
-Facial flushing	-Abdominal cramps	-Tingling	
-Neck flushing		-Itching	
		-Oral burning sensation	

Sources: Becker *et al*. [19]; Ohnuma *et al.* [49].

Table 2: Some potentially scombrotoxi fish of African and tropical fisheries

Fish species/genus	Market name
Arripis spp., *Gasterochisma* spp., *Grammatorcynus* spp., *Scomber scombrus*	Mackerel
Rastrelliger kanagurta	Little mackerel
Pristipomoides spp.	Kahawai
Elagatis bipinnulata	Roosterfish
Nematistius spp.	Roosterfish
Opisthonema spp.	Thread herring
Clupea spp.	Sea or sild herring
Ilisha spp.	Herring
Etrumeus teres	Herring
Flavobrunneum spp.	Snake herring
Lepidocybium spp.	Escolar, gemfish/snake mackerel
Cybiosarda elegan., *Sarda* spp.	Bonito
Pomatomus saltatrix	Bluefish
Anchoa spp.	Anchovy
Seriola spp.	Amberjack
Seriola spp.	Yellowtail
Pleurogrammus monopterygius	Atka mackerel
Scomber spp.	Chub mackerel

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Table 2: continued- Some potentially scombrotoxic fish of African and tropical fisheries

Fish species/genus	Market name
Trachurus spp.	Jack mackerel
Coryphaena spp.	Mahi mahi
Makaira spp., *Tetrapturus* spp.	Marlin
Sardina pilchardus	Pilchard or sardine
Sardinops spp.	Pilchards/Sardine
Harengula/or *Sardinella* spp.	Sardine
Cololabis saira., Scomberresox saurus	Saury
Alosa spp.	Shad
Dorosoma spp.	Gizzard shad
Nematalosa vlaminghi	Gizzard shad
Sprattus spp.	Sprat or bristling
Caranx sexfasciatus	Trevally
Allothunnus fallai, Auxis spp., *Euthynnus* spp., *Katsuwonus pelamis., Thunnus tonggol, Thunnus thynnus*	Tuna

Sources: FDA [26]; Stratton and Taylor [50].

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