

ALLERGIES IN THE WORKPLACE

OCCUPATIONAL ALLERGY IN THE FISH PROCESSING INDUSTRY – TOWARDS PREVENTIVE STRATEGIES

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'Seafood' refers to any aquatic organism that is intended for human or animal consumption.¹ Recent years have seen a growing demand for seafood, which has led to increased production. While adverse reactions (toxic and allergic) to seafood have been reported by a growing number of consumers, allergic reactions in particular have also been documented to occur in the occupational setting as a result of exposure to all three major seafood groupings (Table I).^{2,3}

Table I. Classification of seafood groups causing occupational allergies

| Phylum | Class | Family (common name) |
|------------------------------|--------------------------|---|
| Arthropoda | Crustacea | Crabs, lobsters, prawns, shrimp |
| Mollusca | Gastropoda | Abalone |
| | Bivalvia | Clams, oysters, mussels, scallops |
| | Cephalopoda | Squid (cuttlefish) |
| Pisces (sub-phylum Chordata) | Osteichthyes (bony fish) | Salmon, plaice, tuna, hake, cod, herring, sardine, trout, anchovy, yellow fin |

The seafood industry and working populations at risk

Occupational exposure to seafood allergens occurs mainly in the food and fishing industry.^{4,5} Workers in a number of these industries are exposed to seafood, especially those involved in either manual or automated processing of crabs, prawns, mussels, fish and fishmeal. Other occupations associated with seafood exposure include oyster shuckers, laboratory technicians and researchers, jewellery polishers, restaurant chefs, fishmongers and fishermen.¹

The Food and Agriculture Organisation (FAO) of the United Nations estimated that in 2002, fishery and aquaculture production activities produced direct employment and revenue for 38 million people worldwide (www.greenfacts.org/fisheries). The number of fishers and fish farmers has been growing at an average rate of 2.6% per year since 1990. Among these workers 52% worked aboard fishing trawlers, 32% were involved in aquaculture production (marine and

freshwater) and 16% worked inland as capture fishers or in other land-based activities such as processing. It is estimated that more than 90% of the world fishers and fish farmers are from developing countries, producing 60% of the over 100 million tons of world fish.⁵ In many countries, labour in the fishing industry tends to be divided along gender lines with men almost exclusively going out to sea to catch the fish and women doing the majority of on-land processing.⁶ Most of these workers are seasonal workers. The degree of exposure is likely to be highest during the harvest season when most of the processing occurs.

Seafood processing plants vary in technological levels, with some of the smaller workplaces relying entirely on manual handling of the seafood and larger companies using modern, highly automated processes. There is great variation in processing procedures for the different types of seafood.⁵ Common processing techniques employed for the major seafood groupings and sources of potential exposure to seafood product/s are outlined in Table II. There is great variability of exposure within and among various jobs involved in seafood processing with reported airborne environmental allergen concentrations ranging from 1 to 5 061 ng/m³.¹

Constituents of seafood

The allergic and inflammatory reactions to seafood experienced by workers in the seafood processing industry are the result of exposure to the seafood itself (Table I) (muscle and connective tissue, exoskeleton, blood, fish juice, skin, skin slime/mucin, gut) or to the various non-seafood components present in the product. Fish juice contains high molecular weight proteins (meat, skin, skin slime/mucin, gut), biogenic amines, histamine and cadaverine, degradation compounds in old fish, and digestive enzymes (pepsin and trypsin), all capable of causing adverse reactions in exposed individuals. The major fish allergens are parvalbumins, in crustaceans tropomyosin is most common and molluscs contain various unknown allergens.^{7,8} Non-seafood components include various contaminants such as parasites (e.g. *Anisakis simplex*); protozoans (e.g. *Hoya*) and algae (e.g. dinoflagellates *Hematodinium*); coral and sponges (e.g. marine soft sponge and red soft coral); marine or bacterial toxins (e.g. histamine); chemical additives (e.g. sodium metabisulphite) and spices (e.g. mustard, paprika, flour additives, garlic); and hidden ingredients (e.g. casein) in canned or processed fish products.^{1,9,10}

High-risk work processes, sources of exposure and routes of entry

The production of seafood aerosols during processing has been identified as a potential high-risk activity for allergic sensitisation by high molecular weight seafood proteins through inhalation. These processes include degutting, heading and cooking/boiling of fish, mincing of seafood, fishmeal milling/bagging and cleaning of the processing line and storage tanks with high-pressured water (Fig. 1) (Table II).⁵ Occupational asthma is commonly related to crustaceans (e.g. crabs and prawns) and fishmeal production. Skin-related allergic symptoms may be due to direct contact with the actu-

Table II. Common processing techniques used for seafood groups that are potential sources of occupational exposure to seafood and their products

| Seafood category | Processing techniques | Sources of occupational exposure to seafood product/s |
|--|---|---|
| Crustaceans <i>Crabs, lobsters, crawfish</i> | Cooking (boiling or steaming), 'tailing' lobsters, 'cracking', butchering and degilling crabs, manual picking of meat, cutting, grinding, mincing, scrubbing and washing, cooling | Inhalation of wet aerosols from lobster 'tailing', crab 'cracking', butchering and degilling, boiling, scrubbing and washing, spraying, cutting, grinding, mincing, prawn 'blowing', cleaning processing lines/tanks with pressurised water |
| <i>Prawns</i> | Heading, peeling, deveining, prawn 'blowing' (water jets or compressed air) | Skin contact from unprotected handling; hand immersion in water containing extruded gut material |
| Molluscs <i>Oysters, mussels, clams, scallops, abalone</i> | Washing, oyster 'shucking', shellfish depuration, chopping, dicing, slicing | Inhalation of wet aerosols from oyster 'shucking', washing Skin contact from unprotected handling |
| Finfish <i>Various species</i> | Heading, degutting, skinning, mincing, filleting, trimming, cooking (boiling or steaming), spice/batter application, frying, milling, bagging | Inhalation of wet aerosols from fish heading, degutting, boiling Inhalation of dry aerosols from fishmeal bagging Skin contact from unprotected handling |



Fig. 1. Bulk loading and bagging of fishmeal causes spillage and aerosolised dust particulate if inadequately removed by local exhaust ventilation systems, resulting in work-related asthma.

al seafood, vegetable additives (e.g. spices) or a systemic response to inhalational exposures. Occupational skin exposure occurs mainly as a result of unprotected handling of various fish and their products at various stages in the production process (Fig. 2).

Allergic health effects associated with seafood

Occupational seafood allergy can manifest as rhinitis, conjunctivitis, asthma, urticaria and protein contact dermatitis (Table III).¹ Systemic anaphylactic reactions have also been reported.¹¹ Another condition known to be associated with occupational exposure to seafood is extrinsic allergic alveolitis.¹² The overall proportion of adult asthma (new and reactivated disease) attributable to occupational exposure is estimated to be 10%.¹³ The reported prevalence of occupational asthma among seafood workers varies from 7% to 36%.¹

The major skin manifestations associated with seafood are contact urticaria and eczematous contact dermatitis of various types.¹ Contact urticaria is associated with direct contact with raw seafood proteins. At least 75% of eczematous dermatitis in the fish-processing indus-



Fig. 2. Fish sorting and handling activities under wet conditions generates fish juice that contributes to irritant contact dermatitis, urticaria and protein contact dermatitis.

try is of an irritant nature commonly caused by contact with water and fish products (fish juice, slime, skin, fillet).¹⁴ Contact with the proteinaceous material also causes a chronic recurrent dermatitis commonly known as protein contact dermatitis (PCD). However, biochemical sensitisers (e.g. garlic, onion, spices) added to seafood can also cause a delayed allergic contact dermatitis. In the seafood industry, the reported prevalence of occupational PCD is between 3% and 11%.¹

Findings of a study investigating occupational fish allergy among workers along the West Coast of South Africa

The South African seafood industry employs over 28 000 mainly female seasonal workers involved predominantly in bony fish (hake, pilchard and anchovy) processing activities.^{5,6} A study investigating the risk of occupational allergy associated with pilchard and anchovy processing on the West Coast of South Africa found that workers were at substantial risk of inhaling aerosolised fish antigens that resulted in an increased risk of developing occupational asthma. High fish antigen levels, ranging from 81 to 75 748 ng/m³, were encountered during fishmeal production and bagging activities.^{15,16} A high correlation was found between ambient pilchard and anchovy antigen concentrations (Pearson $r = 0.71$, $p < 0.001$).

Table III. Occupational allergies associated with seafood

| Pathological mechanism | Occupational disease outcomes |
|--|--|
| General systemic response | Anaphylaxis (rare) |
| Allergic/toxic inflammatory lung reactions | Rhinitis, conjunctivitis Asthma Hypersensitivity pneumonitis (extrinsic allergic alveolitis) |
| Allergic/toxic inflammatory skin reactions | Urticaria, angioedema and protein contact dermatitis Contact irritant dermatitis Contact allergic dermatitis |

The study also found that workers were at risk of developing occupational allergies, with rhinoconjunctivitis (2.6%) being more prevalent than asthma (1.8%) and PCD or urticaria (1%).¹⁷ A dose-response relationship was demonstrated between the ambient level of fish antigen exposure at the time of symptom onset and the risk of such work-related asthma symptoms. Workers with work-related asthma symptoms had a twofold increased likelihood of being exposed to pilchard antigen concentrations >30 ng/m³ at the time of onset of symptoms (OR:2.25, CI:1.06-4.75). In respect of skin problems, workers with recurrent skin symptoms were more likely to be involved in canning/jetty activities, associated with high levels of skin contact with fish and fish products. These workers were also more likely to have positive skin reactivity to fish on skin-prick testing.

Furthermore, sensitisation to the fish parasite *Anisakis* was high (8%), with *Anisakis*-specific IgE reactivity being strongly associated with PCD and bronchial hyperreactivity. A detailed exposé of the underlying immunological mechanisms has recently been characterised.¹⁸ The findings of these studies add to the growing body of evidence on occupational allergy among fish processing workers.

Prevention of occupational seafood allergies – a focus on fish processing

In the light of the findings in the South African study reporting substantial exposure to fish antigens and related adverse health outcomes, it is evident that preventive measures need to be instituted to reduce morbidity and other adverse social outcomes (e.g. workplace absenteeism, job loss, decreased productivity, loss of earnings, increased health care expenditure) associated with occupational asthma and dermatitis among fish-processing workers. Firstly, *regulatory exposure standards* for fish allergens should be developed in the long term since none currently exists internationally. This requires standardisation of immunoassays for the evaluation of allergen exposure that can be implemented by most laboratories. In the meantime the most practicable strategy would be to identify departments and activities with high aerosol exposure (fishmeal bagging, gutting machine) during the initial risk-assessment process. Baseline and follow-up exposure measurements can be used to assess the effectiveness of local extraction ventilation systems using total particulate as a proxy for fish allergen levels (since there exists some degree of correlation between these two measures). Employer compliance and law enforcement of the Regulations for Hazardous Biological Agents (HBA) under the Occupational Health and Safety Act (OHSA) in South Africa are also crucial to this strategy.^{19,20} Key aspects that also apply to food-processing plants include:

- Regular biennial risk assessment and categorisation of workplace by employers
- Employees to follow safe procedures for HBA disposal and decontamination and to report all incidents of accidental exposure to HBA
- Employer to provide information and training to employees on potential risks of HBA and risk-reduction measures
- Regular exposure monitoring and medical surveillance of employees
- Workplace health and safety committee approved protocol for procedures dealing with abnormal results
- A requirement to follow the hierarchy of control measures using standard and transmission-based precautions.

Secondly, *workplace interventions and control measures* need to be implemented to reduce the emission of bio-aerosols in fish-processing plants. Process separation or enclosure, and the use of local extraction ventilation systems for processes and equipment (gutting machine, steam exhaust box and fishmeal bagging) are activities needing special emphasis. Workplace practices such as broom sweeping especially in the fishmeal bagging plants should be prohibited and vacuum cleaners or wet mopping implemented instead. Where there is significant potential for skin contact with the hazardous agent (fish sorting, spice mixing), appropriate gloves (cotton-lined to prevent excessive sweat retention) with long plastic sleeves should be worn. Puncture wounds and lacerations should be treated expeditiously to prevent infection and skin exposure to allergens in fish juice. An appropriate combination of emollients and moisturisers can be used prophylactically to protect skin barrier function and help prevent the development of irritant contact dermatitis.⁵

Thirdly, ongoing *industrial hygiene and medical surveillance* is required to assess the effectiveness of interventions. Although exposure monitoring of total dust particulate as opposed to allergen levels has its limitations in that dust levels may only partially correlate with the actual allergen concentrations, it may be the only realistic exposure measure. For this as well as other reasons, medical surveillance programmes have an important role to play. Such programmes should include annual symptom screening questionnaires, skin-prick testing with fish extracts and clinical skin examination. Where these screening activities offer evidence of possible work-related health problems, additional tests (e.g. spirometry and challenge tests, skin-patch tests with fresh fish and blood tests for specific IgE) can be used to confirm the presence of adverse health outcomes such as occupational asthma or contact dermatitis. The following guidelines used for management of other occupational allergies could be used to deal with abnormal results obtained from medical screening, surveillance and individual case management:

- Asthmatics sensitised to seafood should change to non-seafood work
- Asthmatics without sensitisation to seafood should be relocated to less exposed seafood tasks
- Workers with rhinitis and sensitisation should be investigated closely and relocation to less exposed tasks should be considered
- Workers sensitised to seafood but without respiratory symptoms should be re-examined annually
- Workers with rhinitis only but without sensitisation to seafood allergens do not warrant re-examination unless symptoms worsen.

Finally, *education and training programmes* for employers, workers and occupational health service providers are required. Essential components of such programmes should include knowledge of allergic disease end-points, competence and skills to monitor allergic diseases and prevent them, as well as provision of information for those workers at risk in the fish-processing industry.

Future research directions

Future research needs to be directed at the detailed biochemical analysis of the offending fish allergens causing occupational allergies. This will contribute to the development of more sensitive and specific diagnosis techniques for evaluating affected workers. Furthermore, more user-friendly methods for the environmental detection of fish allergens that have more widespread application in the workplace need to be developed. The influence of other possible contributory factors to allergic responses such as endotoxin, histamine and parasites needs closer investigation, especially among fishmeal processors.

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