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Fish Drying in Indonesia

Proceedings of an international workshop held at Jakarta, Indonesia on 9–10 February 1994

Editors: B.R. Champ and E. Highley

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Opening Remarks

DISTINGUISHED guests and participants, ladies and gentlemen, on behalf of the Agency for Agricultural Research and Development I welcome you all to this workshop on fish drying, especially the overseas participants who have shown their strong interest by participating. I am very pleased that the workshop is so timely, since it is being held at the beginning of the Indonesia's Second National Long-Term Development Plan, which is emphasising human resources development.

The Ministry of Agriculture has a strong view that agribusiness and agro-industry have an important role in improving the socioeconomic status of farmers and fishermen, especially in increasing their incomes. Recognising this role, the Department of Agriculture has just established a new Agency for Agribusiness Development that is expected to deal with the challenges in agricultural development in the coming years. Likewise, AARD is now in the process of restructuring, anticipating the growing complexity of agricultural development and an increasing need for research support in the future.

Among the important steps taken in the restructuring of AARD is the establishment of agricultural research institutes in each of the 27 provinces in Indonesia. It is expected that these regional research institutions will generate technologies specific to local end-users. It is hoped that this will enhance the probability of widespread adoption of the technologies and accelerate technology transfer, thus improving the well-being of the targeted farmers and fishermen.

In the context of the important role of agribusiness and agro-industry in agricultural development, we cannot neglect postharvest technology as an essential element of these activities. Adoption and application of appropriate postharvest technologies offer a wide range of advantages, such as increased value-adding and incomes, more efficient use of natural resources, wider distribution and consumption of fish, and creation of job opportunities. In this connection, I expect this workshop to take into account innovation in postharvest technology, especially in developing good quality fish products that are affordable by low income groups. We hope to see an increase in fish consumption, leading to improvement in human health and nutrition.

Fish drying as a traditional method of fish preservation has long been practiced by Indonesian fishermen. The products are well known by the people, and for decades have been associated with the Indonesian diet, especially that of low income groups. Nowadays, as the people's welfare improves, there is a trend to falling dried fish consumption. Nevertheless, the fact remains that about 50% of the processed fish is still produced by traditional drying, and a considerable quantity of the product is exported.

For this reason, a fish drying workshop remains very relevant for us. Therefore, I expect this workshop will lead to improvement of the processing technology. I also believe that appropriate drying technology is needed, not only for fish but also for other agricultural commodities. The decreasing trend in dried fish consumption, especially that produced by heavy salting, is another challenge to scientists to produce dried fish with relatively low salt contents but with reasonable shelf life. Bearing in mind the continuous change in consumption pattern of the Indonesian people, I would like also to appeal for research support for new fish products based on drying techniques in particular, to provide a wider choice of quality fish products for increasing domestic fish consumption. As we are aware, fish are a nutritionally important food as they are a good source of essential amino acids and of fatty acids.

From a socioeconomic point of view, it has long been recognised in Indonesia that fish drying, distribution, and marketing make up a complicated business. In relation to improved social status of small-scale fish processors on the one hand and benefits to vendors, traders, and consumers on the other, I would expect socioeconomic studies to bring about realistic solutions to this problem, though they are unlikely to be easily implemented. They would be a basis for government policy in this area.

I take this opportunity to express my thanks to ACIAR for its support in this workshop, and for a long period of research collaboration with us. I hope the collaboration will be continued for the mutual benefit of both Indonesia and Australia.

I have pleasure in declaring this fish drying workshop, jointly organised by AARD–ACIAR, as officially opened. I hope that it will have fruitful results and lively discussions, and that overseas participants will have a happy stay in Indonesia.

Thank you.

Dr Faisal Kasryno
Director General
Agency for Agricultural Research and Development
Ministry of Agriculture
Republic of Indonesia

Government Policy on Fishery Agribusiness Development

IN the Second Long-term Development (PJP II), we are asked to be able to maintain and take advantage of the good development momentum which has been created during PJP I. Therefore, national development in PJP II, particularly fishery development, can be continued based on the previous achievements. This development must consolidate improvements made during each Five Year Development (Pelita) stage.

The National Guideline for Development (GBHN) 1993 advises that developments in the agriculture sector, including the fisheries subsector, will be increased in order to be able to produce enough food for national demand, to provide enough raw material for agroindustry activities, to increase public buying power, and to maintain the industrialisation process. These should integrate with industry and service developments to create productive agroindustry and agribusiness activities.

Available fishery resources which have not been optimally utilised, and the existing strategic environment, are basic resources for fishery development in the Sixth Five Year Development Plan (Repelita VI). Solutions need to be found for the problems and obstacles still facing fisheries development. One of the problems which has to be faced is that fishery commodities are perishable and this means that the products require good handling and processing. Most fishery products are processed using simple methods such as drying and salting. Dried and salted products can reach remote areas which do not have any capacity to produce fishery products at affordable prices. On the other hand, some people believe that consumption of dried/salted products has few benefits to human health, and may even create a health problem. These issues need attention.

Overview of Fishery Development

The agriculture sector, consisting of food crops, plantations, livestock, fishery and forestry subsectors, showed about a 4.0% per year growth rate during the period of Pelita I–Pelita III. The growth rates in Pelita IV and V are 3.6 were 2.8% per year, respectively, and this condition has reduced the contribution of the agriculture sector to national gross domestic product (GDP) from 44% in Pelita I to 20% in 1990.

The contribution of the fishery subsector to national GDP by the agriculture sector is relatively small, but it is growing. The fishery subsector contributed 4.8% to the component of GDP attributable to the agriculture sector in Pelita I, increasing to 7.8% in Pelita V. The contribution of the fishery subsector to the GDP increased by 5.6% annually during Pelita V and that rate is higher than the target increase rate, which was 5.5% per year. This indicates that the fishery subsector shows the potential to be a new growth source for the agriculture sector in PJP II.

Though the contribution of the agriculture sector to the GDP is decreasing, the sector has a strategic role in the national economy. The agriculture sector has overcome an unemployment problem due to a slow absorption by other sectors in PJP I. The agriculture sector absorbs about 50% of the total labour force in Indonesia. Also, agriculture development activities have helped to solve poverty problems. The proportion of the population living under the poverty line during PJP I decreased from 40% in the 1970s to 14% in 1990.

As a new development source in the agriculture sector in PJP II, fishery development has a strong foundation. Total fishery production during PJP I increased 3.5% per year and the total production reached 3.35 million t in 1991. Marine fishery production contributed 75% of total fishery production, increasing by 4.3% per year during PJP I. Meanwhile, inland fishery production increased 1.8% per year, except for the aquaculture fishery. Total production of aquaculture activities increased significantly, by about 8.1% per year.

Exports of fishery products grew significantly during PJP I. The average export volume increased by 5.4 % per year, while the value increased by 37.5% per year. The export volume in 1968 was 19700 t valued at about US$1260 million. The growth of fisheries exports was dominated by shrimp (61.3%), tuna/skipjack (14.7%) and other marine products (13.9%). Other prospective commodities for export are frog legs, seaweed, ornamental fish, shrimp crackers and canned fish. Dried and salted products have also begun to be exported. The main export destinations are Japan, Hong Kong, South Korea, Singapore, Thailand, and USA.

With respect to export growth rate, the contribution of fishery products to agricultural product exports was 1% in 1969, and rose to 30% in 1991. That growth rate indicates that fishery product exports will have a greater role in agricultural product exports in Repelita VI.

The increase in fishery production has led to growth in domestic consumption levels from 9.96 kg/capita/year in 1968 to 15.91 kg/capita/year in 1991, with an average annual growth rate of 1.9%. Thus, animal protein consumption has risen in Indonesia and this is expected to improve labour productivity. Fishery commodities contributed about 60% of total animal protein consumption during PJP I. The increase of protein consumption is in line with the success of national development shown by the improvement of income and welfare. The contribution of processed fishery products to the fishery product consumption is significant. This fact indicates that the consumption level of fishery commodities will continue to rise in the future.

In relation to the absorption of labour force in the period of 1976–1990, numbers of fishermen involved in marine fishery, inland fishery and coastal culture activities increased 4.8%, 0.1%, and 4.2% per year, respectively, and the present numbers of fishermen engaged in those activities are 1.5 million, 470000, and 161 000, respectively. Meanwhile, the number of fish farmers culturing freshwater fish also increased.

Despite the success of fishery development, as previously explained there are still some problems and obstacles to be overcome.

The fishery subsector faces the risk of quality degradation of fishery resources and the environment, as well as negative external impacts of other economic activities. Siltation and environmental pollution are increasing, while explosive and poisonous materials are still being used for catching fish, which is causing the deterioration of coral reefs.

In relation to the utilisation of fishery resources, we find that there is an imbalance in resource exploitation. For instance, around West Java, northern waters are crowded, whereas the contrary is the case to the south.

In terms of fishing vessels, though motorisation and modernisation are well developed, the fishing fleet is still dominated by non-powered boats which make up around 65.8% of the total number of fishing boats. At present, the total number of fishing boats is around 334000 units. About 50% of these boats are small vessels called *jukung*. Consequently, most catching activities are conducted in coastal areas which are already crowded. Another problem is that the number of fishermen in the coastal area increases according to the growth of the population.

Open water fisheries also face some problems which inhibit the growth of production with strategic value for increasing fish consumption. These include environmental deterioration due to pollution and the spread of *gulma* (bio-fouling) and siltation, and limitation in fish reservoir development and juvenile restocking in open water.

Concerning fish culture, there are problems which have to be solved. They relate to quality reduction of juveniles (fish and shrimp), and feed. Spread of diseases, and uncertain land utilisation plans in fish culture areas, are other problems which have to be solved through intersectoral cooperation. Brackish-water ponds have some constraints, such as low productivity due to low capability in juvenile supplies, technology absorption and capital. Development of brackish-water pond areas is impeded by low efficiency of pond irrigation systems, while in some areas there is no pond irrigation. Surveys show that the pond productivity in some areas has already decreased due to water pollution and excessive use of chemicals.

Education levels in the fishery subsector are low: only 26.2% of fishermen complete elementary school. In general, education statistics for labour in the fishery subsector are similar to other agriculture subsectors. The pyramidal shape of labour in the agriculture sector broadens in the bottom and narrows at the top, but not sharply, because relatively small numbers of labour complete diploma III (D III) compared with the labour having a university degree (S-1). In the fishery subsector, the difference between the labour having DI/DII/DIII diploma and S-1 degree is significant. For instance, the education backgrounds of personnel in the Directorate General of Fishery in March 1993 consist of 1306 S-1, 822 BSc/Diploma, 2432 secondary high school, 108 primary high school, and 169 elementary school.

The above pyramidal form tends to inhibit the flow of technology to lower levels in the labour force. Consequently, fishermen and fish farmers at the lowest level have difficulty in adopting new technology and improving their skills. Thus, the fishery productivity differences between production shown by experiment and production actually obtained by fishermen are greater than they should be, since the technology and information flow of research achievement to the fishermen is blocked.

Besides the economic problems, the inhibition of technology transfer will also retard improvement in the structure of fishing communities. Fishermen will find it more difficult to escape from the problems they face without outside intervention. In addition, the education structure problems will influence the access of fishermen to technology absorption and the ownership of production assets and investment. Labour with a better educational background has a better chance in utilising technology, production factors, and capital. Technology utilisation will also affect the added-value structure received by fishermen. The welfare of fisherman is affected not only by labour quality, but also external variables such as market mechanism, infrastructure availability, and capital accumulation processes and modes.

In terms of labour rank (according to the Indonesian rank classification), most of the labour force in the fishery subsector is hard labour. This indicates that support for fishery subsector development from labour of higher rank is weak. Consequently, this reduces the chance for hard labour to utilise technology and available market opportunities. The labour force structure makes it difficult to diversify fishery business activities. This structural problem must be overcome quickly. When it is, it will induce structural transformation of labour distribution in the fishery subsector.

In terms of extension officers, the number of officers working in fisheries is limited and the lowest of all the agriculture subsectors.

In general, the positive results which have been achieved by fishery development during PJP I can be used as a strong foundation for entering PJP II, especially the next Repelita VI. This is supported by the fact that most fishery resources have not been fully explored and there are promising opportunities that have not been utilised.

The market outlook for fishery products is promising. High economic growth, which is about 9.5% per year, and the increase of job opportunities, will give a positive impact to income and welfare levels. The increase in per capita income from US$407 in 1992 to US$2600 at the end of PJP II will increase demand for foodstuffs. The growth of population, which is about 1.5% per year, will also increase this demand. Efforts to relieve poverty will eventually increase the buying power of the public which will eventually flow through to demand of foodstuffs, particularly food from animal protein sources. The existing data indicate that income elasticity on fish demand is positive. This correlates with a trend to more balanced menus in Indonesian households, in terms of consumption of carbohydrate and protein. The demand for fishery products as raw material for industries increases according to the growth of economy and the increase of average per capita income.

In relation to the global market for fishery products, Indonesian products have good opportunities. We realise that the growth rate of fishery production in the world, which is mostly affected the total catch of marine fish, has levelled out at a total catch of about 99 million t/year. On the other hand, world demand for fishery products is tending to increase. For instance, the import volume of fisheries commodities in the world during period 1980–1989 increased 6.3% per year, i.e. from 9.8 million t to 16.8 million t.

The development of the Asia–Pacific region has opened great opportunities for export of Indonesian fishery products due to the geographical position of Indonesia, which is more advantageous than that of other countries supplying fishery products to the region. While the European Economic Community and the US have market potential for Indonesian fishery commodities, at the moment those countries import only small quantities of our fishery products.

Improvement of labour force quality as a result of the PJP I will improve its ability to be more active in fishery development. One of the important improvements is the ability of fishermen and institutions to apply fisheries science and knowledge.

Fishery Development Policy

With regard to the achievements, strategic environments, and problems, as previously explained, the orientation of agricultural development, including fishery development, in Repelita VI is towards support for creating an agriculture sector that is advanced, efficient and strong. This will be done through improvement of labour productivity, incomes, poverty relief, optimal and sustainable natural resource utilisation, and human resource development, as well as improvement of science and technology absorption and utilisation. Advanced, efficient, and strong agriculture is characterised by its ability to improve the welfare of farmers and fishermen and to support the growth of related sectors.

The goals of fishery subsector development in Repelita VI are:

1. Improve human resource quality and the welfare of fishermen through efforts to optimise fishery resource utilisation by the environmentally sound application of science and technology, and by adding value to fishery products.
2. Improve supply and distribution of fishery commodities, in order to improve the nutritional status of the population.
3. Encourage and increase employment and productive business opportunities.
4. Encourage domestic industrial growth by providing raw materials and increasing national income.

In order to achieve those goals, fishery subsector development in Repelita VI is expected to increase GDP by 5.2% per year. To realise that GDP growth, total fishery production is projected to increase 4.9% per year and the projected production in 1998 is 4.77 million t. Marine and inland fishery production levels are projected to increase 4.4 and 6.0% per year, respectively, reaching 3.45 and 1.27 million t at the end of Repelita VI. An increase in fishery production is also expected from aquaculture, by 8.4% per year over the same period.

Both volume and value of fishery product exports in Repelita VI are projected to increase 9.7% per year. Thus, the volume and value will reach 800000 t and US$2134 million, respectively, at the end of Repelita VI. The supply of fish for domestic consumers is projected to be 19.20 kg/capita/year in 1998, representing an increase of about 2.4% per year. The labour force which will be absorbed will be around 229000.

In order to achieve the above goals, the development of economic activities in the villages and the encouragement of villager roles are strategic objectives. Villager participation will be increased through quality development of human resources and farming communities, which will finally create advanced and independent farmers and entrepreneurs. Fishery development in Repelita VI will be performed through quality development of fishery human resources by a basic strategy of developing sustainable integrated agribusinesses. By this strategy, fishery development orientation does not only increase production at the level of individual fishermen, but also in respect of the whole agribusiness system. Fishery agribusiness is developed through a nucleus estate mode of fishery by strengthening cooperation and development of advanced technology application in various fish culture activities in coastal, pond and freshwater, as well as fish catching in coastal and off-shore areas. Catching activities in Indonesia's Exclusive Economic Zone will be regulated through a model of activities which can result in maximum income for the country. Special attention will be given to the cooperative, together with protection and development efforts of traditional fisheries. This strategy aims to encourage the restructure of the village economy, which will offer productive job opportunities.

By the above strategy, the fishery development orientation mainly emphasises increasing efficiency and profit, including manpower productivity, added and processed product values, product quality and regional development, as well as the increase of productivity per fishery unit effort. Through integrated fishery activities, fishermen/fish farmers and entrepreneurs can utilise resources and infrastructure according to the optimum economic scale in a democratic economic environment. In agribusiness, fishermen and fish farmers are counterparts as well as independent economic players.

Because of the fact that most fishery activities are still small scale, special attention will be given to the protection and development of small-scale fisheries in order to improve the income and welfare of fishermen/fish farmers through application of the sustainable and integrated agribusiness system in fisheries and improvement of living standards in coastal areas.

In order to apply agribusiness principles to fisheries, the following policies will be introduced:

(a) functional linkages among subsystems will be developed, thus every activity in each subsystem can run continuously at a high efficiency level;
(b) development of agribusiness should be able to increase village economic activities;
(c) development of agribusiness is directed to the development of harmonised joint ventures between large-scale and small-scale business;
(d) development of agribusiness is performed through the development of fishery production centres at efficient economic scales.

In order to carry out fishery development through agribusiness development, the development of human resources in the fishery subsector, which is the key to success in the development, is conducted in a wider and more comprehensive context, which covers not only technical dimensions but also more basic dimensions such as increase of price and self confidence and improvement of entrepreneurial capacity and responsibility, as well as efforts to make gradual change of attitude/life style of fishermen/fish farmers to greater consumption. Improvement of human resource quality in the fishery subsector is directed to supervise fishermen/fish farmers, youths and women in the villages to make them better equipped and more independent. Advanced and independent fishermen and entrepreneurs can be achieved by improving analytical, technical and managerial capability, while maintaining the basic values of the villagers, such as motivation, discipline, honest, belief in god, and good conduct.

Therefore, improvements of fishermen/fish farmers are directed not only to their function as labour, but also to their function as individuals, trying to balance their physical and mental welfare. Consequently, quality of environment and housing must be attended to. Housing is an integral part of a fishery agribusiness design system, without neglecting health and environmental aspects. Introduction of the agribusiness system requires readiness of human resources as the main role. Therefore, orientation of human resource development is not only directed to their capability in production, but also to manage a business. Development of fishermen/fish farmers is conducted through extension activities, vocational training and dissemination of technological packages, as well as field study.

In order to improve fishery product quality, improvement in postharvest practices, which is one of the segments in agribusiness system, will be continuously carried out. In this case, it will be developed as an integrated quality improvement and control scheme which is able to face requirements which change rapidly, such as activities on postharvest packaging, storage, processing and quality standards. In terms of fishery processing activities, it will encourage the establishment of small and medium-scale processing industries through application of suitable technology according to processor capability, including fish drying/ salting technology, so we will obtain good results in terms of health and safety, and protein content.

Improvement of fishery product marketing, which is another agribusiness segment, will be continuously conducted, with the main goal to create a rational marketing system supported by timely and sufficient price information. It will also develop the application of a cash and open market system at producer level. In order to create more international markets for Indonesian fishery products, establishment of overseas trading houses will be encouraged. Trading houses are very important for gaining information on prospective markets, fishery commodity demand in importing countries, import requirements and other matters relating to trade. Trading houses will also act to promote new commodities which have not been recognised, and will organise business meetings and transactions.

Conclusion

The success of fishery agribusiness development is determined not only by activities based on policies released by the Directorate General of Fishery, but also depends and relates to other activities such as capital support, transportation and communication facilities, technology, and an environment that encourages investment.

It should be understood that the role of society and the unity of actions in conducting development will also determine the success in executing the agribusiness development strategy for fishery development in Repelita VI, in which the fishery subsector is expected to be one of a number of new sources of developments in the agriculture sector with human resource development as a focal point.

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This paper is translated from Indonesian version.

An Overview of Fisheries and Fish Processing in Indonesia

N. Naamin*

Abstract

Marine fishery resources are important to the economic development of Indonesia. They are significant not only as a source of food, but also in employment creation and as a source of export earnings. Exploiting a total of 5.8 million km^2 of marine area, Indonesia's fisheries have a maximum sustainable yield of about 6.6 million t per year. Marine capture landings in 1991 totalled 2.5 million t. The landings were made up of 87% finfish, 6% crustaceans, 4% seaweed, and 2% molluscs. Over 90% of fisheries production is consumed domestically, with over half of the catch consumed as fresh fish. In 1991, 54% of fisheries production was utilised fresh, 38% was dried/salted, boiled, fermented, made into sauce, or smoked, 6% was frozen, and 1% each were canned or made into fish meal. It is estimated that in 1991 about 1.3 million t fish (40% of total production) was processed and consumed using traditional methods such as drying, salting, smoking, boiling, or fermenting.

INDONESIA, the world's largest archipelago, is a geographically diverse country. Some 75% of the nation's total area of 7.7 million km^2 is ocean. The country has over 17500 islands with land area of 1.9 million km^2. Indonesia stretches 4500 km from Sabang in the west to Merauke in the east, and 1900 km from Talaud in the north to Cilacap in the south.

Marine space is divided into territorial waters, archipelagic waters, and the Exclusive Economic Zone (EEZ). Indonesia's territorial waters cover 0.3 million km^2 and archipelagic waters 2.8 million km^2. With promulgation of the 200 nautical mile EEZ in 1983, Indonesia's jurisdiction was extended by 2.7 million km^2 to a total of 5.8 million km^2. Indonesia's coastline of 82600 km is one of the longest in the world.

Fisheries play an important role in Indonesia's economic growth, not only as source of food, but also as a strong foreign exchange earner and as a creator of job opportunities. Fish is the most important protein source in the Indonesian diet, contribution 63% of total animal protein intake. Forming only a modest per cent of GDP (2.0% of 20% agriculture GDP), fisheries makes a disproportionately large contribution to employment, providing in 1991 direct jobs for 4 million workers, including about 1.6 million fishermen. In addition, the fisheries sector provides employment for an estimated additional 100000 workers in fish processing, transportation, marketing, and support industries (e.g. boat building, fishing gear manufacture, etc.). Direct and indirect employment is equivalent to 5% of Indonesia's total labour force.

As a result of the increasing investment in fishing, aquaculture, and fish-producing industries, exports of fisheries products have recorded impressive growth in recent years. From 1987 to 1991 the export value of fisheries products increased at an annual rate of 28.1%, from $475 million to a record of $1256 million.

Marine Fishery Resources in Indonesia

Production and potential

With total 1991 fisheries production of 3.35 million t, Indonesia had the eighth largest fisheries landings in the world, contributing 3.3% of global landings of about 100 million t (Martosubroto et al. 1989). From 1987 to 1991 total fish production grew at an annual rate of 4.7%. In 1991 marine capture contributed 76% of all yield, followed by aquaculture at 15%, and inland capture at 9%. The estimated maximum sustainable yield (MSY) of marine fisheries in Indonesia is about 6.6 million t.

Marine capture landings in 1991 totalled about 2.5 million t of which Sumatra accounted for 29%, Java

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23%, Sulawesi 18%, Maluku/Irian Jaya 10%, Bali/NTT 10%, and Kalimantan 9%. Since nearly two-thirds of Indonesia's population reside on Java, landings in Java fall far short of demand. Thus, Java is the main market outlet for marine fish landed elsewhere in the archipelago. As the country's greatest fishery resource potential is in the eastern region, it is anticipated that Java's share of landings will continue to decline and the movement of fish products from outer islands to Java will grow steadily.

The 1991 marine harvest was comprised of 87% finfish, 6.5% crustaceans, 4% seaweed, and 2% molluscs. The following eight groups had yields of about 100000 t or more in 1991 (see Table 1): layang—round scads; tongkol—eastern little tuna; lemuru—oil sardines; kembung—horse mackerels; tembang—fringescale sardine; teri—anchovies; tuna dan cakalang—tunas and skipjack; and rumput laut—seaweeds.

Of these major fisheries groups, the fastest annual growth from 1987 was recorded by lemuru (oil sardines) with 18.7%, followed by layang with 8.0% growth over the same period. All other groups grew by 5.0% or less.

Per capita fish consumption

Fish is the most important protein source in the Indonesian diet, contributing 63% of total animal protein intake. Continued increase in per capita fish consumption is considered essential to improve nutritional standards and bring concomitant health benefits. Over the 5 year period 1987 to 1991, total fisheries production increased from 2.7 to 3.5 million t, equivalent to an average annual growth rate of 4.6%. On a per capita basis, fish supplies rose from 15.5 kg in 1987 to 18.0 kg in 1991, equivalent to 3.0% per year, thus allowing for a steady growth in per capita fish consumption despite a 1.6% increase in population over the same period.

Fish consumption varies greatly through the nation, influenced primarily by location and culture. For example, the 1991 per capita fish consumption of 74.4 kg in Maluku/Irian Jaya was more than eight times that of Java's 8.7 kg. Per capita fish consumption has nearly doubled over the last 30 years, from 8 kg in 1960 to 15.9 kg in 1991. Per capita fish consumption has continued to increase and is expected to reach 17.5 kg in 1994. A 2.4% annual growth in consumption is projected over Pelita VI, reaching an average of 19.2 kg per person in 1998 (Anon. 1993).

Fish Handling and Processing

Domestic consumption

Over 90% of fisheries production is consumed domestically, over half of this in the form of fresh fish. In 1991, 54% of fisheries production was used fresh, 38% was processed (dried/salted, boiled, fermented, sauced, smoked), 6% was frozen, and canning and fishmeal production accounted for 1% each (Tables 2 and 3). Fresh and processed products were largely consumed domestically: 99% of inland capture, 97% of marine capture, and 81% of aquaculture industries.Although domestic prices for

Table 1. Marine fisheries production (t) by major species in 1991.

Species	Production	Per cent of production
Total catch	2 537 612	100
Finfishes	2 215 143	87.3
Layang – round scads	213 274	8.4
Tongkol – eastern little tuna	150 439	6.8
Kembung – mackerel	144 094	5.7
Lemuru – oil sardine	145 055	5.7
Tembang – fringescale sardinella	136 626	5.4
Teri – anchovies	135 633	5.3
Cakalang – skipjack	132 695	5.2
Ikan Kue – trevallies	95 989	3.8
Tuna	78 383	3.1
Tenggiri – king mackerel	52 510	2.1
Gulamah – croackers, drums	28 008	1.1
Kakap – barramundi	22 520	0.9
Blanak – mullets	24 060	0.9
Ekor Kuning – caesio	21 183	0.8
Bawal Hitam – pomfret	18 885	0.7
Layur – hairtails	18 897	0.7
Bawal Putih – silver pomfret	14 096	0.6
Ikan Lainnya – others	927 851	36.6
Crustaceans	164 134	6.5
Jerbung – banana shrimp	41 731	1.6
Dogol – endeavour shrimp	16 348	0.6
Windu – black tiger shrimp	13 743	0.5
Udang lainnya – other	8677	0.3
Kepiting – mud crab	4022	0.2
Udang Karang – spiny lobster	1398	0.1
Udang Lainnya – other shrimp	78 215	3.1
Molluscs	54 578	2.2
Other aquatic animals	5942	0.2
Seaweeds	97 815	3.9

Source: DGF (1993a).

fish have risen rapidly over the last decade, fish—and particularly cured products—remain the cheapest source of animal protein, with unit prices generally 40% below those of beef or chicken.

Of the marine fisheries production that is domestically consumed, approximately 95% comes from artisanal or small-scale fisheries (Table 4).

Fishing season and problems of fish processing

The small pelagic fishes such as layang (round scad, *Decapterus* spp.), lemuru (oil sardine, *Sardinella lemuru*), kembung (horse mackerel, *Rastrelliger* spp.), selar and kue (trevallies, *Carangoides* spp.), teri (anchovy, *Stolephorus* spp.), and tembang (sardine, *Sardinella* spp.), make up a large part of the Indonesian fish catch. During the peak season (lasting about 4 months), the landings of small pelagic fish may reach 750000 t. The peak season usually coincides with the rainy season, which causes a large problem for small-scale fishermen, and for fish processors who cure the catch for salted dried fish. The problem arises because there are not enough hours of

Table 2. End uses of marine fishery production (t), 1984–1991.

Use	1984	1985	1986	1987	1988	1989	1990	1991
Total	1712804	1818725	1922781	2017350	2169557	2271994	2370107	2537612
Marketing fresh	853647	878607	928944	1061060	1188406	1230455	1266462	1322850
Drying/salting	561493	636566	665298	626887	667373	660416	682769	745851
Boiling	121210	121599	125248	119554	84036	118416	121157	134323
Preservation								
Fermentation								
Making belachan	33152	40834	39004	45262	51723	55077	56562	53190
Making fish peda	10536	6599	15095	7706	6619	13586	13641	12092
Making fish sauce	118	501	969	2005	1145	311	874	1242
Smoking	44531	44294	52867	54998	431886	44752	52182	60866
Others	16113	17389	19568	17412	16439	16141	21456	17998
Freezing	46183	58573	66851	65163	81541	84605	108768	122104
Canning	16504	7772	5587	13015	11991	28063	25945	33488
Fish meal production	9317	6001	3350	4288	17098	20182	20291	33588

Table 3. Production of preserved and processed fish (t), 1983–1991.

Commodity	1984	1985	1986	1987	1988	1989	1990	1991
Total	549229	568307	582709	608150	614734	652943	648392	671151
Preserved fish								
Dried/salted	337746	349391	362395	371964	366076	391808	385759	410312
Boiled	96396	97619	92487	97779	93473	83755	81323	107014
Fermented								
Belachan	16018	13911	12874	15232	18228	20310	29285	16070
Fish peda	7148	6928	6738	5618	4706	10577	7828	4912
Fish sauce	91	664	566	1904	1822	1920	1481	1684
Smoked	28930	29587	36957	39018	32418	32508	37905	30904
Others	8764	8017	9600	10172	9277	8524	9638	8993
Frozen	41626	53996	56623	57875	70957	78494	70465	70700
Canned	9567	6421	3541	7331	12285	17358	18601	10556
Fish meal	2943	1773	928	1257	5492	7689	6107	10006

sunshine to dry the salted fish. As a result, fish are often over-salted, yielding a poor quality, low value product. A new technology for fish drying which does not depend upon the sun would thus very much assist small-scale fishermen and fish processors. Such a technology has been developed and tested in ACIAR Project 8846, which began in 1988 and ended in 1992. This was a collaborative project between ACIAR and the Research Institute for Marine Fisheries, Agency for Agricultural Research and Development, Indonesia.

Table 4. Catch composition of artisanal and small-scale fisheries in Indonesia.

Species	Contribution to domestic consumption (%)
Small pelagic	48.0
Demersal	21.3
Large pelagic	17.2
Reef fisheries	0.8
Shrimps	6.5
Molluscs	2.2
Other aquatic animals	0.2
Seaweed	3.9

Ice plants

In addition to salting and drying, fish are sold fresh and frozen, and are variously boiled, fermented, sauced, smoked, canned, or made into fish meal. Indonesia has over 400 ice-making plants with capacity of 7000 t/day. These are concentrated in urban areas with most ice going to non-fisheries uses. Ice is in common use for preservation of shrimp and other high value fish such as for fresh tuna of sashimi quality.

Cold storage

Paralleling the growth of export markets, the number and capacity of freezing/cold-storage facilities have increased dramatically. Most seafood frozen is for export, with a small but growing proportion for domestic consumption. While there were just 40 freezing plants with a production capacity of 300 t/day in 1980, by 1990 the industry had grown to 175 plants with a capacity of 892 t/day. Similarly, cold storage capacity has increased from about 14000 t in 1980 to about 40000 t in 1990. It was estimated that approximately 214000 t of seafood was frozen in 1991. Since most freezing/cold-storage facilities are dedicated exclusively to seafood processing, with a particular focus on shrimp, on an overall basis it is estimated that less than 60% of national freezing capacity is utilised. In many areas, including East Java and North Sumatra, the situation is even more depressed, with 1993 utilisation estimated at less than 40% of capacity. This was due to falling shrimp production from farms hit by disease.

Canneries

In 1993 there were 22 fish-canning plants in Indonesia. While in the past, sardines and mackerel were the main raw material, this has changed to tuna over the past 5 years, with 12 of the 22 plants concentrating almost exclusively on tuna. Indonesia is now one of the largest tuna canners in the world. Total annual production capacity for all fish canning is estimated at 500000 t, of which tuna canneries comprised 70% (350000 t). While canned tuna is mostly exported, sardines and mackerel are usually consumed domestically. Over 80% of the plants are located in either East Java (45%), Bali (18%), North Sulawesi (9%), or North Sumatra (9%). On a production basis, most canning capacity is in East Java, followed by North Sumatra, then Bali.

The highest concentration of new tuna canneries is in Bitung, North Sulawesi. While estimates are not made for domestic consumption of canned fisheries products, if it is assumed that 20% of the sardine and mackerel catch is canned, this would amount to about 100000 t. There are statistics for exports of canned fisheries products, which totalled 43287 t in 1991. Therefore, total 1991 production of canned fisheries products is estimated at 150000 t, or less than 30% of capacity. This low capacity utilisation is acknowledged by the industry. It results from lack of coordination between canneries and sources of raw materials, limited domestic demand for canned products, and lack of export marketing arrangements.

Traditional processing

It is estimated that in 1991 about 1.3 million t of fish (40% of total production) were processed and consumed using traditional methods such as drying, salting, smoking, boiling, or fermenting. On a tonnage basis, modern mechanised factories produce about 30%, and approximately 4300 traditional units (70%) of processed fish products. Traditional processing units are encouraged as labour-intensive activities useful in enhancing the consumption of low-value fish. The most popular processing method is drying, with about a quarter of all fish landed dried and salted. Salted dried product is a very popular dietary item largely because it is easily transported and stored, and is relatively cheap. Dried product often has a shelf life of up to 3 months.

Drying and salting is done almost entirely by traditional means, using both pelagic and demersal fish as a raw material. Smoking is undertaken for both preservation and flavouring. Boiling in brine is a common method of short-term preservation, especially for mackerels and large pelagics. However, boiled product is a delicacy with a shelf life of only about a week. Boiled and smoked fish are relatively cheap but largely consumed only in Java. The most popular species for drying and smoking is skipjack in eastern Indonesia and aquaculture produced milkfish in Java. Significant potential exists both to expand the number of modern curing plants and to upgrade traditional products. In view of the lack of transport options from capture grounds in eastern Indonesia to the consumption areas on Java and Bali, further development of these processing technologies could be especially useful.

Fish meal plants

Largely in response to increased demand for aquaculture feeds, fish meal production in Indonesia grew at an annual rate of over 50% between 1987 and 1991. The number of fish meal plants has also expanded rapidly over the past 5 years. By 1991 there were approximately 50 fish meal plants with a total installed capacity of about 150000 t/year. However, capacity utilisation is extremely low, with 1991 production of 11000 t only about 10% of capacity.

Since fish meal is the largest fisheries import item both in terms of quantity (in 1991, 68% of all fisheries imports by volume (48676 t)) and value (in 1991, 58% of all fisheries imports by value ($30.6 million)) it is likely that efforts for import substitution will continue. Pushed by strong demand for aquaculture feeds, a drive to increase installed capacity utilisation, and a move to decrease imports, the trend toward increased domestic fish meal production is likely to continue.

Fisheries Distribution and Marketing

With nearly two-thirds of the national population, Java is the primary domestic market for fish. Since less than 30% of Indonesia's fish production comes from Java, it is a large net fish importer. Fresh fish supplies for Java's large urban markets are mostly generated by marine landings and aquaculture production along the northern Java coast. The fresh-fish marketing chain is comprised of numerous transaction steps among producers, intermediaries, and customers. Although there are many variations, fish buyers typically make purchases from fishermen and fish farmers at fish landing sites and bring the catch to nearby local auctions where it is purchased by rural wholesalers. The rural wholesalers in turn, pack and transport the fish to urban markets where it is sold or auctioned to urban wholesalers. On Java, the largest fresh-fish markets are Jakarta, Pekalongan, and Juwana. At this point, the fish may be consigned to fish dealers who, in turn, supply retailers, or in some cases the dealers may be by-passed, with fish going directly from the wholesalers to the larger retailers in public markets or supermarket chains.

The inter-island transport of fisheries products to Java involves primarily dried, salted, and smoked fish with virtually all shipments utilising small, private, unrefrigerated cargo vessels. In addition, salted dried fish is transported within Java by overland transport. The largest wholesale market for dried salted fish in the country is located in Jakarta where annual turnover is estimated at 60000 t. The dried or cured fish marketing chain is more direct than that of fresh fish, with sales from provincial collectors/traders to urban wholesalers to urban dealers to retailers.

Fisheries exports and imports

As a result of enhanced investment in fishing, aquaculture, and processing industries, Indonesian exports of fisheries products have recorded impressive growth in recent years (DGF 1993b). From 1987 to 1991 the export value of fisheries products increased at an annual rate of 28.1%, from $475 million to a record $1256 million. Relative to other agriculture exports, fisheries performance has been outstanding, increasing from 1% of all agriculture exports in 1968 to 30% in 1990. A healthy trade balance was maintained. Compared with exports, fisheries imports are very small. Total 1991 fisheries imports were only 4% by value and 17% by volume of exports.

National development goals encourage increased exports and decreased imports of fisheries products. These goals were generally fulfilled over the 5 year period 1987–1991 when the overall balance of trade both as a per cent and in absolute terms consistently improved. In 1987, fisheries exports exceeded imports by $448 million, with imports 6% of exports. By 1991 exports exceeded imports by $1203 million, an increase of nearly two and a half times, with imports only 4% of exports.

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Problems Associated with Dried Fish Agribusiness in Indonesia

Soegiyono*

Abstract

Processing of traditional fish products, especially dried salted fish, faces various problems. The problems are those commonly associated with small-scale fishery agribusiness, such as lack of capital, low skill and knowledge in processing techniques, use of poor quality raw materials, inadequate infrastructure and facilities, and an ineffective marketing system. Government support for small-scale fish processing industries has been less than for other fishery activities such as fish capture and aquaculture.

Fish drying, as other traditional fish processing, is an important economic activity in coastal village communities. It provides employment opportunities, adds value to products, improves fishermen's income, and has multiplier effects on economic activities in the area. For dynamic development of small-scale fish processing industries it is necessary to set up an industrial estate and a cooperative organisation specially designed for the activities. These establishments are expected to resolve the above problems and to remove current inefficiencies and backwardness in the industries.

TWO thirds of the Indonesian region consists of sea, covering an area of 5.6 million km^2, with total fishery resources potential estimated at 6.6 million t/ year. The potential resources consist of the coastal area (4.5 million t/year) and the Exclusive Economic Zone (2.1 million t/year). Total production of marine fisheries reached 2.6 million t in 1992 which represents utilisation levels of about 38% of the estimated total resources.

At present, 90% of utilisation of marine fishery resources is carried out by traditional fishing mainly concentrated in densely populated coastal areas such as the northern coast of Java, the Bali Strait, and the eastern coast of Sumatra (Malaka Strait). The fishing is generally performed from small wooden boats. The landing facilities and markets are not well developed. Such conditions are unable to improve fishermen's incomes and, in some cases, are responsible for deterioration of the catch, especially in the peak fishing season. Similarly, traditional fish processing is carried out in conjunction with fishing activities at almost every fishing centre. It uses simple equipment and skills and has generally failed to adopt any new technologies.

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Traditional Fish Catching

The artisinal fishery, often called the traditional fishery, is characterised by long-established fishing techniques carried out by untrained fishermen. Boats are generally of less than 20 t gross weight, and are made of wood. They are rarely equipped with insulated fish holds or refrigeration. In 1992, the total number of fishing boats recorded in the country was about 362000, with about 300000 of these categorised as small boats (< 20 t gross). Their production was 2.655 million t. Of this production, only about 0.421 million t went for export and this included cultured prawns, frog legs and other commodities. Therefore, most of the catch is consumed as fresh fish or processed into various products for domestic consumption. Most fishing craft are traditional small size fishing boats operated by fishermen along coastal waters. Their catches are generally of poor quality at the time of landing.

Traditional Fish Processing

Traditional fish processing in coastal villages in Indonesia generally uses simple processing equipment and skills passed down within the family. Traditional fish processing is more important in catch utilisation by small- or middle-scale processors than by large-scale industries, which used other processing methods.

The activities of small- and medium-sized processers include the following.

- Securing the fishermen's catch through processing into dried fish, boiled fish, smoked fish, fermented fish and other traditional products.
- Utilising unsold fresh fish for the following reasons:
  - *Deterioration of catches due to:*
    - Weather or climate factors. Indonesia, as many other tropical countries, is hot and humid, conditions which accelerate deterioration of the catch during handling both on-board and on-shore. The deterioration causes undesirable changes in colour, odour, and taste.
    - Lack of facilities on fishing vessels. Small wooden fishing boats are generally constructed without insulated fish holds for icing the catch. Therefore, a longer fishing trip could be hazardous to the catch due to deterioration.
    - Postharvest handling techniques. Most traditional fishermen are untrained and have poor knowledge of fish handling on-board in spite of some species needing extra care in handling in order to ensure optimum freshness. Rough handling is commonly observed, such as use of metal implements causing physical damage to the fish and therefore accelerating spoilage.
    - Fish landing facilities. At present, fish handling at landing places does not generally promote quality in fresh fish reaching the consumer because of the following factors:
      - Poor sanitary conditions at landing places, due to lack of clean water, poor design and construction of the floor and drainage system, poor sanitary measures being practiced, and overcrowding.
      - Poor knowledge and skills of people engaged in handling/unloading the catch in the landing places.
      - Time taken for auctioning, especially during peak seasons, may lead to deterioration due to melting of ice.
      - Most landing places are inadequately equipped with chilling rooms to preserve the catch from deterioration, thereby reducing the price. Prices are further depressed by activities of middlemen.
    - Secondary fish market. Fish markets such as Muara Baru in Jakarta and Pasar Kobong in Semarang essentially function as distributing channels for that part of the catch which cannot be absorbed by fish processing industries. The markets are generally considered as of poor standard and are managed by people who lack skills in proper handling. Unsold fish are usually kept with minimum care, causing severe deterioration by the time they are sold on the next day.
    - Fresh fish distribution. Fresh fish distribution from primary to secondary and later markets is undertaken without a proper cooling system. Bamboo crates, plastic barrels, and wooden boxes lined with teak leaves are commonly used as containers for transportation. The fish are usually packed with only small amounts of ice in these types of containers, leading to severe deterioration during distribution.
  - *Consumer preferences*

    Indonesian marine fishes consist of a wide range of species but, apart from tuna, skipjack, mackerel, and sardines, most are found in only small numbers. Therefore, during catching of a target species there is also a large amount of by-catch. Among various species caught by fishermen only a few such as frigate and striped mackerel, yellowstripe trevally, and scad have a consumer market as fresh fish. On the other hand, some small-sized species such as anchovies, black-tipped pony fish, and oil sardine, and larger species such as rays, sharks, and marine catfish are usually unsaleable as fresh fish, and therefore have to be processed.
- To increase added value

In coastal villages, fish processing is generally carried out by traditional methods using simple equipment. The processing places are commonly located in overcrowded housing areas of poor fishermen. However, processing contributes considerable added-value to various species available in the area. There are several points to be considered regarding the traditional processing:

  - *Freshness of raw materials*
    - That a good quality end-product needs good quality raw material is well understood by the processors. In practice, low-quality raw materials are often used, though selling prices of the products fall as a result. These types of products are primarily aimed at low income groups.
  - *Skill level*
    - To obtain a good processed product a special skill is needed in terms of knowledge on use of salt, ice and chemicals, and on processing techniques for each type of raw material.
  - *Equipment*
    - At present processing machinery is generally not used for traditional fish processing, apart

from a few areas where it is used to replace manual operations, such as in processing of fermented fish paste (*terasi*) in Juwana. In this processing a milling machine of 16 h.p. is used to grind the raw material (i.e. small shrimp).

– *Preservation of raw material*
  – In the course of processing, raw material is left unchilled. When large amounts of raw material are available, the last batch may suffer severe deterioration, causing quality reduction of the final product and a lower selling price.
– *Sanitation*
  – As most traditional fish processing is carried out close to or within houses, good sanitary and hygienic conditions are rarely found. Waste disposal creates environment problems, and smoke generated from the smoking houses causes air pollution. Clean water for processing is also in short supply, causing poor hygiene and foul-smelling surroundings.

Technology of Traditional Fish Processing

In all coastal fishing communities, some traditional fish processing will invariably be found. The technology used has been passed down through many generations. However, in some areas traditional processing methods, such as dried smoked fish (*katsuobushi*), have been introduced from elsewhere. Traditional technologies known and widely practiced in the coastal villages include boiling (*pemindangan*), smoking, salting/drying, and fermentation of fish paste.

Since this workshop deals with fish drying, I will concentrate my discussion on that area, although all forms of traditional processing have common problems. It is worth mentioning that specialised processing in one particular product is rarely found in many coastal villages. Therefore, various types of processing may be done in accordance with availability of raw material and market demand.

Traditional Fish Drying

Basically all kinds of fish—demersal, and small or large pelagic fish—can be processed into dried product. This paper deals mainly with processing of small pelagic fish in Juwana, Central Java which is representative of dried fish businesses commonly found along the north coast of Java and the coast of Bali Strait where there are extensive small pelagic fishery activities.

At Bajo Mulyo's landing place the landed catch reached 47217 t in 1993. The catch consisted of scad mackerel 17902 t, striped mackerel 7413 t, yellow striped trevally 3700 t, round herring 7180 t, and sardines 6816 t. The remaining 4237 t consisted of large pelagic and demersal fish. Small pelagic fish are commonly caught by purse seine. Frigate mackerel and barred Spanish mackerel are caught by multi-filament net, whereas demersal fish are caught by long-line. Some demersal species such as grouper, red snapper, frigate mackerel and barred Spanish mackerel are sold as fresh fish, whereas marine catfish, shark and ray are generally used as raw material for smoking.

Some pelagic fish such as striped mackerel and yellow stripe mackerel of high quality are sold as fresh fish or are used as raw material for boiling. Good quality scad mackerel, short-bodied mackerel and sardines are used for boiling. Lower quality fish of these species are dried.

Types of fish-drying processes

There are three methods of drying small pelagic fish: drying of salted fish using raw material Grade III; drying of unsalted fish using raw material Grade II; and drying of lightly salted fish using raw material Grade II.

Equipment for processing

- Washing tank made of concrete or wood with a capacity of 1–2 m^3 for washing of salted and lightly salted fish
- Plastic barrels for clean water, also used for transporting fish from the landing place to the processing site
- Trays of size 3 m × 1 m made of small split bamboo bound by plastic rope, for sun drying
- Raised drying platform made of bamboo, 14 m long and 1 m above the ground to support trays
- Parabolic bamboo wooden sieve for draining dipped salted fish and to carry the fish to the drying yard
- Scales, capacity 100 kg, for weighing the packaged dried product

Supporting materials needed are:

- Salt, for salting fish
- Minawet pesticide, for used in wet season.

Labour

Workers in dried fish production generally consist of a male group responsible for heavy work such as washing and dipping of fish, and a female group for light work such as drying, draining, and packaging of the product. To process 3500 kg of raw material per day, requires 5 men and 25 women with payments of Rp 2500 and Rp 2000 per day, and working hours from 0700 to 1600 h.

Table 1. Price (Rp/350 kg) of raw materials for processing of dried fish in 1993.

Fish	Grade I	Grade II	Grade III
Scad mackerel	250000	140000	90000
Sardine[a]	60000	60000	25000
Sardine[b]	150000	110000	70000
Short-bodied mackerel	100000	80000	60000
Mixed species	–	–	40000

Note: Grade I is used for production of boiled fish.
[a] *Sardinella longiceps*, [b]*Abligaster sirm*

Production process

The raw materials are brought from the landing place to the processing sites by bicycle. Where the processing site and landing place are relatively far apart the raw materials may first be transported by boat and then by bicycle or by hand. When the fish are already salted on the fishing boat (usually the first week of a three-week fishing trip), the fish are washed in the washing tank. When they are sufficiently drained, the washed fish are carried to the drying yard and are arranged on the trays. When the fish are dry enough on one side, they are turned upside down to complete the drying process.

The dried product is then placed in the shade to prevent condensation during storage in the basket, otherwise the product will be wet during prolonged storage which will cause further reddening. For production of lightly salted product, fish are washed, mixed with salt (30% of weight of fish) in addition to a small amount of water and left for overnight before sun drying.

Packing of dried fish

The product is commonly packed in a bamboo crate of 50 kg capacity. The crate is lined inside with cement paper before being filled with the product, covered with cement paper, then tied with plastic rope.

Marketing

Marketing of dried fish depends on market demand, information on which is provided by wholesalers in various cities of East, Central and West Java. Consumer preferences for dried fish vary significantly. People of most inner cities of West Java prefer dried salted fish. Central Javanese consumers prefer dried salted as well as lightly salted fish. East Javanese, on the other hand, appreciate dried unsalted fish.

Processing waste

In the processing of dried fish, the percentage of raw material rejected for the process reaches between 5 to 10% although the fish are still used for the processing. This poor quality raw material produces very poor quality end product with a very low selling price. For instance, dried unsalted fish and dried salted fish of this quality are priced at Rp250 and Rp200/kg, respectively.

Liquid waste generated from processing mainly comes from washing water and dipping solution. From the 10 processing units in Juwana, 44400 litres of liquid waste is produced per day. This is dumped into the river. There is no waste-water treatment available in the location.

Table 2. Retail prices (Rp/per kg) of dried fish in December 1993.

Fish	Unsalted	Lightly salted	Salted
Scad mackerel	1300	1050	500
Sardine[a]	500	350	275
Sardine[b]	1000	700	400
Round herring	700	500	350

[a] *Sardinella longiceps*
[b] *Abligaster sirm*

Investment

The dried fish processing business in Juwana, Pati Regency has been implemented purely as a self-finance entrepreneurship. For instance, procuring raw material, processing costs, and distribution of the products are self-funded, with no bank finance. The only facility obtained is an offer of payment for purchasing raw material from the auctioning place in which some proportion of payment may be deferred to the next day. Interest is charged on the debt at 0.1% per day.

Management

Traditional fish processing is commonly undertaken as a home industry, with all personnel involved in all aspects of the business.

Management of the business is under the direct control of the owner, from raw material procurement, through processing until marketing. Administration is therefore simple. Management policy is based purely on family relationship where the labour and the owner are considered as working partners. All parties use their knowledge and expertise to pursue a successful business, working in harmony with no conflict of interests.

Problems

Traditional fish drying carried out by processors in the coastal villages faces a number of general problems:

- the industry generally lies in areas close to fishermen's houses;
- appropriate supplies of raw material in terms of quantity and quality are not always assured;
- good processing techniques are not well implemented;
- there is little capital investment;
- market share is primarily taken by low income people.

The above problems make it difficult to add value to processed fish, although such conditions have positive impacts on the following aspects:

- provision of job opportunities to school leavers in the coastal villages;
- marketing of fishermen's catch is more assured;
- growth of supporting industries and services needed by processors, such as small-scale manufacturing industries for bamboo carts, trays, etc., is fostered;
- increasing local government income is obtained from a retribution fee (3% of the value of raw material purchased by the fish processors);
- increasing economic growth and poverty alleviation in the area.

As traditional processing has an important role in the local economy and because of the problems currently encountered in this type of industry, it is expected that the government (especially the local fishery service) and private institutions involved in this activity will turn their attention to solving the above problems.

Fish-processing Industrial Estate: a Proposal

In conjunction with solution to the problems it may be important to consider establishment of a centralised traditional fish-processing industrial estate.

Objectives

The objectives of a centralised industrial estate would be as follows:

- To centralise the present scattered processing units, particularly those currently located in fishermen's houses, at a single fish-processing industrial zone.
- To improve sanitation and hygienic standards in the processing line from handling of raw material, through processing, to distribution of the end product.
- To minimise environmental pollution from washing/dipping solution, used boiling water, smoke from smoking houses, and foul odour from fish paste fermentation (*terasi*).
- To foster export-orientated processing industry development in the area.
- To improve quality of human resources of the traditional processors and business management.
- To facilitate improvement and control of the industry by government services related to this industry.

Steps in planning and implementation

- Land procurement with the area and location able to accommodate all local fish processors.
- Establishment of the fish processing industries: boiling; drying; smoking; fermentation; and other processing.
- Establishment of supporting industries:
  - Stores to supply goods needed by the processors
  - Chilling room for preservation of raw material
  - A small-scale fish-meal processing plant to process rejected raw material
- Establishment of public and social facilities:
  - Connecting road to facilitate transport of raw material and end products
  - Water pump, water tank tower and reticulation of water to the processing units
  - Collective waste-water treatment and storage tanks
  - Parking for trucks
  - Electricity supply
  - Communication facilities (telephone)
  - Auditorium
  - Mosque.

To implement the project it is necessary to appoint a private developer with some basic expertise and vision in fisheries so that the compound would be in harmony with characteristics of fish-processing activities. Therefore, the processors would be willing to settle in the establishment. It is also important to consider involvement of a private investor as a 'foster parent' in the business, to ensure marketing of the product.

Funding and related matters

1. Local government

As an owner of the project the government should have the following tasks:

a. Assisting all required licensees as needed by:
   - fish processors
   - investor/entrepreneur partner
   - developer
b. Providing subsidies for:
   - feasibility study
   - public and social facilities establishment
   - land procurement
   - trusteeship for banking
c. Management and control of industrial estate development

2. Developer

a. Implementing industrial estate construction based on the feasibility study
b. Organising the industrial estate on behalf of local government, based on production sharing
c. Assisting the processors to gain access to banking

3. Processor

a. Paying establishment cost periodically
b. Paying facilities costs such as for use of electricity, clean water, telephone, etc.
c. providing guarantee loan to the bank if possible

4. Investor

a. Providing all production facilities needed by the processors
b. Constructing chilling room for leasing to the processors
c. Constructing fish-meal processing plant
d. Marketing of processed products

Benefits of an industrial estate

To the processors:

a. Guarantee of fish processing business
b. Profit derived from the processing
c. Improved skill in processing techniques and management
d. Production cost efficiencies
e. Improved quality of end products
f. Improved marketing
g. Improved sanitation and hygiene conditions of processing establishment
h. Banking trust

To the fishermen and community:

a. Assurance of market for fishermen's catch and fish culture product
b. Employment opportunity to the community
c. Creating business opportunities in various supporting industries such as:
   - manufacture of crates, trays and other packaging materials
   - supplies of processing materials (salt, alum, Minawet)
   - transport services
   - fish-meal processing manufacture
   - chilling room
   - food stall
   - firewood supply

To the local Government Regency:

- acceleration of poverty alleviation in the area
- increase local government income through retribution fee, taxes and so on
- attracting fishing boats from other regions to sell their catches to the estate
- organise processing units into a clean and neat environment
- improve fishery productivity in the area
- facilitate management and control in terms of:
  - technology dissemination
  - application of quality control and standard in the production line.

Fish Processing Business System

For many reasons fish processors need an organisation, preferably in the form of a cooperative. The cooperative is expected to resolve various problems encountered in the fish-processing business such as competition for raw material supply and marketing of the processed products. At present the processors are not affiliated with any cooperative.

The need for organisation is in line with today's era of global markets, whereby every group of business should take part for specialised industries and improve their products to meet the market demands. Consequently, it is important to set a program of activities to develop the industries by taking into account the following existing local environment conditions such as:

1. Production of fresh raw material
2. Fish processing techniques
3. Quality of human resources and supporting industries
4. Available infrastructures in the area.

The program therefore should cover the following aspects:

1. Assuring continuity of supply of fresh raw material in terms of quality and quantity by collective procurement,
2. Improving fish processing techniques:
   - improving skill and knowledge in the processing,
   - improving processing equipment,
   - diversification of fish processing.
3. Improving marketing of processed products:
   - stabilising existing market share,
   - creating new markets,
   - participation in fish trade promotion,
   - improving packaging techniques to stimulate sales.

4. Improving human resource quality of the processors:
   - training in fish processing techniques
   - training in packaging techniques
   - training in marketing techniques
   - training in business management.

With the above business system it is expected that quality of processed fish products could be improved, consequently increasing market demand not only from the low income group but also from the medium and high income groups. This, in turn, would increase incomes to the processors and the surrounding community.

Conclusion

1. Fish catching in Indonesia is still dominated by small-scale fishing fleets or traditional fishermen operating small fishing vessels of less than 20 t gross weight. The vessels are concentrated in Malaka Straits (eastern coasts of Sumatra), the north coast of Java and the Bali Strait, where the areas are most densely populated.
2. In 1992 from total national fish production of 2.655 million t, a part of production was exported (i.e. 0.421 million t). This suggests that fish available for domestic consumption reached 2.235 million t which was marketed as fresh fish and processed products.
3. Traditional fish processing plays a significant role in utilisation of the catches especially in glut seasons and for unsold fresh fish. The processing also adds value to the fresh raw materials available in the area.
4. Fish processing in Juwana, Central Java is representative of traditional fish-processing industries along north coast of Java and Bali Straits. In the area, fish drying is usually carried out by utilising low quality raw material so that the products are marketed to the low income people. It also renders very low added values earned by the processors.
5. Problems encountered in traditional fish processing generally flow from lack of capital investment, poor supply of fresh raw material, inappropriate processing techniques, low human resource quality, and poor conditions at processing sites.
6. The local government and nongovernment organisations are expected to play their role in management and improvement of the fish-processing industry in their areas especially to centralise processing sites previously spread over fishermen's residential areas.
7. Traditional fish processors are urged to associate in an organisation preferably a fish processing cooperative to improve professionalism in fish processing and create unity of entrepreneurship by collective efforts in their business.

Recommendations

1. Considering traditional fish processing as practiced by processors in coastal villages has played important roles in utilising catches and adding value, therefore the government is expected to give serious attention to the development of centralised small-scale fish processing industries. The development of an industrial estate would strengthen the rural economy, contributing to employment and poverty alleviation in the area.
2. The skill and knowledge of fish-processing techniques of the traditional fish processors are usually poor. It is therefore necessary to introduce appropriate technologies to the processors. Technology would preferably be transferred through a cooperative organisation specially established for the processors. The cooperative is also expected to serve as a workshop for demonstration of any fish processing technology introduced and be a tool for solving their business problems
3. Continuous supplies of appropriate raw material for processing in terms of both quality and quantity are rarely achieved at present. For this reason the government needs to support the following efforts:
   - improving on-board fish-handling facilities, especially insulated fish holds on fishing vessels.
   - improving skill and knowledge on fish handling on board fishing vessels.
   - improving fish landing places and secondary fish markets especially in terms of sanitation and fish preservation techniques.
   - improving skill and knowledge of workers dealing with loading and unloading fish at the landing places to ensure better handling.
4. As the fishing season differs from one area to another, the government should provide an information system regarding geographical distribution of catching areas, which would include time, quantity, and price of catches for each area. The processors should be provided easy access to the system. Therefore, in instances when raw material in one area is inadequate for processing the processor can immediately turn to over-supply areas. This action will also protect local fishermen against a possible threat of price drops due to over-supply at the landing places.

Salted Fish Consumption in Indonesia: Status and Prospects

V. T. Manurung*

Abstract

Salted fish is an important food item in Indonesia, but there has been little research on patterns of its consumption. In general, based on an analysis of census data, the Bureau of Population Statistics (BPS) demonstrated that expenditure on salted fish accounts for a relatively high share of the household budget in Indonesia. Within certain limits, it appears that salted fish consumption rises with increasing household income, particularly in rural households. The average expenditure elasticity of salted fish consumption is positive, for both rural and urban household.

Based on an analysis of these data it is expected that domestic demand for salted fish will remain high in the long term, especially if improvements in quality can be made. Quality gains, which will come from improvements in processing and marketing of salted fish, should benefit both consumers and producers.

THE pattern of food consumption of the Indonesian household is very variable. A diversified diet is seen as important only from the point of view of nutrients. Salted fish, for example, is a traditional item having a dual role in the diet of the people, as a food and an appetiser. As an appetiser the level of consumption will remain limited, in contrast to major food items such as tempe/taufu and meat.

The presence of salted fish in the menu of the people is mainly due to its low price relative to that of other protein sources, such as meat and eggs. Most of the protein consumed by households in Indonesia is fish protein, salted fish included.

Income levels in rural and urban areas vary from low to high. How important salted fish is in the menu of the local people can be assessed from the level of consumption. Regional population characteristics may also be important.

Knowledge on salted fish consumption patterns in Indonesia has up till now been very limited. In general, research activities conducted have been case studies from which it is difficult to extract general conclusions. This paper assesses salted fish consumption in Indonesia on the basis of 1987 census data. Criteria used to describe consumption are: (1) expenditure share; (2) per capita consumption; and (3) degree of participation in consumption, linked to differences in household consumption. The information generated from the analysis is important not only for policy purposes but also for fishery development in general, especially smallholder fisheries as the major source of fishery production.

Utilisation of Fishery Production

The characteristics of Indonesian fishery production, especially its size, perishability, and often long distances from the fishing to consumption areas, mean that the catch must be rapidly handled. Fish processing is the key to success in the development of the fishery. Table 1 gives a breakdown of uses of sea fish production and Table 2 of freshwater fish.

Table 1 shows that, in 1983, about 48% of sea fish production was processed traditionally, and about 43% in 1987. For freshwater fish, the proportion was 33% in 1983 and 29% in 1987 (Table 2). The proportion is tending to fall with time. Nevertheless, in absolute terms, the volume processed traditionally has increased as fish catches are rising. Thus, salted fish production has also tended to increase. On the other hand, use of modern processing methods such as canning and fish meal processing, remains relatively insignificant. Suparno et al. (1991) reported that changes

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towards modern postharvest technology are proceeding very slowly in Indonesia. This means that traditional products, especially salted dried fish, will remain important in fishery development for some time to come.

Manurung et al. (1993) showed that salted fish processing in several production regions of the north coastal region of West and East Java had a high profitability level for processors: 14–18% of the selling price.

Current and Prospective Patterns of Consumption of Salted Fish

Expenditure share

Expenditure share of a commodity reflects its degree of importance in household consumption, to the extent that it can be used to measure economic development (Koutsoyiannis 1982). The percentage shares of household expenditure on fish, meat, and milk and egg consumption are shown in Table 3.

Table 1. Composition (%) of sea fishery production by type of use, 1983–1987.

Use	1983	1984	1985	1986	1987
Fresh/live marketed	46.47	49.84	48.22	48.31	52.60
Traditionally processed	48.06	45.96	47.80	47.75	43.31
Dried/salted	32.10	32.78	34.94	34.60	31.07
Steamed/'pindang'	6.19	7.08	6.67	6.51	5.93
Fermented:'peda'	0.50	0.61	0.53	0.79	0.38
'terasi'	2.57	1.94	2.24	2.03	2.24
'ketchup'	–	0.01	0.03	0.05	0.10
Smoked	4.60	2.60	2.43	2.75	2.73
Others	2.10	0.94	0.96	1.02	0.86
Cold storage	3.59	2.70	3.22	3.48	3.23
Canned	1.03	0.9	0.43	0.29	0.65
Fish meal	0.85	0.54	0.33	0.17	0.21

Source: Directorate General of Fisheries, Jakarta 1988.

Table 2. Composition (%) of freshwater fishery production by type of use, 1983–1987.

Use	1983	1984	1985	1986	1987
Fresh/live marketed	66.47	66.42	68.82	66.99	68.05
Traditionally processed	33.46	32.43	31.07	32.74	29.10
Dried/salted	27.09	28.23	26.56	28.26	26.68
Steamed/'pindang'	0.17	0.18	0.22	0.21	0.24
Fermented:'peda'	0.05	0.05	0.03	0.02	0.03
'terasi'	0.50	0.54	0.31	0.32	0.37
'ketchup'	–	–	–	–	–
Smoked	4.02	3.29	3.25	2.99	0.89
Others	1.63	1.14	0.70	0.94	0.89
Cold storage	0.07	0.15	0.11	0.27	0.32

Source: Directorate General of Fisheries, Jakarta 1988.

Table 3 shows higher expenditure on fish than on meat, and on milk and eggs, confirming the important place of fish protein in the diet of the people. In 1987 about 58% of total animal protein intake was supplied by fish, including salted fish. The importance of fish is reinforced by its relatively low price compared with other sources of animal protein.

Table 3 also indicates that expenditure on fish initially increases with increasing expenditure class, but falls away at the highest level of expenditure. This differs from the steadily increasing expenditure share for meat, and milk and eggs. The steadily increasing share of meat, and milk and eggs, reflects the relatively low base level of consumption of animal protein in Indonesia.

In general the two major forms of fish consumption are fresh and salted fish. The consumption pattern is shown in Table 4.

Table 4 shows that the average expenditure share of fresh and salted fish in urban area was 9.2% and 1.8% respectively, while in rural areas it was 9.2% and 2.5% of total household expenditure. Fresh fish appears to be more important than salted fish, in both urban and rural areas. This accords with the role of salted fish as an appetiser or snack food, the consumption level of which will remain limited. We can also see that salted fish is more important in rural areas.

The comparatively low salted.fish consumption in urban areas is believed to reflect the relative abundance of other sources of protein sources in urban markets. In other words, there is a choice of protein sources in urban markets.

Table 4 also suggests that salted fish consumption tends to decrease in the higher expenditure classes, especially in urban areas. Fresh fish consumption differed also from salted fish consumption: it increases initially with increase in expenditure, later falling again. In general, the changes of consumption pattern, both for salted and fresh fish, appear to follow Engel's Law, which states that 'expenditure share for food will decrease with the increasing level of income and vice versa'.

Level of consumption

In 1987 the average salted fish consumption in Indonesia was 2.22 kg/person/year. There were differences between regions and economic classes, both in rural and urban areas, as detailed in Table 5, which gives average levels of salted fish consumption, by expenditure class, for Java and outside Java, further desegregated into urban and rural.

Salted fish consumption, both urban and rural, was lower than outside Java. This is believed to flow from the larger choice of protein sources in Java: there are many animal protein substitutes for salted fish (Manurung et al. 1993). Besides animal protein sources, there are also many sources of vegetable protein in Java, particularly tempe. A large number of factors, such as taste and tradition, may affect the pattern of consumption of the people.

Table 5 shows also another interesting feature; the trend of increasing income in urban areas is correlated with a decrease in salted fish consumption. This was not apparent in rural areas where levels of salted fish consumption were similar in all economic classes. The relative importance of salted fish is also higher in rural areas both in and outside Java.

Table 3. Expenditure share (%) of household consumption on fish, meat, and milk and eggs in Indonesia, 1987.

Expenditure class (Rp/month)	Expenditure share[a]		
	Fish	Meat	Milk/eggs
< 25000	9.61	0.93	1.80
25000–49999	10.08	1.27	1.80
50000–74999	11.11	2.41	2.40
75000–99999	12.00	3.26	3.24
100000–149999	12.51	4.30	4.24
150000–199999	12.30	6.02	5.70
200000–299999	12.07	7.80	6.66
> 300000	10.80	11.11	7.68
Average	11.31	4.63	4.19

Source: Sub-Research Institute of Sea Fishery, Jakarta 1991.
[a] With respect to total food expenditure.

Table 4. Expenditure share (%) for salted and fresh fish with respect to total food expenditure in urban and rural areas of Indonesia, 1987.

Expenditure class (Rp/month)	Urban		Rural	
	Fresh	Salted	Fresh	Salted
< 25000	7.44	2.22	6.95	2.65
25000–49999	7.61	2.43	7.21	2.87
50000–74999	8.85	2.11	8.29	2.84
75000–99999	9.56	1.94	9.41	2.74
100000–149999	10.07	1.71	10.20	2.77
150000–199999	10.23	1.51	10.66	2.42
200000–299999	10.28	1.42	10.82	2.20
> 300000	9.59	1.05	9.84	1.82
Average	9.20	1.80	9.17	2.54

Source: Sub-Research Institute of Sea Fishery, Jakarta 1991.

Table 5. Salted fish consumption (kg/person/year) in urban and rural areas of Java and outside Java by classes of household expenditure, 1987.

Expenditure class (Rp/month)	Consumption					
	Java			Outside Java		
	Urban	Rural	Average	Urban	Rural	Average
< 25000	1.468	2.278	2.183	1.549	1.762	1.738
25000–49999	1.705	2.140	2.092	2.641	2.416	2.438
50000–74999	1.763	2.073	2.015	1.991	2.713	2.617
75000–99999	1.456	2.197	1.965	1.920	2.940	2.534
100000–149999	1.336	2.280	1.809	1.612	2.940	2.487
150000–199999	1.138	2.040	1.407	1.588	2.954	2.232
200000–299999	1.152	2.350	1.404	1.614	2.810	1.983
> 300000	0.881	2.117	1.059	1.356	2.816	1.604
Average	1.362	2.184	1.742	1.784	2.669	2.204

Source: Sub-Research Institute of Sea Fishery, Jakarta 1991.

Table 6 shows the estimated expenditure elasticities in rural and urban areas in and outside Java. Expenditure elasticities are positive but small in all areas. This indicates that salted fish consumption will increase with increasing expenditure. Manurung and Kasryno (1986), using the 1981 census data, concluded that, in general, salted fish consumption increased with increasing income, especially in rural areas, indicating that salted fish is not considered an inferior commodity. This was in agreement with the results of research in East Java carried out by Hermanto and Andriati (1986), who determined an income elasticity of 0.117. However, to obtain more accurate information, comprehensive research on salted fish consumption is needed. In particular, information on quality specifications and grading, price differentials and market share is lacking.

Level of participation in salted fish consumption

Levels of participation in consumption of salted fish are shown in Table 7. The average level of participation in 1987 was 51.49, segregated for urban 47.40% and for rural 56.11%. The high level of participation again reflects the importance of salted fish in Indonesia.

Table 7 also shows that there was a trend for the degree of participation to initially increase in urban areas but later fall again with increasing expenditure. This was not apparent for rural areas. The trend in urban areas can be explained in terms of the ready availability of alternative protein sources.

Table 8 shows levels of participation in salted fish in and outside Java by various expenditure classes in 1987. On average, the level of participation in Java (55.11%) was higher than outside Java (48.92%). This difference is believed to be due to a better infrastructure and transportation system in Java, making the commodity more accessible to consumers.

Table 6. Expenditure elasticities for salted fish consumption in Indonesia, 1987.

Region	Java	Outside Java	Indonesia
Urban	0.042	0.030	0.033
Rural	0.211	0.025	0.049
Average	0.127	0.028	0.041

Source: Sub-Research Institute of Sea Fishery, Jakarta 1991.

Table 7. Levels of participation (%) in consumption of salted fish by rural and urban households in Indonesia, by expenditure class, 1987.

Expenditure class (Rp/month)	Urban	Rural	Average
< 25000	31.25	42.07	40.84
25000–49999	59.51	52.08	51.08
50000–74999	48.41	56.52	55.25
75000–99999	48.74	59.27	56.71
100000–149999	50.22	61.46	57.41
150000–199999	48.97	60.37	53.72
200000–299999	49.20	57.79	51.38
> 300000	42.89	59.35	45.49
Average	47.40	56.11	51.49

Source: Sub-Research Institute of Sea Fishery, Jakarta 1991.

Table 8. Levels of participation (%) in consumption of salted fish of households in and outside Java, by expenditure class, 1987.

Expenditure class (Rp/month)	Java	Outside Java
< 25000	48.63	34.96
25000–49999	57.29	46.21
50000–74999	60.11	52.35
75000–99999	60.07	55.16
100000–149999	59.39	56.19
150000–199999	54.88	53.16
200000–299999	56.40	49.10
> 300000	47.32	44.23
Average	55.51	48.92

Source: Sub-Research Institute of Sea Fishery, Jakarta 1991.

When the degree of participation is considered in terms of expenditure class, it can be seen that the degree of participation initially tends to increase with expenditure, but later falls again at higher expenditure levels. This trend is apparent both in and outside Java.

Independent of the trend in salted fish consumption, the high degree of participation reflects the importance of salted fish to the Indonesian people. Salted fish has long been a part of their diet and this is unlikely to change rapidly with increasing incomes and expenditure. Indeed, it is speculated that the degree of participation will increase as the market quality of the product improves. Recently, better packaged salted fish has become available in restaurants and supermarkets, indicating that its consumption is spread across a wide range of income and expenditure classes in urban areas.

Future prospects for salted fish

Currently, about 30% of Indonesia's annual catch is processed as salted dried fish. In absolute terms the quantity is increasing over time in line with increasing total catch. This reflects the relatively high demand for salted fish because of increasing population and incomes and consumer preferences.

Analysis of consumption patterns shows that salted fish is not considered an inferior commodity. In 1987, the share of salted fish consumption in total food expenditure in urban and rural areas was 1.69% and 2.76%, respectively. Though there was a trend to decreasing salted fish consumption among the higher expenditure classes, this does not necessarily mean that salted fish consumption will fall with rising incomes.

Salted fish consumption in rural areas of Java in particular tended to increase at the middle levels of increasing expenditure. In urban areas, on the other hand, there was a tendency for salted fish consumption to decrease with increasing expenditure. Nevertheless, income elasticity was estimated to be positive for both rural and urban areas. In other words, salted fish consumption tended to increase with increasing of income, within the limits of the development of the economy to date.

This suggests that salted fish production has the potential for further long term development; particularly to fulfil demand in rural areas. Most of the Indonesian population lives in rural areas. The high trend in annual population growth (2%) should ensure an increasing demand for salted fish.

This prognosis is also supported by the analysis of levels of participation in consumption of salted fish, which were high, both in and outside Java. When rural and urban markets are separated, specific differences can be observed. In rural areas the levels of participation in consumption are tending to increase, while the reverse is true in urban areas.

The decrease of levels of participation in consumption in the highest expenditure classes, particularly in urban areas, is believed to be due to the shift from salted fish to superior substitutes. Consumer preferences are rapidly changing in urban areas.

The long term prospects of salted fish in urban areas are not necessarily diminishing. In general, the quality of salted fish marketed in Indonesia is low. If higher quality salted fish can be produced, there are possibilities for increasing participation in consumption and per capita consumption of salted fish. The technical means for improving the quality of salted fish are readily available.

The difficulty will be in convincing the various parties involved in the business of salted fish that quality improvement will bring increased profits. The recent appearance of salted fish in supermarkets and restaurants suggests that some groups, at least, can see returns from quality improvement and proper packaging.

The benefits of quality improvement will not be restricted to the high expenditure classes in urban areas. Substitutes for salted fish will appear progressively in the market place, so that without quality improvement the demand for salted fish will certainly decrease in the long run.

Improvements in salted fish processing technology have the potential to increase the incomes of artisanal fishermen the producers of the raw material. Consumers will be better off because they have a wider spectrum of quality and price from which to choose.

Conclusions and Recommendations

1. The proportion of fish production processed into salted fish has been relatively large and stable

from year to year, reflecting the high level of demand for this product.

2. The share of salted fish expenditure with respect to total food expenditure is considered high and significant, especially in rural areas. This reflects the relatively high consumption of salted fish in Indonesia. Within certain limits, there has been a tendency for the degree of consumption participation of salted fish to increase with increasing expenditure, particularly in rural areas. This is also supported by expenditure elasticities, which were estimated to be positive.
3. Based on observed trends, it is expected that demand for salted fish will remain high in the long term and may even increase if product quality is improved. The quality of salted fish is currently low, reflecting the application of traditional processing technology.
4. Improvement of processing technology would benefit both consumers and producers.

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A Rapid Socioeconomic Assessment of the Salted Dried Fish Industry in Indonesia and Its Implications for Demand for, and Design of, Improved Drying Technology

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Abstract

The core of the project was to translate the concept of a low technology, low capital, low fuel cost fish drying apparatus using agricultural waste as fuel into a design suitable for adoption by artisanal-scale fish processors in Java. The concept involved burning rice hulls in a disused oil drum and using hot flue gases to indirectly heat air and pass it through racks of fish arranged in a drying cabinet. As described in other papers in these proceedings, this system was to be developed to produce salted dried fish (SDF) in the wet season when cloud cover and rain were believed to constrain sun drying and cause loss of quantity and quality of fish available for drying.

Socioeconomic research began after the main project (which continued from an earlier project) had been approved. The principal researcher and cooperating Indonesian food technologists concentrated on refining and adapting the engineering properties of the furnace and cabinet, and technical issues of fish salting and drying; related work was under way or projected on control of insects and their damage, and on improved packaging. The principal researcher allowed the socioeconomic researcher to set his own research agenda.

Goals and Objectives

THE goal of socioeconomic research was to guide the main technical sections of the project to design technology that would be appropriate to the artisanal fish processors and have a maximum chance of adoption, while avoiding adverse effects on vulnerable sectors of the population. That set as objectives, it was necessary to describe socioeconomic features of the processors and their place in the salted dried fish industry, including supply, demand, quality, and price of their raw materials and products, losses of quality and quantity in the industry, and the implications of these for derived demand for and optimum design of improved drying technology.

Potential social or national benefit does not automatically create demand for improved technology by those in a position to use it. In the absence of state compulsion or subsidy, demand for technology comes from operators who expect to profit by using it. They are not likely to use technology unless they think they could use it to supply a product of higher commercial grade and price, or to produce it at less cost, or at less risk, or to realise more repetitions of the production cycle in a given year by eliminating interruptions due to bad weather. If the apparatus would not profit its potential users, artisanal fish processors, then it would not be adopted.

Socioeconomic research set out to test whether the supply of raw materials and their market price relative to prices of finished product (taking into account costs of drying and weight losses during drying), would allow processors to use the proposed technology profitably. It sought to establish whether cloud cover and rain interruptions to sun drying are real or notional constraints to the quantity and quality of fish that processors can dry in the wet season, i.e. whether there is a significant supply of wet fish of economic price for processing that is wasted or falls in quality due to drying problems. If so, then processors lose an opportunity to increase income and/or risk loss of quantity and or quality of fish that they have bought but cannot dry, and/or incur delays in drying that reduce the number of times per year they can turn over their capital. To avoid those costs and risks they might invest in an individually or cooperatively

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owned dryer, or hire the use of one, if the added fixed and variable costs left that a profitable option. Since the dryer was not yet operating, its capacity and drying time, and capital and running costs per kilo were unknown. Therefore research set out to define those parameters for traditional drying, with which the apparatus would compete.

Related feasibility and customer-engineering questions included whether the fixed size heat source of the dryer set a drying cabinet capacity appropriate to the modal batch of artisanal processors, whether rice hulls are available at marine fish processing sites at an economic price as heat source, whether insect damage between processor and retailer is a significant cause of loss, and whether the way in which the product is handled is amenable to improved packaging.

As there had been no scientific loss assessment study for the industry, brief research tried to substitute for it the perceptions of commercial operators concerning the points in the production and marketing chain from boat to consumer at which major losses in quantity and quality occur and become irreversible, and whether the current project addressed those.

Assessment Methods

I read available literature before going to Indonesia, collected more while there, consulted officials and experts, and used rapid assessment methods during three periods of fieldwork, each of 2 weeks. Research with fishermen, processors, and traders of several linguistic groups would not have been possible without help from a number of people. In October 1990 and February 1991, I was fortunate enough to work with Ms Agnes M. Anggawati and with Ms Nurzali Naamin of the Research Station for Marine Fisheries (RSMF), Slipi, Jakarta, in coastal and interior West Java. In June–July 1991, Dr Siegfried Berhimpon of Universitas Sam Ratulangi, Manado, facilitated and shared research in North Sulawesi. For 3 days Dr Elly Ishak of Hasanuddin University, Ujung Pandang in South Sulawesi shared her expertise. For 2 days I accompanied Pak Suyuti of RSMF on a visit in Surabaya, East Java.

I adopted the working premise that each actor in the industry is more or less economically rational, but operates within discoverable institutional settings and economic constraints. One implication for this approach is that, given that the actor has survived in a competitive and risky economic niche, and given what is known of his institutional and economic situation, then until what is known of his strategies and actions makes economic sense, the research remains inadequate. However, given that research funds and time are scarce, once those actions 'make sense', diminishing returns call an early halt to research.

Processors buy raw materials and sell finished products to make a living. Therefore, it may be misleading to try to understand their production activities and the conditions under which they might change, apart from the economics of the industry of which they are a part. In research on the market chain, I used the strategy of making a (constantly revised) sketch of all the kinds and scales of operators through whose hands the raw materials and product pass from boat to consumer, observing the workplace of a small selection of operators of each kind and scale found at each link in that market chain and asking them open-ended questions based on a constantly revised, prioritised checklist. I asked about (i) their relations with each kind of supplier at the previous link and each kind of customer at the next link, and (ii) their own practises and strategies to make a living from transforming what the raw materials market supplies into what the products market demands. The first set of questions supplemented and cross-checked the second.

Research on the market chain covered:

(i) fish landings (inspection; interviewing skippers, voyage financiers, wet fish buyers, and market officials) to establish state regulation of the industry, boat sizes, catch systems, in-boat handling systems for high and low value species, landed condition, marketing channels for fresh and deteriorated quality product, and alternative uses and their prices

(ii) wet fish wholesale markets (observation; interviews with wholesalers, various types and scales of buyers, porters, market officials, and cold storers) to establish the spread of prices according to marketed condition, of fresh and of processors' quality fish.

(iii) processing sites at Muara Angke and Kali Baru in Jakarta; at several landings in Cirebon and Indramayu along the North Java coast east of Jakarta; on the North Sulawesi coast south of Manado, on the other side of the peninsula at and south of Bitung; in South Sulawesi at Barru, Pare Pare, and Paotere Ujung Pandang (observation; interviews with processors of simple salted dried fish at several scales from artisanal to industrial; interviews with processors of specialised processed products; officials) to establish the range of scale of processors; range of batch size for artisanal processors (vis-à-vis optimum dryer size); seasonal and lunar fluctuations in catch volume, and landed price and condition; processors' constraints and strategies given fluctuations in catch volume and price of wet fish and of salted dried fish (SDF); procedures in selecting, brining, cutting, drying for fish of different thickness, species, and condition; use of family versus hired labour; size of fixed and working capital of processors and access to funds or credit for investment in fixed capital (i.e. a dryer); credit ties between wet fish supplier, processor, and SDF collectors and wholesalers; whether significant volumes of processors' price fish are available at seasons when weather is a constraint to sun drying; post-processing grading, packing, marketing, price making, distribution channels, payment systems; insect damage and control; perceptions of constraints to quality; perceptions of constraints to drying.

(iv) salted dried fish bulk-making collectors and transporters at transport nodes e.g. Cirebon on the north Java coast, at Manado, N. Sulawesi, Ujung Pandang, S. Sulawesi; central place wholesaler storers including those with cold stores at Bandengan, Jakarta and Pasar Andir, Bandung, at Ujung Pandang and at Surabaya, East Java; break-bulk wholesalers at Pasar Kali Baru and Pasar Minggu, Jakarta, and Pasar Andir, Bandung; retailers at a sample of Jakarta markets stratified by income class of their customers (observation; interviews with traders, officials) regarding grading and pricing systems, secular trend and seasonal fluctuations in volume, quality, price of supply; counter-seasonal storage, storage life; grading, pricing and payment—including at a distance; credit chains; wholesalers' account of the total supply system including proportion caused by poor quality wet fish, by processing procedures, drying problems per se, insect damage, post-processing packing, transport and storage damage and time deterioration—all sensitive to place of origin of the product; class and regional patterns of demand, consumer preferences by class for quality versus price; secular trends and seasonal fluctuations in demand including effects of rising money incomes, low rice price, substitutes.

Findings

Information acquired from the research was the subject of preliminary seminars at RSMF Slipi. A long report to ACIAR (Fegan 1991) was circulated early to Indonesian participants in the project and is in preparation as an ACIAR Working Paper. Some papers jointly prepared by RSMF Jakarta staff who participated in the Java research indicate some transfer of research orientation and method.

The industry

Indonesia's fish catch is increasing, but the proportion of the catch processed as the cheap product—SDF—is declining, and the quantity of SDF rising slower than the catch. The major supply side reasons for this seem to be the spread of motors and iced handling on board, plus ice-chain handling ashore, which mean more of the catch is landed at quality suitable for the higher-priced fresh fish market. An increasing tonnage of high priced tuna and prawns is exported.

On the demand side, Indonesia's real per capita income has increased since the 1970s. Although the distribution of income remains very uneven, a declining proportion of the population is under the low poverty line and an urban middle class has emerged. Consumers prefer fresh fish to SDF when they can obtain and afford it. SDF (especially that of lower grades) faces a slowly declining market. Nevertheless, the large numbers of very poor people, notably poor inland farmers, continue to provide a large market for a cheap product that can be transported, stored, and sold without refrigeration.

Java is home to two-thirds of Indonesia's 185 million people. Fisheries within economic range of this large market are heavily exploited. Fisheries experts in Dinas Perikanan say there is considerable potential for increasing catch in eastern Indonesia.

Brief research explored this issue with Bugis inter-island cargo skippers in Manado, Bitung and Ujung Pandang, Sulawesi, with SDF traders in those ports (on shipping routes connecting Java to the eastern archipelago), and with SDF wholesalers in Surabaya the main port in Java receiving from the east. They indicated three main constraints:

- Shipping schedules are not yet frequent, regular, and fast enough to handle a perishable product. It is easier to fly expensive tuna to Tokyo than ship ordinary fish to Jakarta.
- Freight costs are falling as ships compete for back-loads, but still exceed inter-island price margins for SDF.
- Ships may take 4 days from Ujung Pandang to Surabaya, but 2 weeks from Sorong in Irian Jaya, given stopovers in intermediate ports. At ambient temperatures, SDF loses quality as a function of time.

These constraints delay development of marketing systems that would stimulate increased fishing in the eastern archipelago for ice-chain and processed fish for the large Java market. Until transport systems improve, processing in the eastern islands is likely to remain part-time and non-professional.

Researching the market chain

There is limited material available on the SDF marketing chain. One paper (Singgih et al 1985) starts from the processors, classifies the types of trader, and schematises the paths that product takes between them. It contains no empirical material and is not concerned with product grades or consumer stratification. No material could be located on the size of fixed and working capital of the processors and traders, hierarchy of central places, or how the types of actors interact with each other to make the whole system work. There is nothing in fisheries statistics or published work on whether there are generally agreed commercial grades, or how actors negotiate on quality, price, quantity, delivery date, credit, and how buyer and seller communicate, strike a bargain, and make payment at a distance.

Officials of every kind and level in the Dinas Perikanan fisheries research bureaucracy in Java appeared to focus on the conduct of laboratory research under technically optimum conditions without reference to traditional practices as controls, or to economic constraints. Development of research to make it 'user friendly' was not considered; extension was done by a separate branch of the agency. The research agenda and definition of problems were set by either policy decisions from higher levels in the department, or by what foreign donors defined as problems. There was no visible means by which any interest group in the industry could draw attention to its sources of loss as problems for applied research or could be asked whether outsiders had correctly defined problems in their industry, or whether proposed 'solutions' were technically and economically feasible. The system is focused on controlling producers and on educating them, i.e. on what officials and scientists thought might be their problems and might be technical solutions. The focus on production technology excluded inquiry about economics and the marketing system.

State zoning by boat size and specialisation in fisheries

The Indonesian Government regulates in western Indonesian waters the size of fishing boats and the gear they may operate in successive zones defined by distance from shore. The object is to preserve the livelihood of artisanal fishermen using small boats in inshore waters from competition by large trawlers. Trawling caused social unrest before the regulations. Trawlers are permitted only in eastern Indonesia waters. The zoning regulations may account for some of the fishing practices of different segments of the fleet.

One effect is that large fishing vessels from Java ports must go as far as Kalimantan or the Natuna islands to fish. Time to fill the hold plus the round trip voyage time mean that the fish may have been 25 or more days in the hold, with limited ice and a little salt. Certain peculiarities of rays (which have very little fresh market) allow them to be landed in suitable condition for processing despite this onboard handling. Thus, processors' quality rays are the target species of 'industrial' (i.e. large) boats from Java ports.

A second consequence is that a large number of small boats operates in close inshore waters and returns overnight. They specialise in high-priced species landed in fresh condition. The inshore fleet of small boats is least able to cope with heavy seas and does not put to sea during the season of strong onshore winds and big waves. Catches of inshore pelagics fall during such weather, which occurs in parts of the wet season. Medium-sized boats operate further out, and are less affected by seas. They usually ice high-priced species and may kench (salt) in the hold for processors the lower priced species; they return to port every 3–4 days.

The fleet is almost entirely motorised and an increasing proportion of boats carry ice for at least the highest-priced species. An increasing proportion of fresh-fish landings connect to an ice-chain fresh-fish marketing system to distribute fish ashore.

The Indonesian state does not attempt to regulate the quality of fresh or processed fish for the domestic market. It provides technicians and laboratories at export tuna and prawn landings to certify that export product meets the health standards of the importing country.

Wet fish marketing

Indonesian Government regulations require that all fish landed be first marketed at government-controlled wholesale markets. The buyer and seller each pay a tax of 5% of the wholesale price of the fish to a market official. Certain catch statistics are compiled from the tax records. These regulations seem to be followed in Java, and at large landings in Sulawesi and Lombok. They may be more difficult to operate at small coastal villages in eastern Indonesia, notably where a member of a small fisherman's family sells his share of the catch.

Wherever there is a market for fresh fish within economic distance of the landing, good landed-quality wet fish is first taken there to seek the high fresh fish price. At large landings there is a hierarchy of prices and uses according to the species and condition of the fish. Fresh-fish traders deal in a perishable product and face cash flow problems. They must clear at the end of the market day in order to return to their supply source with funds to purchase fresh stocks.

Table 1 would apply well to sardine or skipjack at its upper end, catfish at the lower. As their characteristics vary, no species fits all possible uses.

Processors face a low price for the SDF end-product and weight loss of 50% or more in processing (water loss in drying; for some species head, fins, guts). They buy raw fish that is cheap because it was:

(i) of species unsaleable fresh and landed in poor quality as a normal strategy of one sector of the industry, e.g. rays and shark up to 30 days at sea in large boats fishing Kalimantan waters

(ii) landed in poor quality unintentionally, e.g. catch exceeded icebox capacity; first catch from bottom

of hold—old, ice melted, crushed; boat delayed at sea by poor catch/bad weather
(iii) kenched in the hold (species with low price fresh, e.g. bycatch to iced target species)
(iv) landed fresh, but in glut market it was leftover and with no or insufficient ice, deteriorated by the end of 1–2 market days and, unacceptable as 'fresh', was sold cheap to clear and to free capital.

Transport and marketing constraints in an archipelago

The present SDF production industry can be thought of as having three sectors that differ in the degree to which they pursue quality, according to the cost and time of transport from point of production to market.

The biggest sector is close to the large but low-income Java market, where it operates as a salvage system for low-value species or spoiled raw material unsaleable as fresh fish. It efficiently converts unsaleable wet fish into relatively stable cheap protein available to consumers off the ice-chain, or poor consumers who cannot afford preferred substitutes including fresh fish (marine or freshwater), mammal and bird meats, eggs, etc. This sector subsidises fresh-fish producers and sellers because processors set an informal floor price that reduces their risk of being left with deteriorating product or caught holding stocks on a falling market.

The second sector, e.g. in parts of the Rhiau archipelago, Borneo swamps, Lampung, South Sumatra, and possibly the Tomong Strait in South Sulawesi (according to Victor Nikijuluw of Dinas Perikanan, Ambon), exploits a rich inshore fishery beyond ice-chain range from a large fresh-fish market, but within 1 day by road or 5 days by sea of a large market for SDF. Fish is landed in fresh condition. Species with a high fresh price are sold locally, but leftovers are cleared at processors' price. However, much of the landing is species specifically for processing, e.g. anchovy and small rays. These places produce the top grades of SDF. The best, sometimes produced to order, is processed with special care for fast export. Export of perishables has been facilitated by reform of the ports to reduce bureaucratic delay. The remainder forms a significant proportion of the top grades of SDF, bought by middle-income consumers for traditional dishes. Some of it is cold-stored by central place wholesalers for release in fish scarcity seasons.

A third sector comprises fisheries in relatively lightly populated areas of eastern Indonesia where there is no close urban fresh market, no fast ice-chain to distant urban markets on other islands, and where trading boats call infrequently. In these places fishing remains a mix of subsistence and local market orientated; SDF is a by-product. Traders in Bitung and Manado in North Sulawesi and in Ujung Pandang, South Sulawesi, say that the main problem in such places is the lack of frequent, regular, and cheap inter-island shipping. Although fish stocks are available they are not worth catching. Coastal fishermen produce small surpluses of mixed species; their wives or small traders hope to sell for the fresh price, but without ice, fish spoil quickly. They process only what is clearly unsaleable and are part-time non-professional sideline processors. Much of the product began from spoiled raw materials and by the time a collector's boat calls, has deteriorated. SDF from such places is sorted only by species and sold *rata-rata* by the mixed lot, varying in grade at time of processing and degree of deterioration since then. The non-graded price gives no incentive to aim for quality. The low end-market price per kilo, less freight, does not make it worthwhile to ship such low quality to a distant market like Java.

Rapid assessment in North and South Sulawesi indicated that, despite lower population and fishing pressure, there is not at present a landed surplus there or elsewhere in eastern Indonesia of cheap wet fish of good quality available for processing and inter-island export. It is likely that in those coastal villages and small islands near ports where inter-island shipping schedules become frequent enough and freight cheap enough, traders will perceive the opportunity to encourage specialised fishing and processing. This is more likely to be induced by changes in transport and marketing than by intervention to train the producers.

Officials of BULOG in Manado described a project to improve fishing villagers' incomes by processing the plentiful scad available in the Sangihe islands

Table 1. Wet fish hierarchy of uses by landed quality.

Wet fish grade	Enduse
I	Fresh fish I (Restaurants, upper income-class ice-chain marketing)
II	Fresh fish II (warungs, lower income-class fresh market); cannery, pindang, kerupuk, smoked, spiced dried; SDF I in a glut
III	Salted dried fish II
Below standard	Salted dried fish III, and dried for feed

(between N. Sulawesi and Mindanao). BULOG is a national logistics agency that handles a number of bulk non-perishable priority commodities, including rice. It provided training in SDF processing and set a floor price. The fishermen swamped BULOG with poor quality SDF but continued to sell good quality to capitalist travelling collectors. In the absence of a transport and marketing chain to a consumer market, BULOG was left with warehouses of deteriorating SDF. It eventually sold some at a loss for stockfeed, dumped the rest, and terminated the project.

Transport and marketing problems cause significant losses. First grade teri anchovy of certain species, carefully dried, fetch a high price for export to Singapore, Hong Kong, and Taiwan, and to Asian populations in Australian and North American cities. However, significant quantities of teri become animal feed or are dumped. Although teri anchovies are in glut supply when dark of the moon and good weather coincide, the preferred product *teri tawar* is unsalted and deteriorates (breakage, browning, insect damage) during storage and shipping before it can reach consumers. Traders in Bitung, N. Sulawesi, and in Ujung Pandang, said that much teri from Maluku has no economic market except as feedmill supplies, and that near Sorong, Irian Jaya supplies of teri are so plentiful that sometimes dried teri is dumped into the sea because the low price by the time it would reach a population centre is not worth the freight. Steel vessels carrying mixed cargo and passengers may be unwilling to carry SDF as hold cargo, because of its smell.

Seasonal, weather and lunar fluctuations in supply

Fish catches and prices fluctuate with the seasons, weather, and the phases of the moon. Processors and SDF traders in West Java talk of the wet season as *paceklik* scarcity time, when fish landings fall and the limited supply is too dear for processing. The main reason is that prevailing onshore winds in the rainy season cause periods of rough seas, making it dangerous for small boats to put to sea. Some move to coasts and havens where seas are less dangerous; others repair boat and gear. However, during lulls in the wind and seas, fish are plentiful because the onshore waves and currents stir up sediments and make the foodchain productive, bringing fish inshore.

Processors say that in lulls in the onshore wind and seas, boats put out, make heavy catches, and prices may fall enough for fish to be processed. But such weather also 'usually' gives adequate sun for drying, especially in the mornings. If there is not, they can leave fish in brine for longer, and/or sun dry whenever there is a break in rains, pulling plastic covers over their racks during rain. They say that in cloudy weather drying is slower but adequate, especially if there is some wind. Despite these options, drying time is delayed, reducing their income frequency. Also, inadequate drying plus flystrike increase the risk of loss by the product falling in grade and price. The project did not collect weather records on daily hours of sunlight, cloud cover, and rain to define how many days are unsuitable for sun drying, or to correlate these to fish landings, or fish of processors' price.

The phase of the moon has a major effect on catch. Small pelagics such as anchovies and scad are attracted to lights when the dark of the moon coincides with fair weather. This causes a predictable fluctuation in pelagics supply and price over the lunar cycle. During dark of the moon gluts, the price of wet pelagics like scad may fall enough to allow processors at landings relatively distant from major consumption centres to produce Grade I, which some wholesalers export or cold store. In coastal areas, demand for SDF is slack in the dark of the moon because of the cheap supplies of fresh fish.

Demersal catches are more stable. Owners of fish cultured in brackish and freshwater ponds and cages can time their harvest for the higher price when the marine catch is low; culture species do not fall to processors' price.

Processor scale and technology

Aside from SDF the simple product, there are dried but not salted products like high volume *teri tawar* anchovies, and some speciality products like spiced and dried fish, fermented and dried *jambal roti* made from marine catfish, and smoked product. Research focused on simple SDF because of its high volume and widespread production.

Processors vary in scale, and in whether they are specialists, or process only as a sideline. Scale affects the size of technology they can use and afford.

The smallest are part-time non-professional sideline processors, whose primary income is from fishing and/or trading wet fish and who process occasional unsold surpluses. They have no use for new technology.

Full-time professional artisanal processors buy wet fish and sell processed fish for a living, using mostly household labour. They process near larger landings and wholesale fresh-fish markets. They produce the bulk of the simple SDF marketed in Indonesia and are the focus of this report.

Medium-scale processors have larger working capital to buy raw materials; they hire labour and some buy processed fish as collector traders. They have more fixed capital in brining equipment and drying racks; some own boats, rented to a skipper for a share of the catch. Some use their greater working capital to buy higher-priced species suitable to be split, spread with a layer of mixed spices, and carefully dried as a high priced product. Processors at this scale interviewed during research had a lively interest in trying new ideas to make money and enough spare funds to risk innovation. One was experimenting with sealed and branded 50 g plastic consumer packs for his spiced dried product, aimed at supermarket and export buyers.

Large-scale professional processors ('industrial processors' in Indonesian terms if their capital exceeds R100 million) are relatively unusual. RSMF interviewed one at Eretan on the north coast of Central Java, but did not comment on whether he has other investments. The labour-intensive processing and drying operations require a hired workforce that may be hard to retain in the face of fluctuating catch, price, and demand that sometimes make it uneconomic to process. The regulatory framework (see page 21) that excludes large vessels from competing with small-scale boats in inshore waters in western Indonesia may account for research not encountering large-scale processors of pelagics. Some Java landings are home ports for 'industrial fishing boats', i.e. large boats that return from fishing for demersals distant waters near Borneo. Some fleet owners have integrated fishing plus processing. Given the time at sea, their target species and on-board handling aim at producing only BS wet fish (notably ray) for SDF of Grades II and III to BS.

Artisanal processors' strategies: primacy of working capital

Research concentrated on full-time professional artisanal processors. No statistics were available on their numbers or proportion of the workforce, or on the proportion of catch handled by them. I estimate that full-time professional artisanal processors handle more than 80% of processing in West Java and Lampung, South Sumatra, about the same in South Sulawesi, but that part-time sideline processors account for about 50% of production at the small landings distant from large markets, that characterise much of Eastern Indonesia.

Artisanal processors think of themselves as margin traders. They think of their returns as trader's profit *untung* and *rugi* loss on *modal* working capital invested in a batch of fish and salt. When describing their strategies, artisanal processors' calculations ignored returns to fixed investment (brining tubs, buckets, knives, site, drying racks) and to their family labour.

Professional artisanal processors' strategy is like that of other traders with scarce capital and expensive credit in an economy that has low opportunity cost for low-skilled labour. They invest as little as possible in fixed capital because they must keep as much as possible of their assets liquid for working capital to buy fish; they use unpaid family labour to cut costs.

Processors and traders of all sizes expressed as a rule of thumb that they divide their capital into three parts: one third cash on hand to purchase new stocks, one third tied up in stocks on hand, one third in product delivered on consignment but not yet paid for.

All complain of cash-flow problems, particularly during the *paceklik* fish shortage season, which occurs in the wet season. Wholesalers in inland Bandung used the same term in a way that implied slack demand (rather than short supply of fish), but named the same months which may correspond with pre-harvest season in agriculture when rural demand is slack. Any delay in payment for the last batch can stop processors' operations.

Artisanal processors said they would be unwilling to shift funds from working capital to fixed capital in equipment such as a dryer. To do so would leave them less funds to buy fish. They perceive lack of working capital, not lack of drying weather, as the main constraint to maintaining or expanding their production and to achieving good quality in the wet season. They were dubious that a dryer would be used enough days per year to pay for itself. But if someone else—government or a big collector—would invest and then custom hire use of a dryer, then if it worked as well as sun drying and was cheap, they'd use it when the sun was not available. Some added that in rainy weather in the wet season there are strong winds, fewer boats go out, and few fish are landed and those are too expensive for processing. In breaks in the weather in the rainy season catches are big and fish cheap, but there is then usually enough sun, at least in the mornings, to dry.

Processors said that their optimum strategy would be to buy a new batch of fish and begin brining (and cutting) as soon as possible after the last batch is put out to dry. That would allow them to turn over their capital the maximum number of times in a year. The constraints to this were, in their order of importance: insufficient capital and no access to credit, shortage of cash to buy a new batch till the last is paid for (seasonal cash-flow problem in the industry or payment delayed by bank holidays), no fish available at processors' price, and poor drying weather causing them to leave the last batch in brine and prevent starting a new batch.

All processors extend consignment credit for one delivery, payable at next purchase, to *langganan* i.e. trusted customers. In addition, wholesalers extend credit to collectors and processors during the fish scarcity season, in order to secure supplies; some industrial-scale processors extend credit to their langganan wholesalers at scarcity/cash-flow problem season, to keep their product moving, then collect in the cash-flow boom season.

Processors say that they are not eligible to borrow from the banks at the low interest of 2% per month because they lack collateral. Interest rates on the informal money market are about 10% per month. If a working dryer were available and if its benefit–cost ratios were economic for a processor of this scale, then few artisanal processors seem in a position to afford the investment without special loan facilities.

Artisanal processors batch size and dryer batch capacity

An acceptable dryer capacity (internal rack area and drying time) would process in the same or less time what can be dried in 2 days good weather by the modal sun-drying rack area of viable artisanal processors. Dinas Perikanan designed, built, and controls the relocation centre for processors at Muara Angke, near an estuary landing west of Jakarta. The designers set a standard drying rack area of 75 m^2, based on measurements of rack areas in the Jakarta processors' slums to be cleared, and in the Pulau Seribu islands. Depending on the thickness of the species and its standard cut, this area can dry from about 500 to 1000 kg. Processors at Muara Angke talk about a standard batch of wet fish to buy as something under 1 tonne. Since most processors have proven viable at that rack area, this sets a target for design of a user-friendly dryer capacity.

However, the dryer concept was technology-driven rather than customer driven: drying chamber capacity was set by the heat output of an oil drum burning rice hulls. The rack area was later experimentally varied between about 10 and 20 m^2. Drying time appears to be about 6 hours. That would allow 8 dryer batches in continuous operation over 2 days and nights, or an equivalent throughput to 80 to 160 m^2 of drying rack area. In practice, loading and unloading the racks and furnace would reduce that potential. No work was done to establish how processors could hold brined fish without excessive salt uptake until the cabinet becomes free for the later loads.

Availability and price of rice hulls at processing sites

The furnace was designed to burn dry rice hulls by pyrolysis, a process that requires a fairly free-flowing and finely divided material. In Java, rice is ordinarily hulled at small mills within villages, where the hulls have alternative uses for burning bricks and tiles, as a cooking fuel, and to insulate ice. No research had been done at the time of project approval on whether rice hulls were available dry in a significant proportion of Java and off-Java processing sites, and if so at what price. If hulls were an agricultural waste, then in rainy weather when the dryer would be operated, presumably they would be wet. That could add to dryer capital cost the cost of dry storage and perhaps diversion of some heat to dry hulls procured wet.

Hulls were not available at the Muara Angke processing site near Jakarta where the project had most to do with processors. They are 'available' at some sites on the north Java coast, but the price was said to be rising. At off-Java sites the only other particulate biomass fuel might be sawdust if available and cheap; coconut husk would first have to be ballmilled, adding to cost.

The market system for SDF

The SDF market system within Java is integrated by good roads, while the truck ferry makes the Lampung region of South Sumatra part of Java's road supply region. Sea transport to other parts of western Indonesia adds the Rhiau archipelago and south Kalimantan as parts of Java's supply area. Significant but unrecorded quantities of high-grade material from Sumatra and the Rhiau islands are said to enter the nearby free port of Singapore, where the price is higher.

Inter-island shipping time and cost do not yet allow the potential surplus in eastern Indonesia to be connected to the Java consumer market. Sea transport to eastern Indonesia, notably to Maluku and Irian Jaya has fallen in price and become more frequent and regular because wooden and steel small freighters that take manufactures out, compete for back cargo. However, shipping is not yet sufficiently cheap, frequent or fast to land in good market condition the large quantities of pelagics like anchovies and the bycatch from prawn trawling (which is still permitted in the east). Some fisheries experts and Bugis traders say anchovies are cheap and frequently dumped in ports like Sorong, Irian Jaya. Post-processing delays while traders accumulate an economic-sized cargo, delays in collector-shippers completing their circuit and returning to a market town, and delays in inter-island cargo schedules mean such material deteriorates to stockfeed quality. Considerable tonnages from Maluku and Irian are processed as stockfeed in Manado and Ujung Pandang.

Quantities of low-grade anchovies, other pelagics, and shark are shipped from Ujung Pandang, and of reef fish from Banggai Islands to Surabaya. Those places are within 3–4 days voyage from Surabaya, which seems to be the current practical limit to shipping distance. Statistics on inter-island SDF shipments are compiled from remittance records of a tax collected at the port of lading. They name that port rather than the production site. One wholesaler alone in Ujung Pandang claims to send to Surabaya in season more than the annual total recorded in statistics.

Communicating prices

Processors and collector traders can telephone wholesalers for quotes on the current price for a batch of given species and grades at Bandengan

Jakarta or Pasar Andir, Bandung. There are no radio or newspaper quotes on market prices. The telephone, and relations of commercial trust between langganan buyers and sellers who regularly trade with each other, plus prices offered by competing buyers who call seeking a batch, link the scattered operators into a single market.

Processors in West Java say they can reduce risk by telephoning their langganan wholesaler in Bandengan Jakarta or in Pasar Andir, Bandung to get a quote on the going price for a certain species and grade before deciding whether to buy a batch of materials.

Telephone quotes are approximate. All commercial buyers, i.e. collectors and wholesalers, make a final price only on physical inspection of the batch, and in accordance with the market on that day.

Wholesalers pay cash if the seller accompanies the batch, or by telegraphic bank draft on the same day or next working day. Banks honour the draft without delay.

These communications arrangements within West Java include the Lampung region of South Sumatra, which is part of Java's road supply area and an important source of better grades of SDF. Similar facilities and arrangements apply to transactions within East Java and to shipments trucked from Surabaya to Jakarta/Bandung. However, between Ujung Pandang in South Sulawesi and Surabaya in East Java, to which it supplies some low quality product in season, the element of commercial trust seems less: the owner usually accompanies his shipment.

Central places in the SDF trade

Brief research identified several nodes in the total system that operate as central places where enough buyers and sellers come together to affect prices for the market as a whole. Wholesalers in the central places receive batches from individual processors, and truckloads from large processors and collectors. They quickly grade, price, and pay, then try to re-sell as soon as possible to smaller break-bulk traders in whichever market in that city, or lower market town in their area, offers the best current price for that grade and species.

Only wholesalers in central places, and only some of those, have cold stores. During a fish glut when SDF is relatively cheap because it is in competition in coastal markets with cheap fresh fish, they put Grade I into store and release it to market when fish is scarce and dear. Only SDF of Grade I enters cold store.

The central place market for Jakarta and for higher grades for the whole of West Java is Pasar Bandengan. That for interior rural West Java is Pasar Andir, Bandung. That for East Java is Pasar Pabian, Surabaya which receives from eastern Indonesia, from East Java, and re-directs some product to Central and West Java.

The wholesalers in central places receive and evaluate daily feedback from their widespread networks of both processor and collector suppliers and from break-bulk and retailer customers. They are encyclopaedias of knowledge about both supply and demand sides of the total system. This paper owes much to the knowledge, intelligence, and helpfulness of several wholesalers, especially to Pak Agus of Pasar Andir, Bandung.

The commercial grading system

There is no official system of grades or criteria for grading, but processors and traders use a system of commercial grading that, with local finer variants at the upper end, classes SDF into four grades: I, II, III, and BS (below standard). It is not clear what 'standard' BS is below. BS grade is about one-third to one-half of SDF sold for human consumption in *pasar rakyat* ordinary people's markets in Jakarta and interior West Java, and approximately the same in East Java, Manado, and Ujung Pandang.

Sellers and buyers roughly agree on the grade of a particular batch of fish but negotiate its price. Buyers grade and price by inspecting the top layers of fish in every container (box or basket) in a consignment. Wholesalers say that the costs of losing both commercial reputation and langganan relations are enough to deter any seller from deception, e.g. by putting a better grade on top.

Grading is an art, not a science; it uses ordinary human senses, and takes into account a number of variables that affect consumer choice and probable shelf life. The criteria are more strictly applied by all parties during a glut than in fish scarcity season.

Each grade has a price band for each species and type of processing; for some species, size is a criterion. That band rises and falls according to seasonal glut and scarcity. The price for a particular batch varies according to its quality in relation to competing SDF supplies currently in the market (and of course the bargaining skills and power of the parties).

SDF prices are also affected by the current price of substitutes, and by fluctuations in demand in accordance with seasonal cash flows in the rural areas, civil service paydays, public holidays and feasts.

Packaging and handling

Processors pack SDF in three kinds of container: light cylindrical baskets, re-used cardboard drygoods cartons, or in approximately 50 kg net coco-lumber boxes. After the product is dried, processors let it temper overnight then grade, sort, and pack. They line the container with dried palm leaves or brown-paper 'cement' bag, then pack the SDF in layers separated by leaf or paper. The container of product of one kind and grade is thenceforth the unit of transport, trade, and storage.

The seller despatching SDF pays freight, the buyer pays unloading. The trucker is paid by the container a rate tied to distance. Wholesalers at Bandung say that truckers must pay compensation or lose business if goods are damaged in transit due to negligence, e.g. if the trucker fails to use tarpaulins to protect cargo from rain.

A wholesaler or collector is obliged to accept the whole of a consignment forwarded by a langganan processor. However, he sets the grade and price on inspection. During a glut, the product may arrive on a falling market and deteriorate before it can be sold. To soften the obligation to accept and to share the risk of deterioration and price fall, the buyer may (with the seller's consent) price the consignment not at the date he received it but at the date he sold it.

The collector or wholesaler opens and prices each container, quotes a price per kg, weighs the lot, and deducts an allowance for the weight of the container. Bandung wholesalers say they let suppliers know that they deduct less than the true weight of wooden boxes. This is an incentive to encourage rigid containers that reduce damage from crushing in transport and storage, compared with soft cardboard cartons or baskets.

The project proposed to introduce sealed plastic liners in the containers as an improved technology *to exclude insects*. Wholesalers say they have experimented with sealed plastic liners and would actually downgrade or downprice SDF received in sealed plastic. They point out that insect damage by fly maggots occurs during drying, and stops when the material dries, i.e. before packing. Dermestid beetle damage is not a problem for salted fish. It is serious for high-priced non-salted anchovies and smoked fish, but occurs at the retail markets—after the processors' containers have been opened for grading by collector, wholesaler, sub-wholesaler and retailer, and may have been transferred to the retailer's own display boxes.

Wholesalers argue that sealed plastic liners would cause more problems than they would solve for their trade packs of 50 kg. They acknowledge that branded plastic consumer packs of under 500 g of Grade I are displayed in upper class Jakarta supermarkets. However they point out that 50 kg trade containers are unevenly heated by sun and shade in trucking and handling. In a sealed plastic pack this can cause sweating, moisture migration, condensation, and sticking, and thereby lower quality.

Wholesalers prefer packaging that allows the product to 'breathe' to equilibrate moisture content and temperature. They are careful to re-temper unsealed containers for at least 24 hours in a shady part of the ambient store, before shifting first grade to cold store, and then to leave airspaces between single row box stacks in cold store. Since wholesalers can and do set penalties or premia to encourage the kind of packaging they prefer, any attempt to improve packaging must begin by convincing them. Processors are unlikely to add to their costs unless wholesalers pay more for product received in the new packaging.

Larger wholesalers sell in a minimum lot of one or more unbroken container. Wholesalers who sell to small local retailers may allow a customer to take less than a full container, e.g. for expensive but low volume products like smoked dried fish. In that case the buyer must provide his own container, usually a brown paper cement bag. None of the liner material or shipping containers is collected back along the chain to be re-used for SDF. The only containers that could transmit insects, bacteria, or moulds from one batch to another are the display boxes used in small retail/wholesale stores and in retail markets.

Rapid turnover strategy reduces spoilage in the chain

All operators along the chain are traders who aim to turn over their working capital as often as possible, even for small margins. All levels of traders say that their main source of loss is being caught holding stock on a falling market rather than badly-processed product deteriorating before they can sell.

They say that as road networks have been improved supplies now arrive from many places, some with different glut/scarcity seasons, and it is more difficult than a few years ago to predict seasonal price fluctuations. They say that cold storage has not significantly evened out supply because it holds only a small proportion of marketed volume and only Grade I.

All traders try to re-sell product on the same day or as soon as possible, so they can buy new stocks and turn over their capital as rapidly as possible. They try to avoid money loss by offering a low buying price for under-dried or under-salted material, then ask a low selling price to clear it extra quickly.

The cumulative effect of traders following this strategy at every link of the chain is that product moves remarkably quickly along the chain to consumers. The system works fastest where processors produce every couple of days an economic load for despatch and are connected by road to a consumption centre. Product is exposed to longer deterioration where small supplies are produced in remote islands. Most of the delay there is at the first few links: while the processor or first-level collector accumulates an economic load to take to a market town, or until a mobile collector calls on his circuit and then until his vessel reaches a major trading town.

Demand for low grades reflects income distribution

The bulk of the product, an estimated 60–70% nationally and in West Java, is Grade 3 and BS. On the demand side, the large proportion of low quality SDF remains saleable because the low money incomes of the great majority of rural and urban Javanese maintain a large demand for very cheap food. SDF, being relatively imperishable, has a long history as an item of trade and consumption for a market chain of traders and consumers without cold storage.

Salted dried fish is a cheap food consumed by inland rural poor peasants and the urban poor, who shop by price not quality. Consumers with higher incomes shift to preferred substitutes such as fresh fish, eggs, and bird and mammal meats. Wholesalers say that the fall in the price of rice due to the green revolution varieties, combined with limited rises in rural cash incomes in West Java, have allowed some families, particularly those in towns, to have more cash income available for non-rice food and become more choosy about SDF quality. Improved rice supply also cheapened substitutes for SDF: farmers shifted some land to vegetables, fruits, fish ponds for carp and tilapia, and feed more chickens on cheap grain. These trends indicate a slow increase in demand for Grades I and II and a slow shift upwards in the lowest grade that is saleable for human food.

Wastes, the lowest grade, and deteriorated product are raw material for stockfeeds. The income distribution in Java shifts the cutoff between these end uses downwards in Java compared with neighbouring countries.

Cheap raw materials result in high-salt SDF

As the end product has a low price, only spoiled fish is cheap enough to be raw material for processors. Processors' raw material can be defined as wet fish that, given the anticipated weight loss in processing, is cheap enough on the day to seem profitable to process in relation to the anticipated price of SDF for that species at its probable processed grade in 4 days.

Very fresh fish tissue accepts little salt. The more spoiled the fish, the more salt its tissues absorb. The tissues of badly spoiled fish take up so much salt that it crystallises out as surface salt on drying. Surface salt is one commercial sign of spoiled raw material. Others include burst belly, disintegration, dull skin, flesh discoloration, ammoniacal smell. These features commonly occur together. Disliked by consumers, they are important criteria by which all commercial operators grade and price.

Indonesian Government officials identified high salt content as a major source of low quality and price, attributed it to poor processing, and hoped that the project could devise processing methods to reduce salt content. Socioeconomic research concluded that salt content cannot be manipulated for the approximately two-thirds of the product made from deteriorated raw material. For that part of the catch processed from raw material in good condition (e.g. in gluts and places distant from a large fresh-fish market), low salt product is already produced using traditional methods.

Any effort to improve processing technology should begin by accepting the unalterable consequences of using poor raw materials. It should make a close description of traditional processing and its costs, then test whether technology can produce superior commercial quality at the same or less money cost from the same batch of raw material.

Conclusion: Lessons for Cooperative International Research

The dryer project was unable to achieve its excellent goals. One reason is that it was concept-driven rather than customer-driven. That is, it started from assumptions from afar of what was the 'the problem', devised a solution of fixed size, then wound up like Procrustes trying to make the user fit.

The University of New South Wales (UNSW) posed the problem as how to solve national losses in quality and quantity of an important dried fish food, that it assumed *must* be lost when sun drying is precluded by rain. This had been the format of successful grain drying grants. However, there had been no prior loss assessment of where in the fish product chain major losses begin and become irreversible. Drying was assumed to be the only or main cause of losses. It was not shown to be so.

More specifically, there had been no empirical study to test whether there were in fact significant landings during rainy weather, whether significant quantities then fall to processors' price, and whether processors cannot, because of rain, dry a significant proportion of that. There had been no prior enquiry to the target customers for the proposed machine—artisanal processors—to test whether they suffered significant real financial loss or a loss between potential and achieved income in wet weather, what capacity of dryer would fit their operations and, if they perceived a drying problem, whether they had any funds or credit to invest in drying technology.

ACIAR 'bought' an attractive concept that fitted a number of its grant criteria. The project offered to save postharvest losses in quantity and quality of an important food with many producers and consumers. It offered a low technology, a low capital cost device using discarded oil drums and village-built drying chambers. It offered low running cost and ecological benefit by burning rice hull agricultural waste to heat the drying air. But the concept was not first realitytested: e.g. whether oil drums and rice hulls are available and cheap near processing sites, or whether the heat output arbitrarily set by the fixed size furnace would make a reasonable fit with the typical batch of the intended user.

As it happened, the design concept originated with a heat-systems engineer Dr Stephen Joseph of BIOMASS. In a previous project he contracted to develop a low technology small dryer concept and produced specifications and a working model for the dryer that became the focus of Project 8846. Dr Joseph claims he advised UNSW researchers that this machine was interesting but unsuitable for its task and requested further funds to develop a practical second model. Funds were refused. Relations then broke down between the UNSW researchers and BIOMASS. Dr Joseph was not part of Project 8846. Neither the UNSW nor the RSMF food technology scientists included a heat systems engineer with theoretical and practical skills to make the furnace and drying cabinet work, or if the engineering concept proved fatally flawed, to switch to a new concept that could achieve project ends.

ACIAR's grant application format and procedures make it conventional to justify spending public funds on postharvest research by arguing that the developing nation, or industry, or poor producers, or poor consumers have a 'need' to save losses of quantity and/or quality of product that project proponents estimate occur between production and consumption. In deciding whether public monies should be spent to 'save' such putative loss it is vital to have a proper loss assessment for the industry to define at what point major losses occur and become irreversible. Without careful definition of the problem, much good science may be done but solve a non-problem, a minor problem or, as in this case, try to correct loss of quality that has become irreversible at a link in the commodity chain *before* the technology could be applied.

National 'need' to save total loss in an industry is not the same as demand for technology by the producer at the point in the commodity chain who could use it before the loss becomes irreversible. None of the project-justifying losers above (the nation, producers, consumers) is an economic agent that suffers a tiny part of the estimated total national loss as a financial loss in his own operations and decides whether to adopt technology in order to save it. Lack of a prior loss assessment study means a project may fail to identify the right 'customer', therefore not design to fit that customer's need.

Some losses in objective quality may not be economic losses from any actor's point of view—e.g. where buyers do not discriminate in price for that feature, or where the cost of that improvement in quality exceeds the price margin for it. Conserving such losses in objective quantity and quality, although technically feasible may be uneconomic for the actor at the critical point in the product chain.

The project assumed it was sufficient to start with the developing country scientists, show them how to achieve higher objective quality and not be concerned with whether the market will pay real producers a premium for quality higher than the cost of achieving it. In some industries, successful improvement in quality has been driven by changes that started at the demand end. When end-users began to discriminate in price for quality, the incentive induces producers to pursue it. An example is the Thai maize industry: when raisers of small livestock became aware of losses from feed containing aflatoxin, they exerted demand to develop a cheap and fast test to detect it, then rejected or downpriced contaminated maize. That set off changes back down the commodity chain that made feedmills and collector traders test and discriminate in price against contaminated maize, in turn inducing changes in farm harvest and drying practices. This sequence proved more effective than to start by teaching producers to achieve standards for which the market will not reward them.

In a vertically integrated operation, a single economic unit carries out all the value-adding functions between production and retailing. In such an operation it is difficult but not impossible for tight management to identify at what points objective losses begin and become irreversible. Saving such losses, at acceptable cost, benefits the firm. In developing countries, the industry commonly consists of a chain of independent firms. Each buys product from the one before, adds value by a single operation then sells to a firm at the next link. In this situation it is difficult for a scientist to identify at what points occur how much of each kind of objective losses in the chain as a whole. Yet that kind of loss assessment is a vital preliminary to selecting the strategic problems for technology research.

From the point of view of each unit in the chain, the objective loss while in its ownership may be small or, on benefit–cost, not worth saving. More commonly, the actor may prevent objective loss from becoming his financial loss by financial rather than technical means. In a market chain, each can adjust his buying and selling prices to cover expected deterioration. Each can minimise his financial loss from deteriorating product by rapid turnover. From the point of view of each unit, it is only the quantity and quality that it buys as an input that it has a technical possibility to conserve and has a financial interest in conserving. Where technology is successfully introduced it may make vertical integration attractive to large firms that can thereby engross the trading profit of the small units they displace.

The conventional economics graph of 'producers' gains' and 'consumers' gains' is a poor guide to whether technology will be adopted. It lumps together as 'producers':

(a) those actors who on technical grounds could adopt or reject the technology, and who decide whether to do so by potential financial gain (in this case only the SDF processors) plus

(b) all the actors before and after them in the production and marketing chain (in this case from the boat to the retail market) who are in no position to adopt the technology (for instance, fishing boat owners, fishing crew, wholesale and retail wet fish traders, salt producers, SDF collectors, transporters, wholesalers, retailers, state officials whose paperwork and taxes at fish landings, markets, and inter-island shipping of SDF present disincentives).

(c) large- and small-scale operators; the technology may be technically or economically appropriate only for producers at one end of the scale and help them capture all or part of the income of eliminated competitors.

Economists tend to assume that the whole population are consumers without regard to cultural preferences or income stratification. They assume that this is a preferred or at least a normal product, such that if supply increases, price falls, quality or income rises, then the population will consume more of it. However,

(a) in a market chain, all commercial operators after the one who might adopt the technology are 'consumers' or at least buyers of its product, and traders may capture some or all of the gain.

(b) the product may be, as in this case, an 'inferior' or 'Giffin case' product (dried versus fresh fish) such that only or mainly poor consumers buy it and when incomes rise they shift to preferred products, i.e. demand *less* of it.

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Salted Dried Fish in Southeast Asia

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Abstract

Due to the frequent lack of chilling and freezing facilities, salting and drying remains the main method of preserving fish that cannot be sold fresh in many countries in Southeast Asia. Almost 30% of the total fish catch in this region is cured, and provides a cheap source of good quality protein. This paper reviews the status and advances in research and development of salted dried fish in Southeast Asia during the past decade, with emphasis on salting and drying studies, reduction of insect infestation, and microbiological and biochemical studies. Possible areas of future research are also discussed.

SALTING and drying are traditional methods of fish preservation in many countries in Southeast Asia, where fish is an important source of low-cost dietary protein, and salted dried fish is part of the staple diet. Due to the lack of chilling freezing facilities, traditional curing remains to date the main method of preserving fish that cannot be sold fresh.

Asia contributes 61% of the world production of salted dried fish (Orejana and Embuscado 1983). In Southeast Asia, almost 30% of the fish catch becomes cured fish (Ah-Weng et al. 1985), with Indonesia and the Philippines as the main producers and consumers (Poernomo et al. 1992) The demand for salted dried fish has become widely established in many countries in Southeast Asia due to the simplicity of the salting and sun-drying processes, which require a minimum of capital investment and therefore providing a cheap source of high-quality protein.

There are two forms of salting: wet salting and dry salting (Roberts 1986a). Brining and pickling are the two methods commonly used for wet salting. Dry salting involves placing prepared fish and salt in alternate layers; the liquid pickle that forms is allowed to drain. Medium-sized finfishes, e.g. Indian mackerel (*Rastrelliger* spp.), round scad (*Caranx* spp.), small grouper (*Epinephelus* spp.), rabbit fish (Siginidae) and smaller breams (Nemidpteridae) are split, gutted, and immersed in saturated brine. Larger fish such as snapper (*Lutianus* spp.), Spanish mackerel (*Scomberomorus* spp.), threadfin (*Polynemus* spp.), and rays (*Dasyatis* spp.) are most often split, gutted and dry salted and stacked, then re-salted and sun-dried. Alternatively, these species may be filleted, dry salted, and sun dried. (James 1983)

The salted fish are usually sun dried on the ground, on rocks or beaches. The technique is inexpensive but results in considerable losses due to microbial spoilage, contamination, and infestation by insects and rodents. Some processors use mats on the ground and raised drying racks to reduced contamination and improve drying rate (Curran and Trim 1983). The prime reason for drying fish is to reduce its moisture content to such a level that the water activity (a_w) is sufficiently lowered to prevent or retard microbial spoilage, as salting alone is insufficient for long-term preservation (Ismail and Wootton 1992). Although few detailed studies have been conducted into post-harvest losses of cured fish, particularly in Southeast Asia, losses of 25% are common in developing countries and estimates as high as 50% have been recorded. (Poulter et al. 1988)

Postharvest losses and the low and variable quality of the final product result from:

- the high-salt content
- inefficient drying
- insect infestation
- microbial spoilage
- formation of toxic compounds
- nutritional losses.

This paper reviews the status of, and advances in, research and development on salted dried fish in Southeast Asia during the past decade. Possible areas of future research are also discussed.

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Research on Salted Dried Fish

Research on salted dried fish in Southeast Asia during the past decade can be broadly classified into three areas:

- salting and drying studies;
- reduction of insect infestation; and
- microbiological and biochemical studies.

Salting and drying studies

Poor quality of final product is mainly due to high salt and moisture contents. The use of high-salt concentrations, very often saturated brine, can be attributed to a number of factors:

- Sufficient salt must be incorporated to reduce water activity and extend shelf life.
- High salt discourages insect infestation.
- Fish are frequently stored in saturated brine until suitable weather conditions permit sun drying.

Poernomo and Utomo (1990) found that the prolonged salting and drying times practiced by traditional processors for *Sardinella longiceps* and *S. fimbriata* were not necessary to obtain acceptable a_w values. Berhimpon et al. (1990a,b), in studies on *Trachurus mccullochi* Nichols, found that appearance, texture, and overall acceptability of uncooked salted dried fish brined in 15% and 21% solutions were most preferred by panellists, and that the lower the temperature of drying (45°C preferred), the higher were the preference scores. In addition, the use of brine with a salt concentration of less than saturated also resulted in a significant reduction in processing time. Yu et al. (1982) also found that oven-dried fish salted at 10% and 20% were most acceptable. Similar results were recorded by Buckle et al. (1988). Poernomo et al. (1992) showed that *R. kanagurta* salted in 15% and 21% brine were preferred by panellists. Salting in 21% brine was recommended because of the longer shelf life of the resulting product.

As incomes increase, a broader range of foods becomes available and consumers are becoming increasingly aware of the health risks associated with the consumption of highly-salted food. This has led to a demand for food containing less salt. Further studies are needed on the effect of reduced salt content on the physical, chemical, and sensory properties of the species commonly used for salting and drying. In addition, subsequent drying and handling of the fish during distribution will have to take into account its lower salt content.

Salting alone does not allow for long-term preservation of fish and therefore drying is often used in combination with the salting process. Sun drying is the common practice in traditional salted dried fish processing in Southeast Asia. However, it is becoming increasingly evident that natural drying is subject to the vagaries of the weather and that the quality of the final products will therefore not be consistent.

Oven-dried *Johnius soldado* were more acceptable in terms of odour, flavour, texture, and overall acceptability than sun-dried samples, which had higher moisture contents (Yu et al. 1982).

In the Philippines, many types of artificial dryers have been constructed to overcome drying problems in the rainy season, when traditional sun drying cannot be practiced. These include solar and agro-waste dryers (Camu et al. 1983; Sison et al. 1983; Sumardi et al. 1983; Orejana and Embuscado 1983). However, although improved quality was obtained, processors were reluctant to abandon traditional sun drying. Increased production costs, and the need to use mechanical and electrical power for the blower or fan coupled to the system in some dryers, are some of the reasons why these dryers are often not used in the rural areas, as electricity is not always available in smaller towns and farms.

The International Rice Research Institute (IRRI) has developed a warehouse-type dryer based on the principles of natural convection, and utilising the wind and agricultural residues as energy sources (Jeon et al. 1986). Villadsen and Flores (1983) have also developed a low-cost agro-waste dryer that does not rely on electricity. Roberts (1986b) has described the construction of many low-cost agro-waste fish dryers in the Philippines which are easy and cheap to make from local materials. Low-cost solar dryers were developed by Espejo-Hermes et al. (1985) in the Philippines, and Suparno (1985) in Indonesia.

Souness (1990, these proceedings) developed an appropriate technology rice-husk-fired furnace in Indonesia where neither the furnace nor drying chamber requires any additional power source or fans to move the air in the chamber. Although work in still needed to finalises the chamber design, initial costings appear to satisfy economic criteria necessary to ensure economic viability.

In the future, the successful development and use of dryers by processors has to evolve from close collaboration between scientists and the end users. Appropriate technical solutions to the problems of a community should be developed in that community, taking into account all the constraints likely to be encountered there. The successful integration of an appropriate drying system into the traditional process will depend on many factors. The desirable features of a dryer have been defined by Souness (1990) as:

- low capital cost
- local materials for construction
- no fuel cost
- no moving parts
- low running and maintenance costs
- constructed and repairable by local tradesmen
- low additional costs (e.g. labour) over sun drying.

Reduction of insect infestation

Insect infestation is a major cause of loss to fish processors. In West Java, blowfly infestation (*Chrysomya megacephala* [Fab] and *Lucilia cuprina* [Wied.]) has been identified as being the most important cause of losses during processing and the early stages of storage (Esser et al. 1985). Blowflies are notorious carriers of disease, particularly the pathogens that cause diseases common in developing countries, e.g. diarrhoea, dysentery, and cholera. Food poisoning organisms such as *Staphylococcus aureus*, and faecal indicators belonging to Enterobacteriaceae and Vibrionaceae, have been isolated from *C. megacephala* (Anggawati et al. 1986). Blowflies are also thought to harbour tapeworm eggs, picked up when feeding on human and animal faeces (Lawson and Gemmell 1985). In addition, beetle infestation by *Dermestes* spp., especially *D. carnivorus* Fab., *D. maculatus* De Geer, and *Necrobia rufipes* De Geer is also frequently found (Indriati et al. 1985). Infestation also occurs at wholesale and retail outlets (Indriati et al. 1992).

Esser et al. (1985) found that a combination of screening during salting and dipping the fish in a pyrethroid insecticide, Fastac [(1Rcis)S and (1Scis)R alphacyano-3-phenoxybenzyl, 3-(2,2-dichlorvinyl)-2, 2-dimethylcyclopropanecarboxylate], before drying proved the most effective procedure for preventing blowfly infestation and reducing losses during processing of marine catfish (*Arius* spp.) in Indonesia. Although Fastac was highly effective at very low concentrations, it did not have FAO/WHO approval for use in fish.

In a survey conducted from 1982–1989 in Thailand, Burma, Malaysia, Indonesia, and the Philippines, blowfly infestation was also identified as the major cause of losses during processing (Esser et al. 1989). Examination of over 3000 blowfly specimens, collected from fish at 20 processing sites in 10 locations in Indonesia and Thailand, showed that one species, *Chrysomya megacephala* (Fabricius), by far predominated. Losses during storage were principally due to infestation by *Dermestes* spp. and *Piophila casei* (L.). The illegal use of household and agricultural insecticides such as Baygon, Startox, Mafu, Swallow, Sevin, Lebaycid, Dipterex, and Neguvon was widespread. This highlighted the urgent need for the development of safe, practical alternative methods for reducing infestation.

Approval of pirimiphos-methyl, an organophosphorous insecticide, for use on fish was obtained from FAO/WHO in 1986 (Esser et al. 1989). The pirimiphos-methyl evaluation trials demonstrated that a 0.03% dip treatment for 15 seconds, was sufficient to control insect infestation during processing and storage, while leaving residues which were within the FAO/WHO maximum residue limit of 10 mg/kg (Esser et al. 1986). Numerous trial conducted in Indonesia (Esser et al. 1990) have consistently demonstrated pirimiphos-methyl to be effective in controlling blowfly infestation during processing, and dermestid beetle infestation during storage. Pirimiphos-methyl received provisional registration for use on fish in Indonesia in February 1988 and is marked by PT ICI Indonesia as Minawet 250 EC (emulsifiable concentrate).

In Thailand, 7–12% of salted dried fish is lost to insect infestation (Rattagool et al. 1990). Tests using deltamethrin, a pyrethroid insecticide, applied as a 0.003% dip protected *Chorinemus lysan*, *Arius* spp., *Scomberomorus commersoni*, and *Megalaspis cordyla* against blowfly infestation during processing and *Dermestes* spp. during storage (Rattagool et al. 1990; Esser et al. 1986). Golob et al. (1987) found that deltamethrin as a 0.002% dip protected against dermestid infestation. Anggawati et al. (1992) used deltamethrin and cycloprothrin protected unsalted *Stolephorus* spp. for more than 3 months, and cycloprothrin (0.5 g/m^2) gave protection for 2 months. However, deltamethrin is not at present cleared for use on fish. Cycloprothrin was developed by CSIRO Australia and has shown insecticidal activity against pests in paddy, fruit and vegetables, and pastures. It also has a very low toxicity to humans (Anggawati et al. 1992).

It would be unreasonable to regard the use of insecticides as a long-term remedy for reducing insect infestation. Possible areas for future research to reduce insect infestation should include screening the salting tank and cost-effective storage and packaging techniques. Identification of the chemicals released by fish during processing that attract gravid blowflies could lead to synthetic analogues being used in blowfly trapping. In addition, pheromones that elicit group oviposition by blowflies could be further investigated. Further information on naturally-occurring insect repellents/insecticides is also required.

Asatyasih and Madden (1986) observed that white pepper, garlic, starfruit extract and acetic acid had repellent effects on *Musca domestica vicina* (Macquart) and *Chrysomya megacephala* (Fabricius). In Indonesia, 10% acetic acid sprayed onto salted fish (*Sardinella longiceps*) towards the end of drying has been found to reduce fly landings. The acidified fish were rated as good or better than the control samples (Buckle et al. 1988). Pepper is used by some fish processors in Burma, Malaysia, and Indonesia to control blowfly infestation. The active ingredients of these plant products should be identified in order to develop more effective repellents.

Microbiological and biochemical studies

Microbiological spoilage

The microbiological stability of salted dried fish during processing and storage is dependent upon the water activity in the fish (Chirife and Iglesias 1978;

Troller and Christian 1978). Water activity, a_w, is a measure of the free water in a food which is available to react chemically or to support the growth of microorganisms during spoilage (Waterman 1976). The a_w of fresh fish is above 0.95 and can be reduced by salting and drying, leading to a reduction in microbial growth. However, microbiological spoilage can still occur throughout the brining and drying processes, and in storage as the a_w is often not low enough.

Ah-Weng et al. (1985) analysed cured fish from Burma, Indonesia, Malaysia, the Philippines, and Thailand and found that 11% had an a_w of 0.80 or above, which would permit visible mould formation with 10 days. Large salted dried fishes had higher water activities and were therefore more susceptible to mould formation. A minimum a_w of 0.81 was reported to be necessary for mycotoxin production (Troller, 1980). Provided that the a_w is maintained below this level, mycotoxicosis is unlikely to occur.

Pitt and Hocking (1985) isolated *Polypaecilum pisce*, three new *Penicillium* species—*P. chalybeum*, *P. corynephorum*, and *P. patens*—and a halophilic fungus *Basipetospora halophila* (*Scopulariopsis halophilica* Tubaki) from Indonesian dried fish (see also Pitt, these proceedings). Wheeler et al. (1986) found that the principle mould causing visible spoilage was a white mould, *Polypaecilum pisce*, which covered the fish in a powdery, white growth. *Eurotium* spp., *Aspergillus* spp. and *Penicillium* spp. were also isolated from nearly 15% of the samples of dried fish from Indonesia (Wheeler et al. 1986). More than 50% of the moulds isolated from Malaysian dried fishes were *A. niger*, with lower amounts of *A. flavus*, *A. fumigatus*, and *A. ochraceus* (Ito and Abu 1985). *P. chrysogenum* was also isolated from many samples. Wheeler and Hocking (1988) isolated four 'xerotolerant' fungi—*Paecilomyces variotii, Eurotium amstelodami, A. candidus*, and *A. sydowii*—from Indonesian dried fish and found that, in most cases, the minimum a_w for growth was 0.02 a_w units above that for germination.

The rapid reduction of a_w is the most important factor in controlling mould contamination in fish products (Reilly 1986). During storage, the relative humidity of the environment must also be controlled in order to avoid resorption of moisture. Other parameters such as temperature, substrate, and mould strain will affect toxin production. Most salted dried fish are stored at 25–30°C, which is optimal for aflatoxin production. However, studies show that aflatoxins will not be produced below 8–10°C (Bullerman et al. 1984).

Mycotoxins are heat stable, and normal cooking temperatures are not likely to reduce the aflatoxin content. Further studies on the heat stability of mycotoxins are required to fully assess the situation. Storage of dry-cured fish in humid environments considerably reduces the marketable life and value of the product, as the water activity quickly rises to exceed the minimum for mould growth. There is also a significant health risk is the consumption of mould-tainted fish. Surface-barrier substances applied after processing were found to retard resorption and extend mould-free storage life (Horner 1992).

Spoilage of salted dried fish can also occur at salt concentrations of more than 13% due to growth of halophilic bacteria (Liston 1980). *Halobacterium* and *Halococcus* are often found in solar salt and are most troublesome when the a_w is above 0.75 (FAO 1981), producing pink discolorations. The predominant bacteria occurring in Malaysian spoiled dried fish were *Pediococcus halophilus, Vibrio costicola*, and *Planococcus* spp. (Ito and Abu 1985). *Micrococcus* spp., *Staphylococcus* spp., and *Halobacterium* spp. have been reported as major spoilage microflora in Indonesian dried fish by Santoso and Quantick (1992). The same researchers found that spoilage by *Halobacterium* could be controlled by dipping salted dried fish in 1% sodium benzoate or sodium sorbate.

Doe and Heruwati (1988) developed a three-dimensional model that predicts microbial spoilage based on growth data of various bacteria and moulds found on salted dried fish in Indonesia. The model also shows the time to a particular level of microbial growth at different temperatures and water activities. The significance of this 'spoilage envelope' is that batches of fish held at a particular temperature and a_w for longer than the time specified are likely to be spoiled. It is hoped that the model will be further developed and its use eventually be extended to fish processors.

Biochemical changes

Scombroid poisoning, associated with the consumption of fish containing high levels of histamine, is due to free histidine being converted to the biologically active histamine by bacteria which invade the fish flesh as it spoils (Wood and Bostock 1985). Symptoms of acute poisoning include severe headache, sore throat, facial blushing, shock, vomiting, diarrhoea and, occasionally, death (Taylor 1983).

Histamine was formed during salting in dried salted *Rastrelliger neglectus* in Indonesia (Yunizal et al. 1985) and Malaysia (Azudin and Saari, 1990). Hanson et al. (1985) found that over half the cured fish samples from Southeast Asia had histamine levels above 20 mg/100 g of fish flesh. Histamine levels increased during salting, drying, and storage. Gutting before salting decreased the rate of histamine formation. Wootton et al. (1989) also found high histamine levels in some Asian dried fish.

Since histamine is produced in fish flesh after death, it is important that fish be handled properly after harvest. Reilly and Santos (1985) and Nasran et al. (1985) found that immediate chilling will inhibit histamine formation in mackerel. The microbiological profile at various stages of salting, drying, and storage should also be monitored in order to minimise histamine levels in the end product.

The lipid of traditional, salted dried fish is highly susceptible to oxidation during processing and storage at tropical ambient temperatures (25–30°C), leading to browning and potential loss of nutritional and economic value of the product (Smith and Hole 1989, 1991). Products from lipid oxidation react with phospholipids and amino acids to produce fluorescence and brown discoloration (Smith 1988). Smith and Hole (1989) and Smith et al. (1990) showed that fluorescence and soluble colour were more suitable indicators of extensive rancidity in salted dried Indonesian catfish (*Arius thalassinus*) stored at 25–30°C for up to 3 months than the usual peroxide (PV) and thiobarbituric acid values. Buckle et al. (1988) have recommended storage at 5°C and 10°C to reduce the extent of lipid oxidation but cautioned against the increase in moisture content. F.W. Ma'ruf, D.A. Ledward, and R.J. Neal (unpublished data, 1989) found that brown discoloration was a better index of loss of nutritional quality. They found that oxidation of polyunsaturated lipids was partly responsible for the discoloration.

Lipid oxidation in salted dried fish may lead to nutritional damage, including losses of essential fatty acids, vitamins (e.g. thiamine and riboflavin), and essential amino acids (e.g. lysine) but little is known about the extent of such losses (Surono et al. 1992). In addition, there are reports on the toxicity and possible carcinogenicity of lipid oxidation products, in particular hydroperoxides, malondialdehyde, and polymerisation products. (Ames 1983; Pearson 1983). This reinforces the need for further studies, especially whether these harmful compounds may be causing health and nutritional problems.

Conclusion

Salting and drying is one of many techniques that can be used to arrest spoilage of fish. However, its effectiveness will be greatly reduced if proper processing procedures are not practiced.

The process of spoilage begins as soon as the fish dies and the rate is very rapid especially at tropical ambient temperatures. It should be stressed that proper salting and drying procedures are in themselves insufficient to ensure product quality. They should be carried out in conjunction with correct handling procedures on board ship, and during distribution at wholesale and retail levels, right up to the time the product reaches the consumer.

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Fish Salting and Drying Studies at the University of New South Wales, Australia

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Abstract

Several studies have been conducted in the Department of Food Science and Technology, The University of New South Wales, on the salting and drying of fish, and on the storage stability of dried salted fish, with particular reference to sardines and yellowtail. These studies provide information on the principal factors affecting salt uptake and moisture removal, including fat content of fish, brine concentration, and air temperature and humidity. The salting and drying rates of small pelagic fish have been studied under a variety of conditions. Salting of low-fat fish such as yellowtail for 24 hours in 15–21% brine can produce a product that not only dries at an acceptable level but also has improved sensory quality. Desalting of highly salted fish before drying also increases drying rate and reduces excessive salt levels, but the extra processing step could be an impediment at the village level where salting and drying controls are more difficult, especially under poor drying conditions.

STUDIES on the salting and drying of fish at The University of New South Wales (UNSW) commenced in 1984–85 during a first ACIAR project (Project No. 8313) on dried fish. This was an applied research project that aimed to define the then current practices, and examine technical and economic aspects of the Indonesian fish drying industry. The objective was to develop improved technology relating to on-board handling of fresh fish, and the processing, storage, and distribution of dried fish, to reduce the level of spoilage and increase the storage life and availability of dried salted fish (Edwards et al. 1985; Buckle et al. 1988). These studies were conducted in both Indonesia and Australia, and made some progress towards understanding the salting and drying dynamics of small pelagic fish, such as the Indian oil sardine or lemuru (*Sardinella longiceps*), and in defining some of the limitations of the traditional practices of salting in saturated brine and sun drying.

A second ACIAR fish-drying project (Project 8846 – Improved processing systems for dried fish) did not include additional fundamental studies at UNSW on salting and drying, since its primary focus was on the further development of the appropriate technology agro-waste fish dryer for use by village level processors. It also sought to develop simple processing guidelines for use by traditional dried fish producers which it was hoped would lead to reduced rates of spoilage and hence increased storage life and end-product quality. Another objective was to examine the current packaging system in order to expand the storage life of dried fish during distribution and sale.

The studies at UNSW over the period 1985 to 1990 were undertaken by Master of Applied Science (formal coursework and project) or PhD students from Southeast Asia, primarily Indonesia (5), Thailand (3), and Malaysia (1). The aim of some of these studies was to provide some fundamental knowledge on the salting and drying behaviour of small pelagic fish such as sardines and yellowtail that would contribute to the ACIAR projects. Some studies, unrelated to the ACIAR research, also examined the salting and drying behaviour of shark, squid, and fish such as morwong.

Packaging is of fundamental importance in reducing post-process contamination and possible spoilage of dried fish during storage, distribution, and retail sale. Various studies have been conducted at the Research Station for Marine Fisheries (RSMF), Jakarta, on the effect of traditional and flexible plastics packaging on the sensory, chemical, and micro-

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biological quality of dried fish. Two preliminary studies at UNSW examined the effect of modified atmosphere packaging on the storage stability of both Australian sardines and lemuru, but definitive results will require more extensive research.

Only the principal conclusions of these studies are presented here. Some of this work has been published in the scientific literature (details in References). Other details are in postgraduate theses held at UNSW.

Experimental

The laboratory dryer

The dryer used for drying fish in most of these studies was designed with flexibility of operation and good control of drying conditions in mind. The closed-loop wind tunnel-type dryer (Fig. 1; Berhimpon 1990) included a fan, a heating section, a steam injection system, and a horizontal drying chamber, although in other drying studies on vegetables such as onions and garlic, a vertical chamber was also used. The tunnel walls were made from flexible, heavy-gauge, ribbed aluminium tubing filled with 5 cm thick fibre glass insulation. The drying chamber (50 cm wide × 30 cm deep × 70 cm long) was made from 2.5 cm plywood painted both sides with waterproof paint, and an aluminium detachable door on the top of the chamber. A perforated aluminium tray (35 × 60 cm) was placed parallel to the airflow and was supported with four rods which passed through the bottom of the drying chamber to a Mettler PE 22 balance connected to a personal computer.

Air was circulated through the tunnel by an axial flow fan driven by a 1.5 kW AC motor. The air speed was controlled using a MSC 300-B solid-state speed controller. Heat was supplied by a three-phase, 6 kW electric heater, and the humidity adjusted by steam injection from a boiler which vented into the tunnel through a valve operated by an electrical actuator. The heater and actuator were controlled using a Eurotherm 820 controller with input from a thermocouple and DC signal from a humidity sensor located before

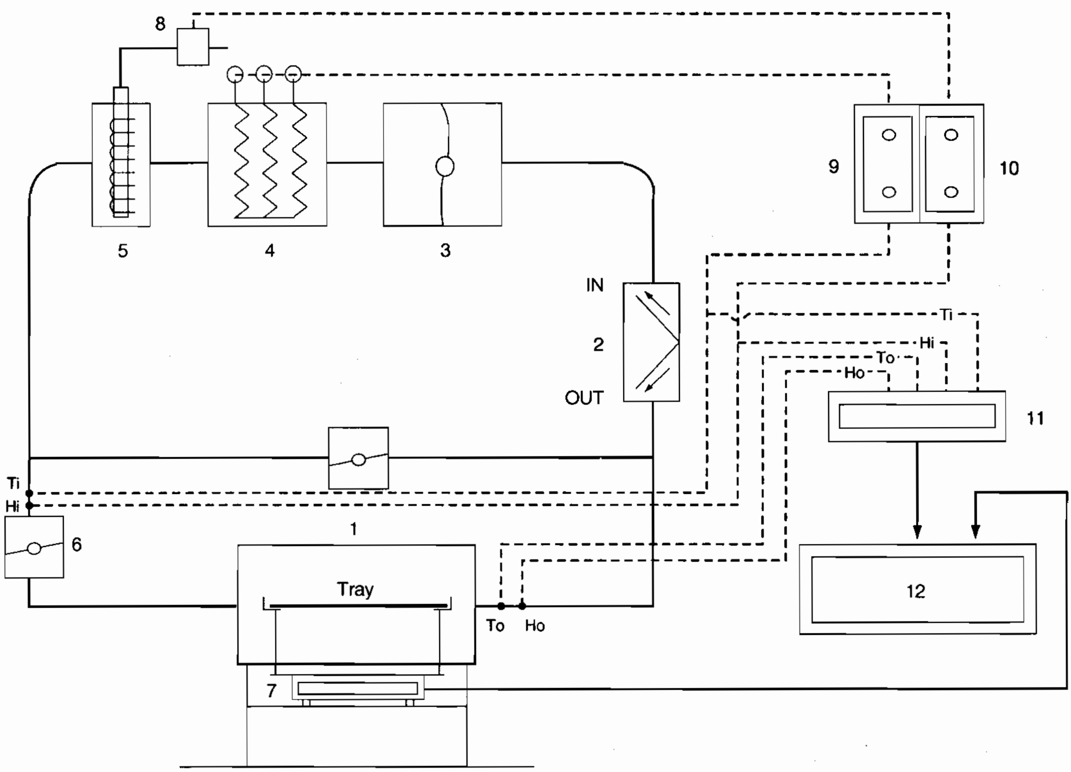

Figure 1. A schematic diagram of the fish drying system used at UNSW (from Berhimpon 1990). Parts of the system are as follows: 1. drying test section; 2. vents; 3. axial flow fan; 4. electric heater; 5. steam distribution system; 6. dampers; 7. balance; 8. electronic actuator; 9. temperature controller; 10. humidity controller; 11. multi logging meter; 12. computer; Ti = temperature of inlet air; Hi = humidity of inlet air; To = temperature of outlet air; Ho = humidity of outlet air.

the drying chamber. The temperature could be maintained to within 0.2°C and the relative humidity (r.h.) could be maintained to within 2% at temperatures <50°C, and to within 5% at temperatures >50°C.

Salting studies

Coarse refined and kiln dried salt (Pacific Salt Pty Ltd, NSW, purity 99.7%) was used to prepare saturated or other salt solutions. Fish were salted in plastic dishes or glass jars held at constant temperatures.

Fish raw materials

Fresh fish were purchased either from a fish market in Kingsford, NSW (a suburb adjacent to UNSW) or from the Sydney Fish Marketing Authority, Pyrmont, NSW. Fresh fish were iced during transport to the laboratory and processed immediately on return. For one study (Lubis 1990), fresh (frozen) and dried-salted Indonesian sardines were airfreighted from Jakarta for further study at UNSW.

Results and Discussion

Initial studies on salting and drying of sardines

Salting

The first study on fish salting at UNSW was conducted by Utomo (1985) who examined the effect of temperature and pH on the salting kinetics of fresh Australian sardines (*Sardinops neopilchardus*). Freshly prepared saturated brine had a pH of 9.4, and this was adjusted with 1% acetic acid to pH 4 and 7. Whole fish were wet salted by packing in layers between salt and saturated brine added, with a ratio of salt : fish of about 1:2 (w/w). Salting was conducted at 25, 30, and 35°C for up to 67 hours and samples taken for analysis of salt and moisture contents and pH. The original fat content of the fresh fish was about 2.8% (wet basis).

Effect of pH. pH of brines changed significantly during salting, and equilibrated after about 5 hours. Fish brined at pH 4 and 35°C softened after about 30 hours in brine. Brines of pH 7 and 9.4 decreased in pH during salting, and after 76 hours salting were about pH 5.5 and 5.6, respectively. The pH of fish flesh after salting varied from about 5.9 to 6.2. There was no effect of brine pH on salt uptake.

Effect of temperature. Salt content of the fish increased with time, and salt uptake was marginally higher at 30 and 35°C than at 25°C. Typical salt uptake and moisture loss profiles show there is little to be gained by salting for longer than about 20 hours at 25–35°C over the pH range 4–9.4.

Salting and drying

Poernomo (1985) examined the salting and drying behaviour of Australian sardines (*S. neopilchardus*) of fat content 2.5–3.1% obtained from the Sydney Fish Marketing Authority. Fish were salted in saturated brine at 25°C for up to 90 hours. For drying, fish were salted for 24 hours, frozen at –20°C, then thawed (5°C, 5–6 hours) before drying at 35°C/50% r.h., 45°C/30% r.h. or 55°C/18% r.h. at air velocities up to 3.0 m/second at orientations both parallel to and at 90° to the air stream. The air temperature/r.h. combinations were based on weather data for Denpasar, Bali where the average temperature and r.h. between 0900 and 1500 h are 28.2°C and 82.8%.

Salting. Both salt uptake and moisture loss were highly correlated ($r = -0.96$–99) with the data predicted by Zugarramurdi and Lupin (1980) (see Fig. 2).

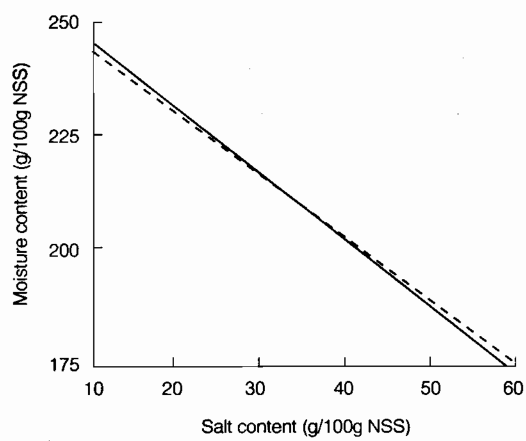

Figure 2. Relationship between moisture and salt contents of Australian sardines (*Sardinops neopilchardus*). Solid line is observed results; dotted line is results predicted by Zugarramurdi and Lupin (1980) (from Poernomo 1985).

Drying. Several equations proposed by Jason (1964, 1965) and others (one to three-term models) were used to match the drying data obtained experimentally for moisture ratio versus time, where moisture ratio $MR = (M_t - M_e)/(M_0 - M_e)$ in which M_t = moisture content at t hours (% db), M_0 = initial moisture content (% dry basis) and M_e = equilibrium moisture content (% db). A two-term model adequately described the data: $MR = A^* \exp(-t/a) + (1-A)^* \exp(-t/b)$.

Effect of temperature and relative humidity. Higher air temperatures and hence lower relative humidity increased the initial drying rate only, more so at the lower air velocity (1 *vs* 3 m/s) (Fig. 3). Fish dried at 55°C were less acceptable due to case hardening than fish dried at lower temperatures. Drying at 45°C/30% r.h. was the most acceptable in terms of drying rate and product quality. The relationship between relative humidity and equilibrium moisture content is shown in Table 1.

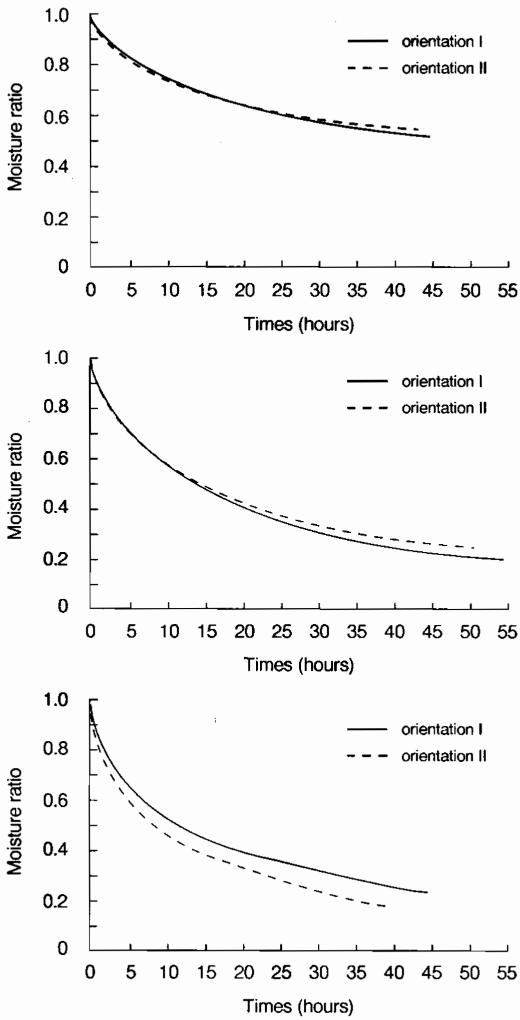

Figure 3. Drying curves of salted Australian sardines at 35°C/50% r.h. (top), 45°C/30% r.h. (middle), and 55°C/18% r.h. (bottom) at air speed 3 m/second. Orientation: I = parallel to airflow; II = 90° to airflow (from Poernomo 1985).

Table 1. Relationship between relative humidity and moisture content of dried salted sardines.

Relative humidity (%)	Equilibrium moisture content (% db)
18	1.9
30	3.1
50	5.8

Effect of air velocity. Air velocity appeared to have little effect on the overall drying rate of whole salted sardines. There was no constant drying rate for these fish, in agreement with the findings of others. The ideal air velocity for a fish dryer has been reported as 1.5–2.0 m/second, but this will depend on the nature of the fish to be dried, pre-drying treatments, and the end quality desired.

Effect of fish orientation. Fish orientation (i.e. fish parallel to or at 90° to the airflow) had no significant effect on drying rate.

Moisture Sorption Isotherms of Dried Salted Fish and Salting and Drying of Sardines

Moisture sorption isotherms

Wuttijumnong (1987) conducted the first detailed (PhD) study on the salting and drying of fish at UNSW. Moisture sorption isotherm (MSI) studies were conducted on trevally (*Usacaranx nobilis*) and Australian sardine (*S. neopilchardus*) fillets/pieces that were salted in 5%, 15% (w/w), and saturated brines for 24 hours at 15.5°C, and desorption and adsorption isotherms were determined. Samples were freeze dried for adsorption isotherm development, and dried in the ACIAR drier at 40°C with an air velocity of about 2.5 m/second for desorption experiments. Equilibration was for at least 7 days in airtight glass containers over a range of standard saturated salt solutions.

He found that the Hailwood–Horrobin equation: $(a_w/M) = A + Ba_w + Ca_w^2$ adequately predicted the water activity (a_w) of dried salted fish in the range 0.3–0.75; that the effect of fish species was not significant; and that there was a small degree of hysteresis at water activities above about 0.60 (Wuttijumnong et al. 1985).

Salting and drying of sardines

Wuttijumnong (1987) also studied the salting of both Australian (*S. neopilchardus*) and Indonesian (*S. longiceps*) sardines (lemuru), the latter transported frozen from Indonesia. The fat contents were 6–7% and 12–13%, respectively. Brining was done in saturated brine (brine : fish ratio 2:1 w/w) at 19–22°C. Salt uptake by Australian sardines was initially higher than for the lemuru due to the latter's higher fat content. He found good agreement between the experimental data and the mathematical model of Zugarramurdi and Lupin (1977, 1980).

Wuttijumnong (1987) examined the effects of air temperature (35–45°C), relative humidity (40–60%), air velocity (0.5–2.5 m/second), and salt content (0.15–0.35 g/g sfffdb) in a factorial experimental design with randomised sequence of trials. Fresh

Australian sardines were salted, rapidly frozen (–40°C), and stored (–20°C), then thawed (12 hours, 5°C) before drying. Preliminary studies had shown that fresh sardines frozen in this way dried at a rate comparable to that of fresh fish.

Higher air temperatures increased the drying rate but scorched thinner portions of fish. Relative humidity had little effect on drying rate. Air velocity increased drying rate initially but the difference was negligible after 4 hours drying. Drying rate decreased with increasing salt content (Fig. 4).

Wuttijumnong also examined various models to predict the drying behaviour and moisture content of salted sardines, and showed good agreement between predicted (two term approximation of a diffusion equation model) and experimental values, especially for drying at 45°C/50% r.h..

Salting and Drying of Marine Products

Ismail (1990), in association with A/Prof. Michael Wootton and independently of the ACIAR projects, conducted a PhD study on the preservation of marine products by salting and drying. She examined morwong (*Nemadactylus macropterus*) fillets (Ismail and Wootton 1985; Wootton and Ismail 1986), whole sardines (*S. neopilchardus*), shark (*Notogaleus rhinophanes*) fillets, and whole, gutted, and skinned squid (*Nototodarus gouldi*) which were salted (brine:fish ratio of 2:1 w/w) in saturated brine at 30°C then dried at air temperatures of 30–70°C (no r.h. control) until moisture contents were below 30% (wet basis). Samples before and after storage were analysed for moisture, fat, protein, and salt contents, a_w, protein solubility and digestibility, amino acids, total volatile base (TVB) and trimethylamine (TMA) contents. Protein bands were examined by isoelectric

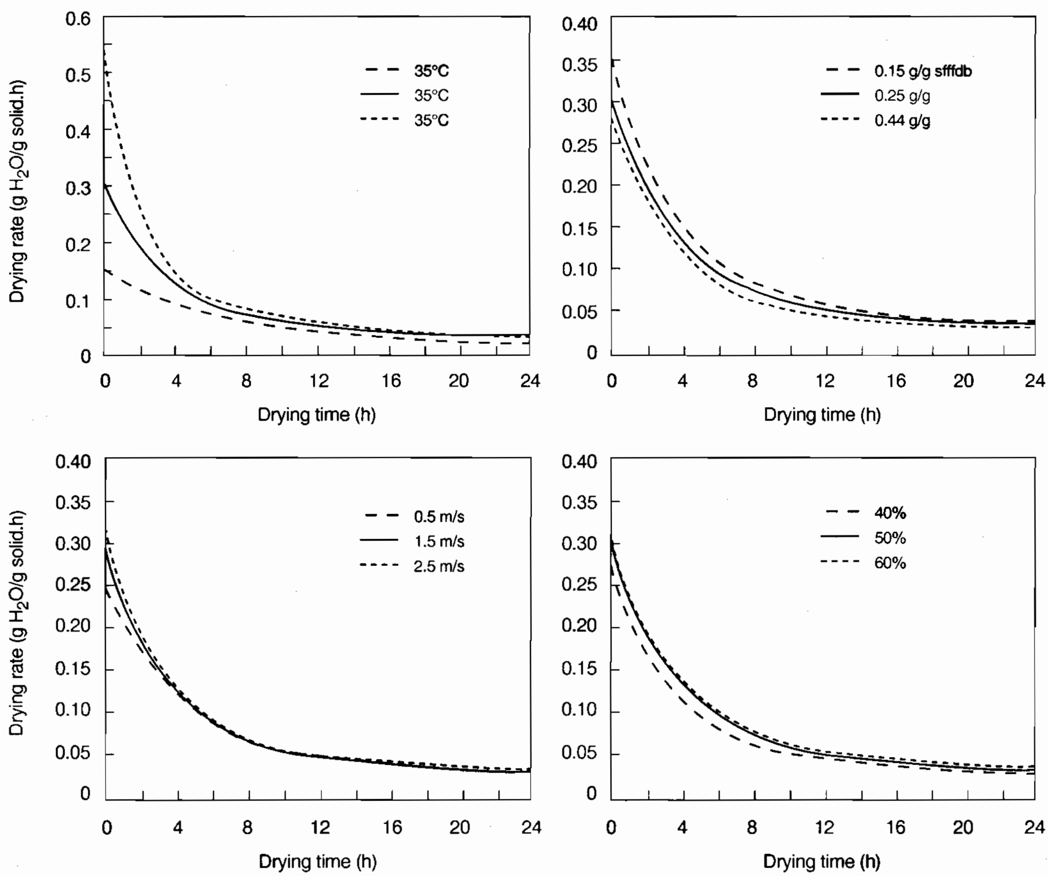

Figure 4. Effect of air temperature, relative humidity, air velocity, and salt content on drying rate of salted Australian sardines (from Wuttijumnong 1987).

focusing, and tissue disruption was assessed by scanning electron microscopy (SEM). Quality was assessed by measuring rancidity (TBA value), reconstitution properties, saltiness, aroma, colour and texture after reconstitution and deep frying. Storage was conducted at 5, 25 and 37°C for up to 6 months in polyethylene bags on products salted for 8 hours (morwong and sardine), 4 hours (shark), or unsalted (squid), and dried at 50°C.

Salt uptake was highest in shark, followed by morwong and sardine, while moisture loss was highest in sardine, followed by shark and morwong. A drying temperature of 50°C gave the best compromise between drying rate and product quality.

Lightly salted products were significantly preferred for all species ($P<0.01$), and products dried at lower temperatures were significantly more acceptable for shark and sardine but not for morwong and squid. Storage at 5°C was superior to that at 25 and 37°C where hardening, brittleness, browning, mould growth, physical breakdown and rancidity developed as early as 4 weeks in storage.

The effects of salting, drying, and storage on the proteins of dried salted products were demonstrated by decreased protein solubility in KCl and SDS+ß mercaptoethanol, and disappearance or decreased intensity of some bands in the IEF pattern of water-soluble proteins. Changes in in vitro protein digestibility and amino acid contents were not significant. SEM examination of fish tissues showed the effects of disruption due to salting and the reduction in compactness due to drying.

For sardines, initial moisture content (74.5% wb) decreased to 57% after 48 hours salting in saturated brine, lower than for morwong or shark. Sardines dried more slowly than the other species, and browned considerably if dried at temperatures above 50°C.

Dried Salted Shark

Ishak (1990) conducted a similar but more detailed examination of the effects of salting (including acidification with acetic acid) and drying temperature/time on the quality and storage stability of carpet shark (*Orectolobus* sp.). Such products are of considerable importance in South Sulawesi and other parts of Indonesia. High salt concentrations (40%) were most effective in reducing the urea content, but produced salted samples of low acceptability showing tissue disruption and poor texture. Dry salting methods were more effective for reducing urea levels than was wet salting. A rapid salting process based on soaking shark in 4% acetic acid for 30 minutes followed by pickling for 4 hours in 20% salt at 30°C and then drying for 18–20 hours at 45°C to a_w 0.70 produced products of excellent quality with desirable taste, odour, and texture.

Product quality deteriorated when air temperature during drying exceeded 55°C. An acceptable product was obtained by drying carpet shark for 18–30 hours at 45°C/30% r.h..

During storage, product a_w and packaging were important variables affecting product quality. Dried product at a_w 0.75 became unacceptable after 4 months, while product of a_w 0.68–0.7 remained moderately acceptable for 6 months. Dried products remained acceptable if the ammonia level did not exceed 40 mg/100 g and the pH was less than 7.2. High density polyethylene packaging was unacceptable for storage of such products in tropical conditions since it permitted moisture uptake and accelerated product deterioration.

Salting and Drying of Yellowtail

Berhimpon (1990) conducted a comprehensive study of the salting and desalting of yellowtail (*Trachurus mccullochi* Nichols) in brines ranging from 5 to 26.5% (w/w) at 25 and 35°C (Berhimpon et al. 1990, 1991); examined MSI of salted fish at 10, 25 and 40°C; examined the drying at 35°C/50% r.h. and 45°C/30% r.h. of whole and split salted and desalted fish with various initial salt contents (Berhimpon et al. 1990; Souness et al. 1991); and examined the acceptability of the dried salted fish.

Salting studies

Salting studies showed that the rate of salt uptake in whole and split fish increased with an increase in brine concentration and brine temperature, with yellowtail (fat content 0.7%) taking up salt faster than higher fat fish (e.g. lemuru).

Salt loss occurred faster in split than in whole fish. In whole fish the rate of salt loss approximated the rate of salt uptake for fish brined in saturated brine, with water uptake faster than water loss, presumably due to protein denaturation. Thus, these studies on the desalting of yellowtail suggest the possible advantage of desalting heavily salted fish in order to increase the rate of fish drying.

A comparison of equilibrium salt content (X_s^+) and specific rate constant (k_s) values obtained in several UNSW studies are shown in Table 2.

MSI

MSI data indicated significant hysteresis at water activities above 0.72–0.74, with differences becoming more evident as a_w increases.

Drying studies

Drying studies (Berhimpon et al. 1990) again demonstrated that drying rate increases with higher temperature and lower salt content. For whole salted fish, after about 2 hours of drying at 35°C/50% r.h., the lower the salt content the faster the drying rate. After 7 hours drying at 45°C/30% r.h., the lower the salt content of the flesh the higher the drying rate.

Two falling-rate periods occurred during drying. The first was linear, after which there was a rapid decline in drying rate. At 35 and 45°C, desalted fish dried faster than salted fish, more so at 35 than at 45°C, indicating the possible advantage of drying desalted fish by sun drying, since the rate of drying at 35°C of desalted fish was faster than for salted fish.

When salting and drying are presented as a total process, the opportunity to manipulate the traditional process to suit the needs of a processor is demonstrated (Fig. 5). During the dry season in Indonesia, a processor could salt fish in 21% brine for 10 hours and then dry the fish in the sun for 1 day. Such a process would optimise the use of brine. During the wet season, a processor with access to an appropriate mechanical or agro-waste dryer could brine fish for 10 hours in 15% brine and then dry them for 8 hours at 45°C to produce a stable product in less than 20 hours. If fish remains in saturated salt for an extended period, some desalting could be warranted before drying is undertaken. The difficulty with these recommendations is the lack of adequate control at the village or small processor level.

Asian panelists preferred dried salted fish with a higher salt content (about 26% db) than did Australian panelists (20% salt db), but overall, lower salt content fish was preferred by panelists. For yellowtail, this salt content can be obtained by brining whole fish for 3–4 hours or split fish for 0.5–1 hours in saturated brine, instead of brining in a lower salt content brine that is more difficult to control. The most acceptable uncooked dried salted fish contained about 33% (db) salt. For acceptable texture, dried salted fish should be made from salted fish with about 11% (db) salt. Splitting fish not only decreased salting and drying times but also improved sensory qualities, especially texture.

Table 2. Equilibrium salt content (X_s^+) and specific rate constant (k_S) for salt uptake of whole fish.

Fish	Brine conc. (% w/v)	Brine temp. (°C)	$(X_s)^+$ (g/100 g NSSB)	k_s/hours	Reference
Yellowtail (*T. mccullochi*)	5	25	18.5	0.08	Berhimpon et al. (1991)
		35	26.1	0.09	
	10	25	35.7	0.07	
		35	36.7	0.13	
	15	25	52.0	0.20	
		35	48.5	0.32	
	21	25	59.0	0.09	
		35	61.0	0.10	
	26.5	25	72.8	0.10	
		25	72.8	0.10	
		35	77.9	0.11	
Yellowtail	15	23	54.0	0.09	Berhimpon et al. (1990)
	21	23	69.0	0.06	
	26.5	23	72.0	0.13	
Sardine (*S. neophilchardus*)	26.5	19–22	73.0[a]	0.07	Wuttijumnong (1987)
Sardine (*S. longiceps*)	26.5	19–22	–	0.04	
Sardine (*S. neopilchardus*)	26.5	25	57.5	0.05	Poernomo (1985)
Sardine (*S. neopilchardus*)	26.5	25	74.4	0.04	Utomo (1985)
		30	79.9	0.07	
		35	71.0	0.09	

[a]Salt-free fat-free dry basis

Packaging Studies on Dried Salted Fish

Sardines

Preliminary studies were undertaken on the effectiveness of modified atmosphere packaging (MAP) on the storage stability of dried salted Australian sardines of 10–12% fat content (Sophonphong 1990) and of yellowtail of 3.5–4% fat content (Agustin 1990). Sophonphong (1990) found that neither vacuum packing alone nor vacuum packing and nitrogen flushing prevented softening of dried salted fish stored for 2 weeks at 30°C/75% r.h., while the volume of exudate from dried fish packed in nitrogen was less than for other treatments. Vacuum and nitrogen packaging reduced the extent of lipid oxidation during storage. Rancidity score increased during storage as did the level of fluorescent compounds (Lubis and Buckle 1990), while the thiobarbituric acid reactive substances (TBARS) value decreased for 4 weeks and then remained stable. Vacuum-packed samples had the best appearance and were acceptable for up to 12 weeks, while nitrogen-packed samples were unacceptable in appearance after 4 weeks.

Yellowtail

Agustin (1990) carried out a similar preliminary study on yellowtail. Sensory assessments (rancidity, texture, sheen and overall acceptability) were not affected significantly by packaging type or storage time. Samples packed in air in low density polyethylene (LDPE) pouches were rancid after 8 weeks at 30°C, while vacuum- and nitrogen-packed samples were not detectably rancid.

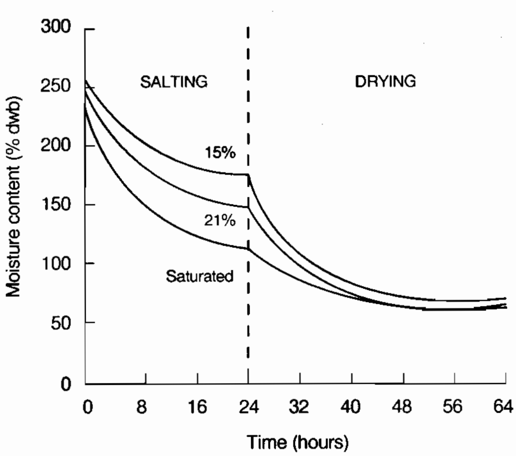

Figure 5. Salting and drying curves of yellowtail salted in various brine solutions and dried at 45°C/30% r.h. (from Berhimpon 1990).

Stability of Lipids in Dried Salted Sardines

Lubis (1990) carried out an extensive study of the stability of lipids in dried salted Indonesian (*Sardinella longiceps*) and Australian (*Sardinops neopilchardus*) sardines (Lubis and Buckle 1990). He examined traditionally salted and dried lemuru of high and low fat content, and the same fish and Australian sardines salted in 21% and saturated brines at UNSW and dried at 45°C/30% r.h. for 24 hours to a moisture content of about 47%. Lipid oxidation was assessed by measuring the TBARS value, diene conjugation (DC) value, level of fluorescent compounds, polyene index (PI), oxygen uptake, headspace hydrocarbons, and lipoxygenase activity. Salting of sardines caused some deterioration of lipids as measured by TBARS value, free fatty acid (FFA) levels, and PI. During drying, TBARS and diene conjugation values increased and PI decreased. Storage life of dried salted sardines increased when storage temperature was reduced.

Sardinella was more stable than *Sardinops* of similar fat content. Lipid stability was higher in dried salted fish containing higher salt levels. During storage the rancidity score, level of fluorescent products, and non-enzymic browning (NEB) increased, while TBARS value, diene conjugation value, PI, and overall acceptability scores decreased. The level of fluorescent compounds correlated most highly with rancidity scores, and is recommended for the measurement of rancidity in dried-salted fish.

Conclusions

These studies provided much information on the salting and drying characteristics of sardines and other fish, and of other factors (packaging, storage temperature, lipid oxidation) that affect the stability and hence acceptability of dried salted fish. The results of such studies carried out under carefully controlled conditions may help traditional processors to optimise conditions for salting and drying, although difficulties of cost and control of conditions at the village level may counteract the technological advantages. Under difficult environmental conditions of rain or high humidity, processors require techniques that will prevent fish spoilage while also giving products of acceptable sensory quality.

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Fish Salting and Drying Studies in Indonesia

Suparno*

Abstract

Dried salted fish is an important fishery product in Indonesia, constituting about 50% of total processed fish. However, the quality of the product is often poor.

The objectives of the studies reported here were to identify the causes of poor product quality and to develop improved processing methods.

Observations were made to identify constraints in commercial handling and processing methods. Laboratory experiments were conducted on salting and drying, in order to determine the factors affecting product quality. High priority was accorded in fish species such as rays, catfish, and sardines that are commonly processed for dried salted products.

Poor handling and fishing trips longer than the storage life of the catch result in low quality raw materials and therefore poor quality products. At the processing stage, the most important causes of poor quality products are inadequate salt penetration, repeated use of the same brine and, in some cases, insect infestation during drying. Improved processing methods that take these factors into account are described.

FISH drying has been practiced in Indonesia for hundreds of years. The products are a staple food, for low-income people in particular. Although dried fish consumption is falling, it remains the largest processed fish product.

Dried fish production is mainly by small-scale processors. In addition to being a simple and cheap method of preservation, salting and drying provides employment opportunities, in many cases allowing housewives to earn additional income for fishing families. It is not surprising that the poor technological knowledge and low capital of small-scale processors, and lack of availability of reasonable quality raw materials, results in end products of undesirable quality.

Salting and drying studies were carried out at the Research Station for Marine Fisheries in an attempt to improve quality of dried salted fish. Various factors affecting quality were identified. Chosen for study was a selection of the more important members of the wide range of dried fish products produced from various fish raw materials available in markets. The studies covered various aspects of salting and drying, including on-board handling techniques. Laboratory experiments were carried out to support development of improved technology.

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Commercial Practice of Dried Fish Production

Field studies were carried out to assess practices in commercial dried fish production. Two important traditional fish processing centres were selected, i.e. Muara Angke, Jakarta and Eretan, West Java. At Muara Angke the most important species for dried fish production are rays. The fish are usually caught in eastern Sumatra and western Kalimantan waters. The usual length of fishing trips is 20–30 days. In Indonesia, ray is commonly processed into a dried salted product and only a small amount is consumed as fresh or smoked fish. Ammoniacal odour from decomposition of urea in the meat limits its use. High quality dried salted ray commands a high price in local markets.

At Eretan the main species dried are sardines, scad, fringescale sardine, and marine catfish caught in nearby waters of the Java Sea during fishing trips of 3–4 days. These species of low economic value can be transformed into high-value-added products by traditional processing, such as dried spiced product for the first three species and semi-fermented products for the last. Spiced products, basically of two types—sweet or salty—also command high market prices.

Raw materials handling

On-board handling methods for rays commonly involve immediate icing of fish in the hold and the addition of a small amount of salt. The amount of ice and salt remains the same, no matter what the size of the catch and fishing day. Ice and salt are often used to cover only the top surface of stored fish from each catch regardless of the amount of fish caught. Melted ice and dissolved salt, as well as blood, slime, and liquid exudate from fish, accumulate in the fish-hold which fishermen rarely drain. Temperatures of fish are not low enough because of inadequate chilling and long periods of storage. In such conditions, extensive deterioration occurs. Therefore, it is not surprising that fish with various degrees of freshness are observed at Muara Angke landing place. It suggests that a wide range of catching days is usually encountered on long fishing trips. Good quality landed fish are consequently obtained only from the most recent catch. Table 1 shows qualities of raw materials for processing at different processors.

Nevertheless, rays are considered to have relatively good keeping qualities, the strength of epidermal tissues perhaps contributing to this. It is also interesting to note that the strong ammoniacal odours in deteriorated rays were not accompanied by extreme physical changes in texture of the muscle tissues during long storage under unfavourable conditions. Ammonia produced from the decomposition of urea may have some preserving effect, as indicated by the relatively low bacterial counts (Table 1).

In Eretan, landed catches were commonly of good quality fish as fishing trips were much shorter. Fish intended for dried spiced product are normally of much higher quality, in order to facilitate easy splitting of the fish. The quality requirement for fresh marine catfish for production of dried semi-fermented fish (*jambal roti*) is unclear. Many processors believe that iced fish cannot be used as the raw material for this product, though this does not mean that deteriorated fish are preferable. Therefore, the fish are not normally iced during on-board handling and only a few fresh fish from the bulk of an un-iced catch yield a product of acceptable quality.

Traditional Processing Methods

Salt quality

Solar salt produced locally is the most common type of salt used by processors. The salt is of very low

Table 1. Quality criteria of ray used as raw material.

Parameter	Processor		
	A	B	C
Organoleptic quality			
Score (max. 10)	4.0–7.0	7.5–8.0	3.5–4.0
Description	Pinkish to brown, fishy to ammoniacal odour, loose tosoft texture	White reddish, slightly fishy and urea odour, firm and elastic	Dark brown, dirty, fishy and strong ammonia odour, soft and juicy
Chemical quality			
Moisture (% w.b.)	76.14–78.73	78.04–79.53	81.06–81.25
Ash (% w.b.)	1.30–1.49	1.31–1.44	1.63–1.67
Protein (% w.b.)	10.46–13.85	13.31–14.91	12.40–13.15
Fat (% w.b.)	0.90–1.21	2.41–2.48	0.62–0.72
NaCl (% w.b.)	0.58–1.66	0.40–0.86	0.45–0.82
a_w	0.95	0.94–0.95	0.97–0.98
TVB (mg % N)	115.85–218.40	42.27–48.98	567.53–579.27
NH_3 (mg % N)	0.42–0.52	0.54–0.57	0.82
pH	7.10–8.60	6.64–7.63	8.79–8.81
Microbiological quality			
Total plate count	8.3×10^5	1.8×10^5	1.3×10^5
	990×10^5	1.9×10^5	1.8×10^6
Fly attack	Very little	None	Little

purity, as shown in Table 2. Magnesium, organic matter, and halophilic bacteria contents are very high which may affect salt penetration into fish flesh, and the appearance and texture of the product. Growth of halophilic bacteria may also present a serious problem during storage of dried salted fish. Neither storage of salt in crystalline form nor preparation of saturated brine stock solutions to prevent halophilic bacterial growth has been practiced by processors.

Processing water

In the coastal areas, clean water is usually difficult to obtain. At Muara Angke, water used for processing is obtained from brackish-water ponds surrounding the processing area. The water is not purified and is therefore of low quality and unsuitable for use in processing. Table 3 shows quality characteristics of processing water. Clean seawater is also difficult to obtain as coastal waters are polluted. The situation was similar in Eretan, although less serious because of availability of well water.

Clean water is essential in the production of good quality salted dried fish. In addition, the number of times a batch of brine is used for salting should be restricted if good quality products are to be obtained. Used brine could be purified to increase efficiencies in using salt and clean water.

Processing facilities

The traditional fish-processing centre in Muara Angke is the largest in Indonesia. Each premises has processing facilities such as washing tanks, salting tanks, storage, and a drying yard with raised racks. Processor families live on the premises. Garbage bins are provided at a number of locations, but the disposal yard is located outside the compound. There is a deep well for water, but often its pump does not work and cannot supply water adequately. Cleaning, washing, and processing of fish cannot be performed satisfactorily. In Eretan, processing premises are, in most cases, part of fishermen's houses.

Processing methods

Steps in production of dried salted rays in Muara Angke are outlined in Figure 1, and of spiced and semi-fermented product in Eretan in Figures 2 and 3. The following undesirable practices during processing were identified:

- Raw materials transported from auction to the processing site were un-iced and exposed to sunlight.
- Fish dressing was done on an uncleaned floor and exposed to sunlight. No ice was used during dressing or storage of raw materials.
- Dressed fish were washed with reused water with very high levels of impurities. The original water was obtained from a brackish-water pond.
- Fly attack was often observed under the poor hygienic conditions of the processing premises, and with poor quality raw materials and fermented fish present.
- The amount of salt used by processors varied greatly—from 17% to 39%—depending on the quality of raw materials. The lower the quality of raw materials for processing, the more salt needed to arrest spoilage processes. Consequently, salt contents of end products also varied greatly.
- Salt concentrations or salting times were often insufficient to prevent spoilage, resulting in inferior products.
- Lack of suitable quality raw materials for processing fermented product and inadequate standard of fermentation.

Table 2. Salt quality used for dried salted ray.

Parameter	Processor		
	A	B	C
Organoleptic quality	Brownish, dark, dirty, small crystal, ammonia smell	White, slightly dirty, slightly large crystal, fishy smell	White, dirty dark, small crystal, more foreign matter
Chemical quality			
NaCl Moisture (%)	76.85	72.62	76.81
Impurities			
Mg (ppm)	0.1125	0.1364	0.1363
Fe (ppm)	0.0052	0.0050	0.0052
Ca (ppm)	0.0142	0.0161	0.0166
Pb (ppm)	0.0016	0.0017	0.0016
Dirt (%)	1.52	0.82	0.92
Count of halophilic bacteria	7.9×10^3	5.5×10^3	3.8×10^3

Table 3. Physical, chemical and microbiological quality of processing water obtained from brackish water pond.

Parameter	Characteristic of value	Standard	Methods of analysis
Appearance	Clear-liquid		Organoleptic
Colour (Pt.Co. Scale)	3.2	5–10	Colorimetric
Odour	Positive		Organoleptic
pH	7.55–7.83		Electrometric
Taste	Normal		Organoleptic
Turbidity (FTU)	7–8	1–10	Turbidimeter
Ammonium (mg/L)	Below 0.04		Colorimetric
Copper (mg/L)	Below 0.03		AAS
Lead (mg/L)	Below 0.01		AAS
Mercury (mg/L)	Below 0.001		AAS
Biochemical O_2 demand 5 days 20°C (mg/L)	14.61–14.28		Wibler Titrimetric
Dissolved O_2 (mg/L)	2.26–4.07		–,,–
Total hardness (mg/L $CaCO_3$)	4976.28–5063.22		AAS
E. coli per 100 mL	Negative		

- Salted fish was placed on the processing floor before slicing. Sliced fish meat was washed with brackish water mixed with used brine.
- Fly attack could occur during drying when poor quality raw material was used, or flesh was dried in thick slices. Household insecticides were sometimes used.

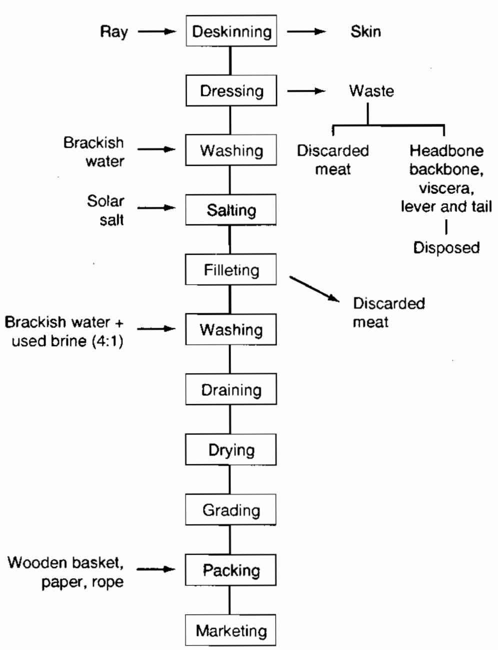

Figure 1. Flow diagram of dried salted ray processing.

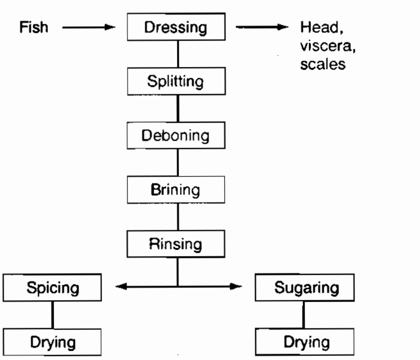

Figure 2. Flow diagram of dried spiced fish processing.

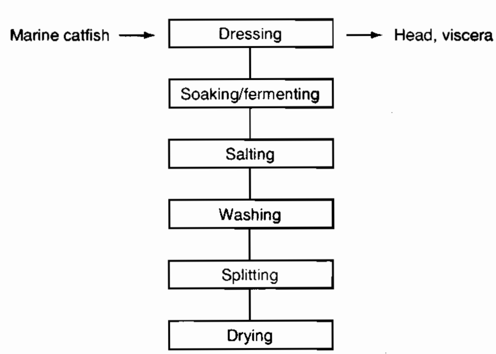

Figure 3. Flow diagram of processing dried semi-fermented marine catfish.

- The garbage disposal yard was a source of air pollution, and was a haven and hatching ground for flies.

Laboratory Studies for Improved Processing

In view of the technological constraints found in the commercial processing of dried fish, experiments were carried out to improve the technology. Among the problems identified earlier in this paper, priority was given to processing dried salted ray since no work has been reported on it, in spite of a great number of studies on other commercial species. Emphasis was also placed on improvement of raw material quality as it plays an important role in quality of the end product.

In the first study, the salting process was investigated as it could be the starting point for an improved technology. Ray wing meat was salted for 72 hours with salt crystals at 30% (w/w). Salt uptake and moisture loss, together with quality changes during the salting process, were investigated. The results indicated that optimum salt uptake occurred between 30–45 hours, when an equilibrium salt content was reached between fish tissues and surrounding brine. This period corresponds with a change in colour of flesh from dull reddish cream to slightly brown, a change in texture from elastic to compact and sticky, and a pronounced ammoniacal odour. Prolonged salting appears to give no advantages as it failed to halt deterioration in all physical criteria.

A second study explored possible on-board handling alternatives during a simulated commercial fishing operation. Using newly caught fresh fish, dressing was carried out to obtain wing meats for storage tests at different treatments. Dressing was expected to extend storage life. The treatments consisted of two methods of preservation intended for on-board handling application. A batch of wings was iced in insulated boxes and another batch salted at 30% (w/w). They were stored for 32 days, a common fishing trip length.

At the end of the storage time, the salted wing meat was sliced, desalted for 2 to 10 hours in fresh water, and subsequently sun dried for 2 days. Iced wing meat was salted for 33 hours, sliced and sun dried for 2 days also. Traditional commercial processing was used as a control. The results indicate that preservation of wing meat by icing yielded a better quality product than did the salting. Salting for extended periods could not maintain good quality raw materials, though it was better than no treatment at all, as is often the case on fishing boats. The salted meat gave a product of poor appearance due to discoloration and alteration to a cooked-like product, although texture and smell were better.

As expected, desalting of thin sliced meat could effectively reduce salt content within a short time (2 hours) from an initial level 29.3% (d.b.) to 1.4% (d.b.). Prolonged desalting times did not yield any appreciable further salt reduction or improvement on organoleptic quality, especially discoloration.

Dried product made from iced meat was higher in organoleptic quality scores than that made from salted meat. The first product was characterised by a creamy yellowish colour with a slight ammoniacal odour. On the other hand, the second product was unattractive in appearance, dullish light brown with some darker spots, tough, and had numerous salt crystals deposited on its surface. Desalting could improve brightness and reduce salt crystals but failed to improve the degree of discoloration. Table 4 shows chemical characteristics of dried products.

In a third study aimed at improving on-board handling, effects of dressing and chilling of raw materials were studied. The experiment was carried out on-board a fishing vessel. Fish were grouped into (a) dressed fish packed in ice, (b) whole fish packed in ice, and (c) whole fish stored un-iced. These were kept until landed, which took about 5 days. It was quite obvious that chilling had a significant effect on quality, and a synergistic effect of dressing was also observed. It suggests that dressing could improve quality by reducing enzymic and bacterial activity in the internal organs. Table 5 shows quality criteria of the raw materials for different handling methods.

These raw materials were used for further experiments on salting and drying. Dressing was carried out for whole fish both from iced and un-iced raw materials. All raw materials were sliced 2–3 mm thick and then salted in saturated brine for 15 hours. Slicing before salting was aimed at improving salt penetration into meat tissues thereby reducing spoilage, as commonly found in unsliced fish during salting. This method proved to have significant advantages. Organoleptic scores for appearance, odour, and texture increased as the salting time increased. It appears that thin sectioning of fish tissues facilitates the removal of undesirable pigment and odorous compounds. This phenomenon was also supported by the results of chemical tests performed on salted fish (Table 6).

Following salting experiments, the salted products were used for drying studies. Drying was conducted by natural sun drying which took 12 hours for each batch of salted products. Quality of the dried products was assessed and compared with commercial product. The results indicate that quality of dried product did not vary significantly with method of handling or salting time, but that the commercial product was inferior in all quality criteria.

Table 4. Chemical characteristics of dried salted rays from various handling treatments.

Analysis	Iced wingmeat	Salted wingmeat	Desalted for 2 hours	Control
Moisture	48.6	21.6	30.0	71.1
Ash (% d.b.)	25.2	41.6	21.8	30.6
Protein (% d.b.)	69.8	54.7	81.4	60.2
Fat (% d.b.)	2.2	1.5	2.3	1.6
Salt (% d.b.)	16.8	25.1	1.3	29.2
TVB (mg N %)	133.3	188.7	76.0	558.8
a_w	0.7	0.7	0.7	0.7

Table 5. Quality of raw materials from different handling methods.

Treatment	Organoleptic test		Chemical tests		
	Descriptive	Score	pH	TVB	a_w
Iced wing	Whitish pink, specific fresh odour with slightly ammonia odour, firm and compact meat texture	8.2	6.8	31.7	0.96
Iced whole fish	Fresh red blood colour, fresh odour with little ammonia odour, slightly loose and watery texture	7.5	7.1	27.8	0.97
Un-iced whole fish	Pale brown colour, fishy and ammoniacal odours, loose, watery and slightly soft texture.	5.2	7.7	69.3	0.97

Table 6. Chemical changes during salting of sliced fish.

Treatment	Salting time (hour)						
	1	2	3	5	7	10	15
pH							
Iced wings	6.6	6.7	6.5	6.5	6.7	6.6	6.6
Iced whole fish	6.6	6.6	6.6	6.3	6.6	6.7	6.9
Un-iced whole fish	7.1	7.0	6.9	6.7	6.9	6.9	7.0
TVB (mg % N)							
Iced wings	29.4	27.7	22.9	20.4	23.4	17.2	26.7
Iced whole fish	23.1	21.0	16.4	13.0	21.0	16.6	27.9
Un-iced whole fish	30.5	27.1	18.3	23.5	28.8	23.7	25.6
$\mathbf{NH_3 \times 10^3}$							
Iced wings	55.0	46.0	35.0	38.0	32.0	4.0	3.0
Iced whole fish	39.0	42.0	28.0	29.0	34.0	7.0	1.0
Un-iced whole fish	42.0	42.0	39.0	35.0	8.0	7.0	7.0

Conclusions and Recommendations

Processing constraints to the improvement of quality of dried salted fish have been identified, particularly for small-scale processing industries. Among the technological problems identified, use of poor quality raw materials, inadequate processing knowledge, and poor sanitation and hygiene are the most important.

The use of poor quality raw materials by processors is widespread. Alternative methods of on-board handling have been studied to improve the quality of raw materials. However, socioeconomic studies should be conducted as processors, for their own reasons, often intentionally use low quality raw materials.

Inadequate facilities and technical knowledge in processing are also responsible for poor quality end products. A demonstration pilot project on an integrated dried fish processing industry should be considered. Such a project could implement all technology improvements derived from research activities.

Product development based on traditional processing should be promoted and provided with research support. Spiced and semi-fermented products are examples of successful products with high economic returns.

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Chemical Reactions and the Quality of Dried Fish

N.F. Haard*

Abstract

Drying is one of the oldest, most extensively used, and important means of food preservation known to man. The process involves heat input, extensive aeration, concentration of solute, disruption of cellular integrity, and changes in physical state. These conditions favour a variety of chemical reactions that influence product quality attributes, i.e., colour and appearance, flavour, nutrition, safety, texture, and processing suitability. Important chemical reactions in drying and dried fishery products include: participation of proteins, carbohydrates, lipids, and non-protein nitrogen compounds in the Maillard reaction and Strecker degradation; denaturation, aggregation, and cross-linking of proteins; and oxidation, free radical reactions, and coupled oxidations involving lipids and other components. Water removal may directly or indirectly influence reaction rates by increasing the concentration of reactants and catalysts, decreasing the concentration of water as a reactant, and altering factors such as pH, and activation energies of reactions. At low water activity, the direction of reactions catalysed by hydrolases may be reversed in favour of acyl-transfer reactions, and reactions associated with the lipid milieu are favoured.

DRYING or dehydration is the process of reversibly removing water from food so that the weight is reduced and the storage life is extended by the prevention of microbial growth. The level of moisture to prevent microbial growth is usually less than 10–15%, whereas that which prevents biochemical reactions in the aqueous phase is less than 5% (Holdsworth 1974). The preservation of foodstuffs involves not only the inhibition of microbial growth, but also the prevention of unwanted chemical and biochemical reactions that influence colour and appearance, texture, flavour, nutrition, safety, and functional properties related to further processing or utilisation. Biochemical reactions are the main cause of quality loss in fishery products preserved by freezing (Haard 1992a) and techniques such as chilling, irradiation, chemical additives, and modified atmospheres (Haard 1992b). Examining the contribution of chemical reactions to quality changes in drying and dried fish is complex because of the genetic diversity and intraspecific variability of the raw materials, and the wide range of methods used to dry or dehydrate fish and fish products.

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Diversity of Raw Material

Interspecific factors

Unlike other food myosystems, fishery products come from a very diverse array of taxonomic organisms. More than 20000 known species, and an estimated 20000 unclassified species, comprise the bony fishes. Squid, an important dried fishery product, includes more than 50 genera. Some squid species sold in the world market do not yield a satisfactory dried product because of their distinctive composition (Haard 1982). Genetic diversity influences the composition of enzymes (Haard 1990, 1992c, 1994), and other constituents (Haard and Arcilla 1985; Gulaeva et al. 1989; Haard 1992d) that participate in chemical changes. For example, the flesh of elasmobranchs contains relatively large amounts of trimethylamine oxide and urea. Both of these constituents can have an impact on the quality of a processed product. Urea is a source of ammonia, and a protein denaturant (Somero 1986), and trimethylamine oxide participates in a variety of redox reactions that can influence colour (Haard 1992d), odour (trimethylamine), safety (dimethylamine) (Spinelli and Koury 1979: Ichinotsuba and Mower 1982), and texture (Haard 1992a), and even appears to prevent protein denaturation in living elasmobranchs (Somero 1986). Another example is gadoid fish, which tend to contain a higher concentration of the enzyme trimethylamine demethylase (Rehbein 1985, 1988; Hultin 1992a,b). The reaction catalysed by this enzyme results in formation of dimethylamine and formaldehyde that may contribute to protein cross-linking at low water activity. Homologous enzymes from cold- and warm-water fish exhibit many differences in both catalytic properties and stability (Simpson and Haard 1987; Simpson et al. 1989, 1991). An important group of enzymes that contributes to biochemical deterioration of fishery products is that involved with adenosine triphosphate catabolism. The rate of inosine and/or hypoxanthin accumulation in fish flesh (decrease in K value) is inversely related to the market life (Uchiyama 1971). The rate and temperature dependency of K value decline is much greater in species from cold water than those from tropical waters (Tsuchimoto et al. 1988a,b).

Intraspecific factors

In addition to interspecies variation, intraspecific factors markedly influence the properties of fish flesh. The processor has limited influence over the quality attributes of the fish; i.e., he can control season of catch but not conditions in the hunt and capture fishery. The fish farmer has additional ways to influence product quality. These include: control of physiological factors, such as biological age and growth rate; control of environmental factors, such as water temperature, pressure, flow, and chemistry; and control of dietary factors, such as feeding cycle, starvation, overfeeding, and the presence or absence of specific dietary components.

It is well recognised by fishermen that intrinsic quality varies with intraspecific and environmental factors. Love (1988) reviews this subject with particular reference to our knowledge of Atlantic cod, *Gadus morhua*. The aquaculturist can also influence the food quality of fish (Mohr 1986; Haard 1992e). The properties of fish muscle may change as the animal ages. In the wild, the diet of fish may change because of feed availability or because as fish grow their habitat or ability to capture prey may change.

Within species, larger fish tend to have a firmer muscle texture than smaller fish. There is an increase in the number of muscle cells in the body, and the diameter of cells, as fish grow (Love 1988). There is a relationship between fibre thickness and firm texture. Heat coagulating proteins, which obstruct the displacement of fibres in cooked meat, may also influence texture (Hatae et al. 1990). Minerals and free amino acids make an important contribution to the taste of fish meat. Concentrations of some minerals increase and that of others decrease in concentration with growth of fish. The accumulation of toxic heavy metals such as mercury, cadmium, and arsenic in older fish has been of particular concern (Laarman et al. 1976). The concentration of free amino acids in muscle tissue tends to increase with animal age as the activity of protein synthesis decreases (Panigrahi et al. 1979).

Maturation of gonads and spawning in fish may have a profound influence on eating quality (Love 1988). Protein depletion, increased water content, and a decrease in water holding capacity of cooked flesh occurs during sexual maturation of Pacific salmon, *Onchorhynchus kisutch* (Bilinski et al. 1984). Seasonal variation associated with spawning may also influence the suitability of raw material for processing, i.e., freezing (Kryzynowek and Wiggin 1979), oil (Miezitis and Wright 1979), and heat-induced gel strength (Beas et al. 1988). Changes in metabolic routes for energy metabolism, e.g. a shift from glycolysis to fat catabolism (Nakai et al. 1970), may also influence postmortem metabolism related to food quality. This is particularly important in free-living fish since enrichment of the gonads does not necessarily coincide with plentiful feed supply. Even when feed is continually available to farmed fish, such as Dover sole (Love 1988), depletion and metabolic changes in muscle tissue may still occur during sexual maturation. Progressive starvation, such as often occurs during sexual maturation, may result in a decrease in long-chain highly unsaturated fatty acids in muscle phospholipids.

Dietary and other environmental effects are often interactive and there is a paucity of experiments under controlled conditions designed to test the influence of environmental conditions on flesh quality. The diet of wild fish varies with many factors, including the ontogeny and geographic location of the growing animal. The prey that fish feed on may contribute to the digestive process (Reichenbach-Klinke 1972), to the formation of specific nutrients (Lesauskiene and Syvokiene 1977), and to the bioaccumulation of compounds that affect flesh quality (Long and Haard 1988). In addition to the health and growth rate of the fish, the kind of diet and other factors can influence the flesh composition of free amino acids, minerals and fatty acids.

Environmental factors to be considered include water depth, illumination, pH, water movement, salinity, oxygenation, temperature, organic contaminants, and stress and population density. Fish harvested from deep water are sometimes soft and watery. Increased illumination can promote physical activity independent of water temperature. Fish from acid water tend to contain more manganese, zinc, and heavy metals such as mercury. Fish from rapidly moving waters have a firmer texture than fish that require less physical exercise. Water salinity may affect the muscle content of free amino acids and hence taste. Low oxygen can result in increased muscle glycogen, and hence influence postmortem pH. Rearing temperature may influence flesh properties, including the thermal stability of muscle proteins, fatty acid composition, proportion of dark muscle, and rates of postmortem biochemical reactions. Some of the mentioned properties of fish flesh are more important than others with respect to suitability for dehydration. In general, a high total solids content is translated into a high yield, and integrity of connective tissues may be needed to hold the tissue together while hanging on racks during drying. Other factors affecting specific reactions that may be important in a particular drying operation are the contents of reducing sugars, free amino acids and amines, minerals, and pH.

Drying Conditions

The use of heat from a fire or hanging in the sun to dry foods appears to pre-date recorded history. It was not until 1795 that a hot air dehydration room was developed in France. Dehydration implies control over climatic conditions within a microenvironment. Sun drying is at the mercy of the elements, requires substantial land area, is normally more labour intensive, and is less amenable to control of sanitary conditions, dust, dirt, insects, birds, and so forth. On the other hand, dehydration can be more expensive and may yield a product with different properties than sun-dried product. Aside from the composition of the raw material. The rate and extent of chemical reactions during drying is a function of several factors, notably temperature (T), time (t), oxygen concentration ($[O_2]$), substrate concentration ($[S_i]$), pH, and catalysts ([C]) as illustrated below:

$$Rate \propto O_2, T, t, S_i \rightarrow n, Ci \rightarrow n, pH, ...$$

It should be kept in mind that, although time is normally much greater for sun drying than it is for dehydration processes, quality attributes such as protein solubility, extent of lipid oxidation, and TMA formation can be superior in properly sun-dried product (Table 1).

Continuous machine drying of squid gives a product with different appearance, flavour characteristics, and physical properties (Haard 1983). The sun-dried product prepared under ideal drying conditions has a fresh, clean odour, sweet taste, good rehydration properties (Fig. 1), tenderness, and less discoloration due to browning than mechanically dried product. This may partly be explained by the observation that some chemical reactions are favoured over others. There is less formation of TMA and lipid oxidation products, and more formation of protein hydrolysis products in sun-dried product. On the other hand, the machine dried product (50°C) is superior to sun-dried product when it is used to manufacture further processed products that require stretching the mantle with rollers. This is because the connective tissues have not been degraded by proteolytic enzymes during the drying process. Accordingly, it is important to know the product characteristics needed by the buyer of the product. Sun-dried squid also exhibit higher *K* values than cabinet-dried product (Table 2).

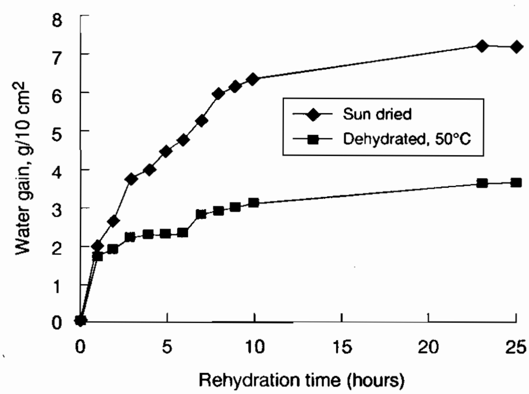

Figure 1. Rehydration of sun-dried and machine dried squid (Haard 1983).

An important consideration in evaluating the relative reaction rates of long-time, low-temperature processes like sun drying and short-time high temperature drying is the Arrhenius energy of activation (E_a) of reactions. E_a describes the relationship between reaction rate and temperature. A high E_a means reaction rate will greatly

Table 1. Some properties of sun-dried and dehydrated squid (*Illex illecebrosus*) (Haard 1982).

Method	Temperature (°C)	Air flow m/min	Protein solubilty mg/g	Peptides (%)	TBA #	[TMA] mg/g	[TMAO] mg/g
Sun	Ambient	Ambient	73.1	38.6	1.69	0.28	5.48
Cabinet	50	40–43	36.7	20.7	1.99	0.61	9.35
Cabinet	25	52–58	90.9	50.1	2.67	0.43	8.18
Cabinet	25	60–120	103.4	58.5	2.64	0.94	4.46
Cabinet U.V.	25	60–120	70.3	45.0	5.09	0.05	6.08

increase as temperature is increased. Thus, reactions with a high E_a will tend to predominate in machine-dried product, while reactions with a low E_a predominate in long-time, low-temperature processes such as sun drying. For enzyme-catalysed reactions like protein hydrolysis, E_a is approximately 42 kJ/mol. On the other hand, Maillard browning reaction has a higher E_a that tends to increase as dehydration proceeds (Fig. 2). Accordingly, browning reactions will predominate in high-temperature, short-time processes like machine drying.

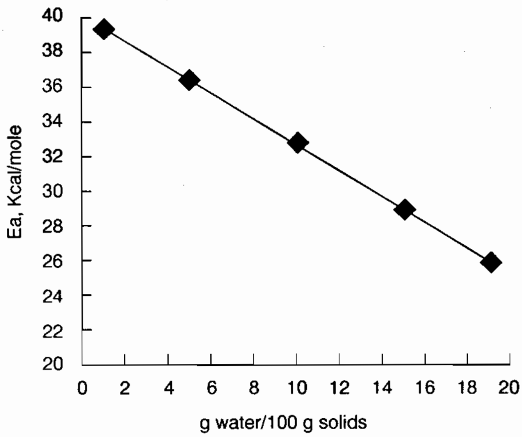

Figure 2. Influence of moisture content on E_a for Maillard browning (Labuza and Saltmarch 1981).

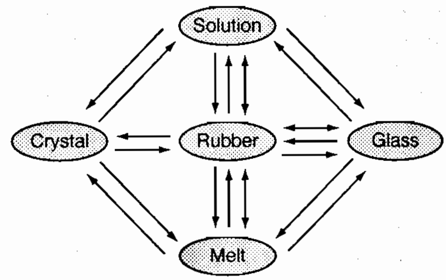

Figure 3. Phase changes associated with solutions.

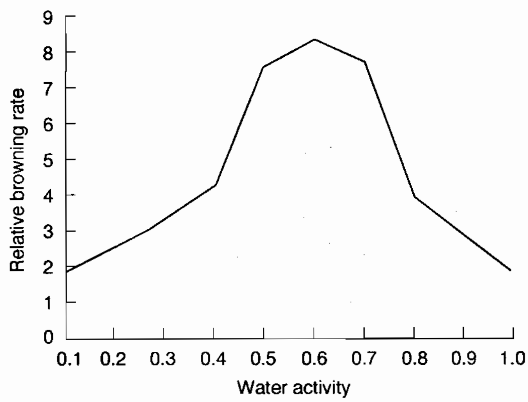

Figure 4. Influence of water activity on Maillard browning reaction.

Chemical Reactions and Quality Change During Drying

Countless different enzyme-catalysed and non-enzymic reactions may occur in drying and dried fish products. As water is removed, cellular integrity is disrupted and reactant mixing occurs. Changes in solution state may occur (Fig. 3) and this may directly affect the diffusivity of reactants and indirectly effect reaction conditions, such as pH, ionic strength, and redox potential.

Water removal increases the effective concentrations of solutes, e.g., reactants and catalysts, which will increase the rates of first- and second-order reactions. A good example of this in drying products is the influence of water activity on Maillard browning (Fig. 4).

Alternatively, for reactions where water itself is a reactant, a decrease in water concentration may decrease reaction rate. However, reactions involving water are normally zero-order with respect to water concentration except when moisture levels are very low. For most reactions (lipid oxidation is an exception), water is a solvent and water removal is more likely to reduce reaction rate by lowering the mobility of other (solute) reactants. As mentioned above (e.g., Fig. 2), reducing water activity can also alter other reaction parameters such as E_a.

A brief discussion of the reactions of principal importance in dried fishery products follows.

Carbohydrates

Although the content of total carbohydrates in fish and shellfish flesh is relatively low (normally <0.5%, fwb), they are quite important because of their contribution to Maillard browning reactions. These reactions can influence all of the quality indices: colour/

Table 2. Sensory characteristics and nucleotides of sun-dried and dehydrated *Illex illecebrosus* (Haard 1983).

Method	Sensory score	[ADP] µmol/g	[AMP] µmol/g	[IMP] µmol/g	[Hyp] µmol/g
Sun dried	4	1.61	1.11	1.19	0.27
Machine 50°C	1	0.56	2.95	2.87	0.29

appearance, flavour, texture, nutrition, safety, and processing suitability. Squid contains small amounts of four sugars (glucose, ribose, glucose-6-P, ribose-5-P) that appear to be responsible for browning during dehydration (Haard and Arcilla 1985). The concentrations of these sugars in raw squid mantle range from 30–60 mg%, below the threshold level for sweet taste. During drying and subsequent storage of the dried product these sugars completely disappear due to the browning reaction (Fig. 5). Browning is important in dried fish products and has received considerable study, as listed in Table 3.

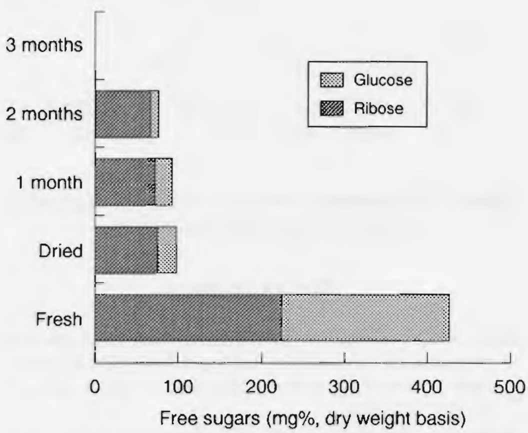

Figure 5. Recovery of glucose and ribose-based sugars during drying and storage of squid.

The digestibility of protein (Nakajima et al. 1988; Singh et al. 1990), as well as the bioavailability of lysine (Kaanane and Labuza 1985), are thus reduced in dried fishery products.

Lipids

The oxidation of lipids is also responsible for quality changes in dried fishery products (Kim et al. 1974; Choi et al. 1977; Lee and Choi 1977; Pan and Chiang 1979; Nakamura et al. 1980; Cho et al. 1989; Tsai et al. 1989a,b, 1991; Singh et al. 1990; Hasegawa et al. 1992; Yoshie et al. 1993). The relative contribution of auto-oxidation and enzyme-catalysed lipid oxidation is not well understood, although lipoxygenase has been identified in fish flesh (Hsieh et al. 1988; Josephson et al. 1987; German et al. 1991; Hirano et al. 1992; Kuo and Pan 1992). Lipid oxidation rate increases dramatically at very low water activities, probably due to concentration of catalysts, removal of hydration shields, and biological membrane disruption (Fig. 6). Lipid oxidation, like browning, may affect all of the quality indices of fish. Products of the enzyme-catalysed reaction may impart pleasant aromas to fish products (Josephson et al. 1985; German et al. 1991; Hirano et al. 1992; Kuo and Pan 1991). Carbonyl products of lipid oxidation contribute to browning reactions in some fishery products (Toyomizu and Chung 1968; Kumta and Kamat 1972; Fujimoto and Kaneda 1973a,b; Nakamura et al. 1973; Pokorny et al. 1974; Choi et al. 1977; Nakamura and Toyomizu 1982; Cho et al. 1988; Tanaka et al. 1988, 1990). Moreover, peroxides can react with proteins causing thiol-disulfide interchange and cross-linking (Pokorny et al. 1974; Kuusi et al. 1975; Gardner 1979; Poulter and Lawrie 1979; Leake and Karel 1985). Co-oxidation of pigments, such as carotenoids, can also influence colour (Haarad 1992d), as can formation of fluorescent products (Davis and Reece 1982; Leake and Karel 1985).

Table 3. References relating to browning of fish products.

Bello and Pigott (1980)
Burt (1971)
Choi et al. (1977)
Davis and Reece (1982)
Fujimoto and Kaneda (1973a,b)
Haard and Arcilla (1985)
Hanaoka and Toyomizu (1979)
Ichinotsuba and Mower (1982)
Ito et al. (1990a,b)
Kaanane and Labuza (1985)
Lee and Choi (1977)
Matsumoto et al. (1992)
Nagayama (1961, 1962)
Nakaue et al. (1983)
Pan et al. (1978)
Pavelka (1982)
Singh et al. (1990)
Suyama and Kobayashi (1980)
Tanaka and Taguchi (1985)
Tanaka et al. (1980, 1993)
Thompson and Thompson (1972)
Togerstrom and Tarr (1963)
Toyomizu et al. (1968)
Tsai et al. (1989)
Yu et al. (1969)

Proteins

Aside from their involvement in browning reactions, the denaturation of proteins is particularly important in dried products. Unfolding of proteins is often followed by aggregation (Fig. 7).

Protein changes in dried fish products are well studied (Enomoto et al. 1965; Kanna et al. 1974; Toma and Meyers 1975; Moledina et al. 1977; Flechtenmacher and Wanke 1978; Nakamura et al. 1980; Niki et al. 1983, 1984a,b; Rustad and Nesse 1983; Nakajima et al. 1988; Ito et al. 1990a,b; Singh et al. 1990; Matsumoto et al. 1992; Niwa et al. 1993). Spray-dried products, like 'active fish protein powder' retain good functional properties (e.g., water-holding capacity, emulsifying capacity) when dried in the presence of protective agents like sorbitol (Niki et al. 1982, 1983). Aside from enzyme catalysed hydrolysis of proteins, mentioned earlier, acyl-transferase reactions are favoured at low water activity (Fujimaki et al. 1970; Onoue and Riddle 1970; Ramakrishna et al. 1987). In effect, enzymes that catalyse hydrolytic reactions at high water activity can catalyse synthetic reactions at low water content. The general reaction for acyl-transfer is summarised below:

$$[E-HZ:+R-CO-X \Leftrightarrow E-Z-CO-R+X]$$
$$E-Z-CO-R+H_2O \Leftrightarrow E-HZ+HOCO-R$$
$$E-Z-CO-R+Y: \Leftrightarrow E-HZ+YCO-R$$

The importance of these reactions in dehydrated foods is not understood at this time. It is possible they represent a class of reactions that influence product quality.

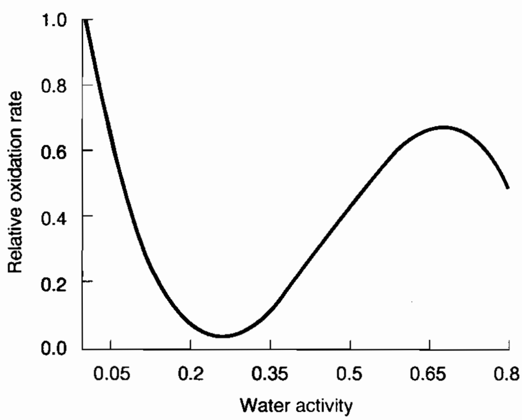

Figure 6. Influence of water activity on auto-oxidation of lipids.

Conclusion

Enzyme-catalysed and non-enzymic reactions occur during the drying process and subsequent storage of dried fishery products. The extent and relative importance of individual reactions is complex because of the highly variable chemical composition of fishery products and the many methods that are used in drying or dehydration. Important and well-studied reactions that have a major impact on quality include browning, lipid oxidation, and protein denaturation-aggregation. Other, less universal, reactions are also discussed. Together, these reactions provide an almost unlimited source of work for the food chemist interested in the quality of dried fishery products.

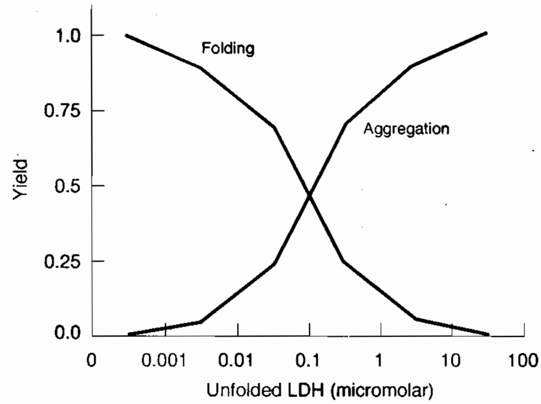

Figure 7. Relationship between unfolding and aggregation of a protein (lactate dehydrogenase).

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Development of a Rice-Husk Fired Furnace and Drying Chamber for Fish Drying in Indonesia

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Abstract

An assessment of traditional salted dried fish production in Indonesia highlighted the need for an alternative drying system, especially during the wet season, when significant losses are reported to occur. The study identified the design criteria necessary for such a system. Rice husks were identified as the most abundant and ubiquitous low-cost fuel available in Java. Using these criteria, a furnace and a drying chamber were developed. The furnace consists of a 200 L drum with a perforated centre-tube and base plate. Approximately 27 kg of husk are loaded into the drum, and to commence operation a fire is started in its base. The operation of the furnace relies on the thermal pyrolysis of rice husks. The gases resulting from pyrolysis are burnt in the perforated centre-tube. The hot flue gases (flue temperature 700–900°C) are used for drying. The original drying chamber was 1 m^3 in volume, with cavity walls and floor through which the hot flue gases from the furnace passed. Heat radiated from the floor and walls to heat the air within the chamber. This chamber design proved unacceptable, principally due to excessive temperature differentials within it. An alternative heat exchanger was constructed, consisting of two sheets of corrugated metal joined in such a way as to form a series of tubes. The tubes were sealed at one end and regularly spaced holes were drilled along the length of each tube, but on one side only. The heat exchanger became the floor of the drying chamber. When hot flue gases passed under the floor, air inside the tubes was heated and flowed into the chamber through the drilled holes, thus drawing more ambient air into the tubes. The chamber concept was developed at the University of New South Wales and further researched and tested in Indonesia.

INDONESIA is a major fishing country with 30–40% of its marine catch preserved by salting and drying. The Indonesian Government has included dried fish as one of a group of food items essential for the well-being of its citizens.

Traditionally, dried fish represent a low-cost source of first-class protein, but the problems of poor quality and limited shelf life lead to excessive physical and economic losses. To achieve the Government's aim of increasing per capita consumption of fishing products it is essential that the high level of postharvest losses be reduced.

In an attempt to address these losses, a joint Australian/Indonesian project commenced in mid-1984 with the financial support of ACIAR. The two research institutes funded to undertake this work were the Department of Food Science and Technology at the University of New South Wales, Sydney, Australia, and the Research Station for Marine Fisheries, Jakarta, Indonesia.

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Multidisciplinary Research Project

The project was divided into several major areas of research covering traditional practices from the time of fish capture to retail sale of the salted dried product. The main research areas were dryer development, salting and drying studies, entomology, and socioeconomics. The multidisciplinary nature of the project required close collaboration between researchers working in each of these areas.

The project personnel were conscious of the need to understand the people the project was trying to assist so that any developments flowing from it would have a high probability of adoption. Any project involving the development of a process or technology and its transfer to a target community must address certain criteria to justify the research effort and ensure the uptake by that community of project outcomes. The essential elements of technology transfer are:

- Community involvement
  - by conducting needs assessment of community;
  - to respond positively to needs; and
  - be innovative but technically sound.
- Research approach
  - define traditional processes in scientific terms;
  - fine tune and optimise traditional processes;
  - define remaining constraints;
  - use high technology resources to develop appropriate solutions;
  - assess the economic, social, and technical acceptance of those solutions; and
  - if acceptable implement the appropriate technology.

The project attempted to address each of these points in planning and executing research activities. The overriding justification for project research was that outcomes should be appropriate to the needs of the target communities and the ability of the community to adopt them.

The target communities identified by Indonesian project personnel during the early phase of the project were the processors of lemuru (sardines) in East Java. Later in the project the lemuru catch declined rapidly due to overfishing, necessitating a reassessment of project objectives. The project went on to more generally target communities that process small pelagic fish in Indonesia. Consequently, project outcomes took on a slightly more general focus for Indonesian scientists undertaking the fine tuning to satisfy individual community needs.

During the initial stages of the project, a detailed needs assessment was conducted, targeting fishermen and dried-fish processors, to identify where major constraints occurred, leading to physical and economic loss. The study was done amongst the fishing communities of East Java where small pelagic fish were the principal raw material for dried-fish production. The traditional process was defined in terms of efficiency, and the product was scientifically characterised.

Constraints on Fish Drying

The study identified three major constraints, all weather dependent, which impact on the quantity and quality of salted dried fish reaching consumers:

- an uncertain supply of fish of the quantity, quality, and price necessary for a salted fish operation;
- the dependence of processors on unpredictable weather and the diurnal cycle, resulting in excessive salting and drying times; and
- the deterioration of dried fish from mould and insect attack during transport and warehousing.

Traditionally, fish is salted in saturated brine for between 1 and 3 days, depending upon the weather. The brine is used many times before it is discarded. The better the weather the shorter the salting time. Drying is done in the sun by spreading the fish on bamboo mats on the ground, or on elevated racks, for between 1 and 5 days, again depending on the weather. The dried fish are then packed in wooden boxes, bamboo baskets, or sacks for distribution to middlemen or wholesalers. Product is transported through the marketing chain either by road or sea, thereby exposing it to conditions which will lead to deterioration.

Within Indonesia dried fish distribution usually flows to Java from other islands, while within Java it flows from East to West Java, where the level of dried fish consumption is highest.

The traditional salting and drying process faces many problems, especially when the peak fishing season coincides with the rainy season, as often happens. Under these conditions salting is frequently extended by several days to await better drying conditions. Drying also takes significantly longer because of the lack of sunshine during the wet season. This forced extension of the processing time leads to a significant reduction in the quality of the end-product because of microbial and insect attack. Although this poor quality product will find a buyer in the markets, the price paid is often lower. Also, its shelf life will be limited.

Poor handling during distribution and storage also plays a significant role in reducing the quality, and therefore the price, of dried fish. Together, detrimental processing and distribution factors result in significant physical and economic significant losses from the time of capture to retail sale.

Alternatives to Traditional Salting and Drying

The research conducted as part of this project was aimed at developing acceptable alternatives to traditional salting and drying practices. The elimination of processors' dependence on the availability of the sun for drying was the cornerstone to this research and led to the development of an appropriate technology dryer.

There have been many attempts to develop a suitable alternative to solar drying for use in tropical regions, but to date no commercially successful, low technology dryers have been developed. Researchers in the joint Australian–Indonesian project studied the traditional process and consulted with processors to identify their requirements for an acceptable device. The resulting requirements placed certain design constraints upon the proposed dryer.

The desirable features of a dryer suitable for use in village level processing were identified as:

- minimal fuel cost

- minimal moving parts
- low capital, running, and maintenance costs
- local materials for construction
- constructed and repaired by local tradesmen
- low additional cost (e.g. labour) over sun drying.

Furnace Development

Fuel

The energy cost incurred in producing the hot air to dry a product is the principal operating cost of a dryer. This is why sun drying remains entrenched. In developing the dryer concept, it seemed that an obvious way to keep fuel costs low was to make use of agricultural wastes. Indonesia's immense agricultural sector produces large quantities of readily available agricultural waste (Table 1). This would be the case in many other areas in Asia. The agricultural waste in Indonesia includes rice and coconut husk, straw, and sawdust with a calculated potential energy value equivalent to 16 million t of coal per annum.

Table 1. Quantities of agricultural waste in Indonesia available as an energy source for drying.

Waste	Coal equivalents (million t/year)
Rice husks	3.6
Rice straw	0.9
Wood waste	1.2
Saw dust	0.9
Coconut husk	6.8
Bagasse	2.3
Total	15.7

Agricultural wastes are often difficult to burn efficiently, and designing a dryer to use them requires a knowledge of the particular fuel together with the appropriate technology to cope with combustion difficulties. After a thorough assessment, rice husk was chosen as the most appropriate fuel source, mainly because of its ready availability close to the coastal fishing villages of Java. Other agricultural wastes may be more appropriate to other areas.

Essentially, these wastes are very bulky and are therefore difficult and expensive to transport more than very short distances. Any dryer would have to be designed to accept whatever local agricultural waste was available.

Rice husks do have some advantages over other agricultural wastes. These include their low moisture content as they leave the mill, the ease with which they can be compressed into bales (which reduces the problem of transporting a low bulk-density material), the ease with which they can be ignited, and their ready availability all year round in many parts of Asia. More than 60 million t of rice husk are produced as a by-product worldwide, and their disposal is often a significant problem.

Rice husks have a little less than half the energy value of coal and they constitute some 20% of the annual Indonesian rice crop, which averages about 30 million t. Husks therefore represent an energy source equivalent to about 3.6 million t of coal. Currently, the main use of rice husks are as fertilizer; occasionally they are burnt and the ash used as an abrasive domestic cleaner.

Rice husks are difficult to burn because they are 20% silica. The design of a furnace for burning rice husks is thus critical. The shape of the rice husk particles and the structure of the fuel bed are the most important factors. Basically, there are two methods of burning husks: combustion, where the combustible elements of the fuel combine rapidly with oxygen; and gasification where the fuel is burnt with limited oxygen so that combustion is not complete. The latter process yields producer gas, a combustible combination of gases including methane, carbon monoxide, and hydrogen. The producer gas can be burnt in the same way as propane or liquid petroleum gas, while producing minimal quantities of smoke or particulate matter. For this reason the gasification of rice husks is the more attractive proposition.

Most gasifiers currently available incorporate complex burners for the use of producer gas. These units were unsuitable for a low-technology fish dryer, so a novel rice husk furnace was designed and developed that satisfied the requirements identified in the initial stages of the project.

Design

The furnace is based on a used 200 L drum equipped with a central perforated tube and a perforated base plate (Fig. 1). It can be constructed in Indonesia in about 6 hours, for approximately US$20. The 200 L drum was selected as the basis of the furnace because these drums are readily available, cheap, and relatively strong. The project team decided to develop a single format for the furnace to focus the research effort instead of trying to satisfy a range of drying requirements. Processors requiring greater drying capacity could employ multiples of the furnace, and in this way would incorporate significant flexibility into their operation. The fishing industry is notoriously unpredictable in the size of its catch. A fish processor has to cope with large fluctuations in the quantity of raw material to process and so requires technical options when determining drying capacity.

Although the design of the rice husk furnace is simple, optimising its performance proved a lengthy exercise. The following design features of importance were identified and quantified.

- Centre-tube specifications — its diameter and the pattern of the holes in it (the percent open space)
- Base plate specifications — the critical factor being the percent open space and the diameter of the holes in the base
- The drum — there is a complex relationship between the diameter and height of the drum and the diameter of the centre-tube
- The start–up procedure — a short period of high temperature input is required to start the furnace
- The addition of husk and removal of ash — required for continuous operation.

These performance variables interact with each other to produce a clean, high-temperature flue gas, so altering one variable by only a small amount can have a significant impact on the performance of the furnace.

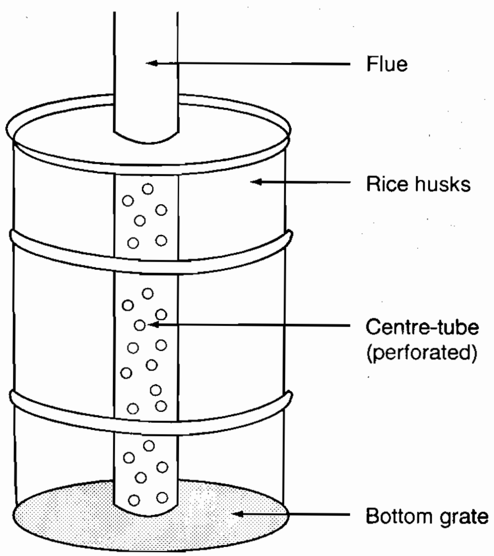

Figure 1. Rice husk furnace.

The main stages in operation of the furnace are as follows:

- A batch of approximately 27 kg of husk is added to the drum
- Intense heat is applied to the base of the furnace
- Within 15 minutes a zone of oxidative combustion is initiated in the base of the husk bed, and the heat source is removed
- As the combustion zone moves up into the bed and oxygen becomes limited, a pyrolysis zone develops
- The pyrolysis zone gradually moves up through the bed and becomes self-sustaining
- Volatiles released by pyrolysis pass into the centre-tube where they spontaneously ignite. Heat passes out the flue. Some heat goes back into the fresh husk above the pyrolysis zone and initiates a new zone of pyrolysis. This process continues until the zone reaches the top of the drum.

Heat output

During the early stage of the development of the furnace, many experiments were done by filling the drum only once and allowing it to burn out, each time varying one parameter. The furnace was extensively instrumented to enable monitoring of conditions in the fuel bed and flue. Fifteen thermocouples were installed in the furnace in 5 rows of 3, allowing continuous monitoring of the temperature profile throughout the fuel bed. Also recorded were flue gas temperature and oxygen and carbon monoxide levels in the gas. The complete furnace was placed on a load cell so that weight loss could be recorded. Weight loss is directly related to the combustion of carbon. The rate of carbon combustion gives a good indication of operational efficiency. In this way the design parameters previously identified were quantified.

The furnace has produced flue temperatures in the range 800–1200°C for prolonged periods. The energy output has been calculated at 12–14 kW for sustained periods, with peak outputs of 20 kW. This output represents a very efficient 80% extraction of the energy from the rice husks (the efficiency of a car engine is about 16%).

Studies on the effect of the numbers and size of holes (percent open space) in the furnace centre-tube and base plate on flue temperature were undertaken. Optimal performance was achieved with 15% open space for the centre-tube and 20% for the base plate.

The flue temperatures measured during recent experiments (Fig. 2), demonstrate the stable heat output that can be achieved with the furnace during continuous operation. To run the furnace for more than 4 hours requires the regular removal of ash from the base and the addition of fresh husk at the top of the furnace every 45–60 minutes. In this way the pyrolysis zone can be maintained at the midpoint of the furnace, resulting in maximum output. The design parameters have been quantified and continuous operation is now possible.

Operating details

The start-up procedure is another critical stage of furnace operation. The time for the furnace to reach operating temperature should be as short as possible, firstly for efficient operation and secondly to minimise the production of smoke before pyrolysis begins in the fuel bed.

Many methods of heating the base of the fuel bed have been tested, including a gas burner and a wood fire. However, in work on a duplicate furnace, the Indonesian research team in Jakarta has developed a rapid, appropriate method of attaining an operating temperature of 800°C in the flue. Originally, more than an hour was needed to reach 800°C, but as the base design was modified times came down to about 40 minutes using a gas burner. This time was reduced further by the work in Jakarta. By using charcoal soaked with kerosene as a heating source the furnace can now be made operational within 15–20 minutes.

The removal of ash, which is at a very high temperature, represents a significant problem. The difficulty arises in designing a removal system that is cheap and easy to construct while allowing the uniform removal of ash from the full cross-section of the drum. This was achieved in Indonesia by using a conical base plate with hole of approximately 200 cm in diameter, equipped with a hinged door. At regular intervals the door is opened and ash released. The conical base plate aids flow of ash from the sides of the drum to the central exit hole.

So as to maximise the life of the furnace, the most appropriate material for fabrication of the centre-tube was sought. The steel 200 litre drums used for the furnace have a very long operational life while the metal centre-tube last for much shorter periods. Centre-tubes made from ceramics were considered. Ceramics have a long history of use for stove construction in Asia and also have the advantage of being cheap and easy to produce. Several ceramic centre-tubes were made in Indonesia, but all failed when tested in the furnace. The tubes disintegrated explosively, probably because they had been poorly fired and contained moisture that rapidly turned to steam when suddenly heated to temperatures of 800–1000°C.

The successful development of the furnace was a major outcome of collaborative research effort from the project. The furnace is not only a heat source for the dryer but is a stand-alone heat source which could be adapted to a variety of uses. The low technology nature of the unit combined with its efficient operation would make it an attractive source of heat in rural communities.

The Drying Chamber

The design criteria identified by the needs assessment undertaken at the start of the project equally applied to the furnace and drying chamber. The drying chamber had to satisfy these criteria as well as integrate with the furnace.

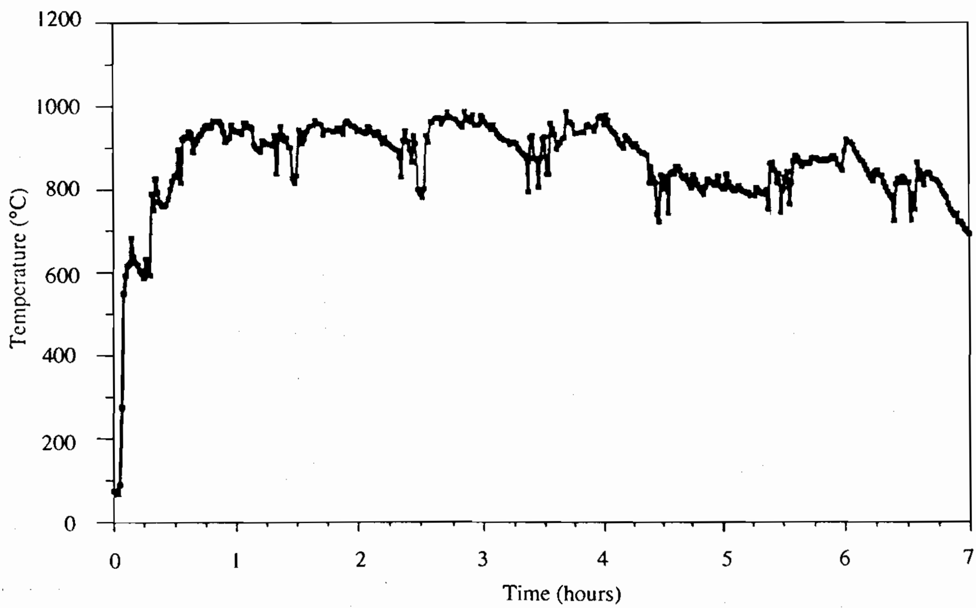

Figure 2. Furnace output.

The scale of the drying chamber had to be matched to the output of the furnace and was expected to have a capacity of 150–200 kg of wet fish. As the furnace was based on a 200 L drum its energy output would determine the size and capacity of the drying chamber. This was not seen as a disadvantage as the dryer was developed as a single, complete drying unit, which could be multiplied depending on needs. A large producer could have several drying units. Any number of them could be started depending on the required capacity.

The three parameters that normally effect the rate of drying are the temperature, relative humidity, and velocity of the air used.

To determine the significance of each of these parameters in the drying of fish, salting and drying studies were undertaken at the University of New South Wales (UNSW) (see Buckle, these proceedings). An experimental laboratory dryer was designed and constructed. Fish were continuously weighed during drying. The sample weight was continuously logged by computer, which produced a drying curve at the end of the experiment.

As it is very expensive and complex to manipulate relative humidity, it was decided early in the research program to rely on ambient relative humidity.

The study of the salting and drying dynamics of small pelagic fish undertaken at UNSW resulted in an understanding of the minimum process requirements to produce a stable product. The main factor affecting the rate of salt uptake and moisture loss during salting is brine concentration. The moisture content decreases at approximately the inverse rate of salt uptake and the rate, although rapid for the first 10 hours, stabilises after this period. There is no benefit in brining fish longer than 10–12 hours except as a means of storage while awaiting suitable drying conditions.

The studies demonstrated that salted fish experience no constant rate period during drying. Rather, the drying proceeds directly into a two-phase falling rate period and it was for this reason air velocity was shown not to be critical to drying rate. This was due to the fish being saturated with salt before drying. It was this finding that air velocity was not critical to drying rate that determined that a natural draught dryer was feasible, removing the need for a motor driven fan to assist air movement.

After considerable research, the conditions to dry salted fish as efficiently as possible while also producing a product of acceptable quality were found to be:

- an air temperature of 40–45°C
- a relative humidity corresponding to tropical ambient air heated to 40–45°C
- an air velocity of 0.25–1 m/second.

Laboratory drying experiments using small pelagic fish demonstrated that salted fish could be dried using optimal conditions in 8–12 hours, depending on size. This meant that salting and drying could be completed in 15–20 hours. This is considerably faster than the 2–5 days taken using traditional sun drying.

A natural draught chamber relies on temperature differentials to create sufficient air velocity to flush out moisture that evaporates from fish within the chamber. No fan or motor is required to move air thus simplifying construction, operation, and maintenance. The original design criteria were thereby adhered to in the development of the chamber. The dryer would remove the dependence on the sun allowing drying during the wet season and at night.

Two versions of the chamber were developed during the course of the two projects. The second version was far more successful. The original design was a 1 m^3 in which the walls and floor acted as heat exchangers (Fig. 3). The cross-sectional size of the chamber, 1 × 1 m, came from Indonesian fish processors who use bamboo trays of this size on which they lie their salted fish in the sun to dry. To minimise the disruption to current practices through the introduction of a dryer, this tray size was therefore adopted.

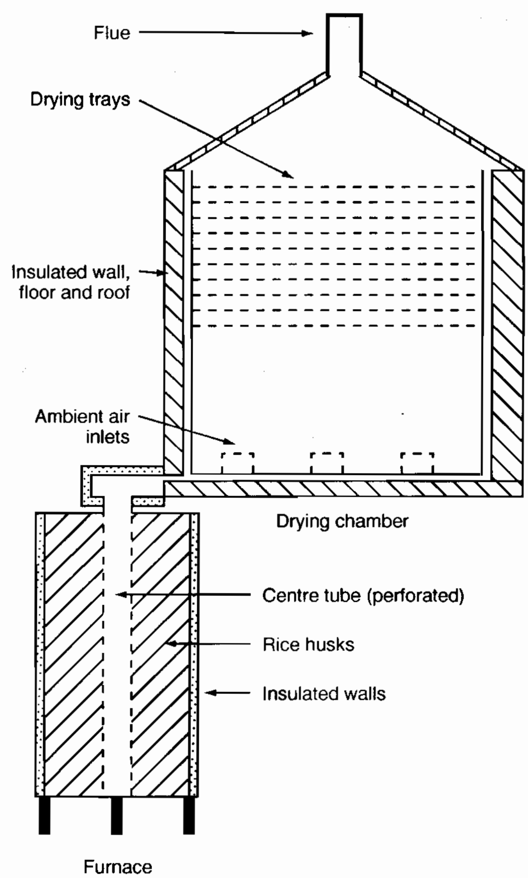

Figure 3. The original natural draught chamber.

The chamber was made of brick, with inner walls and floor of metal and designed to leave a cavity between the two walls. When the furnace previously described was connected via a manifold and started, hot flue gases at 800–1000°C passed across the floor cavity and up the wall cavity to exit into the drying chamber flue, at which stage their temperature was 200–300°C.

With inlet holes for ambient air in the bottom of the drying chamber, the temperature differential between the hot gases exiting the drying chamber and outside ambient air would draw air into the chamber through the holes in the base. This air would be heated as it came in contact with the hot floor and so rise up through the chamber, drawing more air into the chamber. Unfortunately, this chamber did not perform as well as expected. A temperature differential of more than 400°C was required to produce sufficient air velocity to flush-out the chamber but because of the large thermal mass of the chamber, temperature differentials remained below 300°C.

An alternate design was sought and a design concept suggested by Dr B. Fegan, consultant socioeconomist to the project, was developed into the second edition of the chamber. The cavity floor and wall were replaced by a more efficient heat exchanger in the floor. The floor, formed from two sheets of corrugated metal, becomes the sole heat exchanger. The two sheets of metal are joined so that a series of tubes is formed. The tubes are sealed at one end and regularly spaced holes are drilled along the upper side of the tubes. The floor is installed into the chamber so that a gastight cavity is formed under the floor.

When the furnace is connected and operated, hot flue gas at 800°C pass through the cavity exiting at the opposite side of the floor at approximately 300°C. The air inside the tubes is heated by flue gases. The heated air in the tubes rises up through the holes, thereby drawing more ambient air into the open end of the tubes. The transfer of heat using this heat exchanger design was calculated at approximately 70–75%. Indeed, the furnace and heat exchanger design proved so efficient that the chamber size was increased from 1–4 m^3 to accommodate the high chamber temperatures found in the initial model.

Research was undertaken on this dryer design in Indonesia to optimise its performance. The size and distribution of holes in the floor of the chamber determine the temperature and air velocity in the chamber. This research was undertaken by connecting an array of thermocouples within the chamber and reading their output by a data logger. The furnace was started and run for extended periods while air velocity was monitored in the chamber. The chamber configuration would be modified and then re-tested. In this way, the chamber design was refined.

Salted Dried Fish in India: a Review of Methods and Quality Control

K. Gopakumar*

Abstract

Curing is a traditional method of fish processing in India, usually involving sun drying of salted or unsalted fish. The salting process involves kench curing, pickling, and brining. Raised platforms are now in extensive use for drying. Sardines, mackerel, shark, anchovies, and Bombay duck are the major species cured. India's Standards Bureau has developed specific standards for processing dry fish for export and domestic markets.

This paper describes the traditional curing process, improved methods, and packaging and quality control systems employed in India.

In India, curing is a traditionally practiced method of fish preservation, consuming about 32% of the total fish catch. India formerly was an exporter of dried prawn pulp and cured fish to countries such as Sri Lanka, Singapore, and Malaysia, and to some African and western countries. However, at the end of World War II, for economic and political reasons, these markets closed. It was the need to overcome the impact of these market closures in the export industry that sowed the seeds for the development of a modern fish processing industry in India.

Since independence, India has made significant advances in the field of fish production and processing. Thanks to the attention given to the development of essential infrastructure such as modern harbours (Table 1; Gopakumar 1993), deep-sea trawlers, and processing plants. Harbours and landing centres together are expected to provide berthing facilities for about 10000 mechanised boats, 250 deep-sea trawlers, and 50000 traditional craft. As a result there has been a marked increase in the fish catch. A sizeable portion of the fish catch, particularly from deep-sea trawling, is non-conventional, low value fish. A profitable method of using these fish for human consumption is traditional curing. There is significant demand for cured products from domestic and export (Table 2) markets (MPEDA 1992).

Cured fish is a concentrated food rich in protein with a well balanced amino acid make up. This factor, coupled with its low production cost, makes cured fish ideal in fighting the problem of acute protein malnutrition in the poor, especially in rural areas.

Processing Methods

Splitting, gutting, and scoring

Before salting, some preparation such as splitting, gutting, and scoring is carried out for all except the smallest fish. Fish are normally split open along the vertebral column. The flesh of large fish is scored, or they are filleted. Very small fish are salted whole. Splitting of larger fish is essential to expose a large surface area for salting and drying. Inadequate preparation may result in spoilage if the lowered water activity (a_w) which preserves the fish is not achieved rapidly enough.

Salting

It is common practice to salt fish before drying, except for certain varieties such as *Anchiovella* and Bombay duck. There are three common methods of salting.

- *Kench curing*: Solid salt is rubbed into the fish flesh/fish surface, leading to a self-brining proc-

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Table 1. Fisheries harbours and landing facilities in India.

	Commissioned	Under construction	Total
1. Major harbours	4	2	6
2. Minor harbours	23	11	34
3. Fish landing centres (for traditional craft)	96	17	113
Total	123	30	153

ess; the fish are then stacked allowing the brine to drain off.

- *Pickling*: This is similar to kench curing, except that the brine produced is not allowed to drain off. The fish become immersed in a very salty 'pickle' of self brine (extracted fluids).
- *Brining*: The fish/dressed fish are soaked in a prepared, concentrated salt solution.

The proportion of salt to fish ranges from 1:10 to 1:3 depending on the size of the fish. Normally, the amount of salt used must be sufficient for the water inside the fish to become saturated at the end of the process.

Table 2. Export of dried fishery products from India in 1992.

Item	Quantity (t)	Value (R '000)
Dried shrimp	53	3103
Dried fish	3983	59142
Shark fins	174	358414
Fish maws	179	49108
Bêche-de-mêr	39	7590
Dried squid	210	10320

Drying

Fish are normally dried by spreading them in the sun, allowing moisture to evaporate from the flesh. Fish may be laid directly on cement floors, or mats, or raised platforms, or hung from raised racks or ropes. Mechanical/artificial dryers are used only to a limited extent and particularly during the monsoon season. Many improvements to the drying systems have been suggested, many of which have yet to be adopted.

Packaging and storage of cured fish

The general trend in the packaging of dried fish is to pack in bulk for transport to various marketing centres for retail sale. Commonly used packaging materials for cured fish are coconut/palmyrah leaf baskets, bamboo baskets, or gunny bags. None of them is an efficient packaging material for cured fish. Sorption and desorption of water will take place, depending on humidity and temperature. Fish high in moisture in airtight containers are more prone to mould growth because of the increased humidity inside. Packaging of cured fish poses a problem because of the irregular shape and sharp protrusions of the product.

At the Central Institute of Fisheries Technology, Cochin, much work has been done on bulk and consumer packaging of cured fishery products. High density polyethylene (HDPE) gusseted bags laminated with polythene have been recommended for bulk packaging of dried fish under commercial conditions. PEST/LDPE (polyester/low density polyethylene) laminate has been identified as suitable for retail packing of cured fish.

Refrigerated storage of cured fish has been shown to delay discolouration, rancidity, fungal attack, and insect infestation, and to extend shelf life. However, cured fish are generally stored only at ambient temperature in cool, dry, well-ventilated premises.

Commercially Important Cured Products

Cured oil sardines (*Sardinella longiceps*)

Curing of oil sardines is an age-old practice in India. With the development of improved transport and storage facilities, and introduction of modern methods of preservation, the production of cured sardines is falling markedly each year. Sardines are now cured only in certain centres at times when there are bumper catches.

After gutting, dressing, and washing, the fish are salted by the pickling method. The period of pickling varies from one to several weeks depending upon the season and demand. The fish are then sun dried, packed in coconut/palmyrah leaf baskets, and transported to the central market.

Cured mackerel (*Rastrelliger kanagurta*)

Cured mackerel also is a traditional product of India. Mackerel is normally salt-cured by pickling/colombo curing after gutting, dressing, and washing. In some cases the fish are split open from the back before salting. Colombo curing is essentially a pickling process with the addition of a small quantity of Malabar tamarind (*Garcinia cambogea*) which is normally kept in the belly cavity of the fish during pickling. The cured mackerel produced by this method were intended mainly for export to Sri Lanka.

Pickling mackerel in saturated brine fortified with 0.5% propionic acid has been found useful for keeping the fish in good condition for up to one year (Valsan 1968). For the control of reddening and mould growth, Valsan (1985) suggested treatment of cured fish with 3% calcium propionate in saturated brine for 30 minutes. By use of this method, storage life could be extended from the normal 19 weeks to 52 weeks.

Dried shark

Both kench and pickle curing are generally practiced for salting of shark, depending upon the size and species. In kench curing, fish fillets or round fish split open longitudinally and deeply scored are rubbed with salt in the ratio 3:1. The pieces are placed in salting tanks in layers with salt distributed evenly between layers. The body fluid is allowed to drain off and the meat dries somewhat. The fish pieces are briefly washed in water, drained, and then dried.

In pickle curing, fish are salted as in kench salting, but the brine formed is not allowed to drain off. The top of the stack is weighted down to keep the fish immersed in the brine formed. The salted fish are dried either in the sun or in a mechanical dryer to a moisture content of about 35%.

Dried anchiovella (*Stolephorus* spp.)

Dried anchiovella are generally prepared by simply spreading fresh fish on sandy beaches for 1–2 days (Kandoran and Prabhu 1988). The quality of the product is not satisfactory due to insect infestation, yellow discolouration, off odour, high sand content, breakage of head portion, belly bursting, and disintegration. To overcome some of these problems, Prabhu and Kandoran (1991) suggest a modified method. In this, the fish are first washed in clean seawater or 5% brine, then drained and spread uniformly on wooden-framed plastic wire mesh trays. These trays are held on a four-deck drying system.

Dried Bombay duck

Bombay duck (*Harpodon nehereus*) has a very high moisture content of about 85–90% in the fresh form. Traditionally, Bombay duck is dried whole and unsalted simply by interlocking the jaws of two fish and draping over a horizontal wooden pole or rope. The fish are left to dry for 2–3 days, to about 18–20%.

The Central Institute of Fisheries Technology (CIFT) has developed a method for making a high-quality laminated Bombay duck. The method consists of gutting the fish and briefly drying before removing the head, tail, and fins. The fish is then split and the backbone exposed before further drying. It is dried until firm (16–17% moisture) and then pressed to flatten it. A further brief drying period removes any moisture released from the crushed backbone, giving a final moisture content of 14–15%. The product may also be prepared in a bone-free form by cutting out the backbone when the fish are semi dry.

Dried ribbon fish (*Trichiurus* spp.)

Ribbon fish constitutes about 5% of Indian marine fish landings (MPEDA 1992). Until recently, the majority of the catch was cured, but an appreciable quantity is now being exported as frozen fillets. Nevertheless, curing remains important.

Whole and, in some cases, gutted fish are salted by the pickling method for 18–24 hours then sun dried, suspended from ropes or frames. The dried fish are made into bundles and packed in polythene-lined gunny sacks.

Dried catfish, seer, and similar fishes

Fish are washed with clean water. They are then ventrally opened, the gut, gills, etc. removed, then washed again. The flesh, in two halves, is given superficial vertical cuts, then salted by the kench curing method. After 18–24 hours the fish are washed in brine solution to remove excess adhering salt, then sun or mechanically dried to a moisture content of about 35%.

Dried Lacarius, jew fish, kilimeen (*Nemipterus* spp.), and similar fishes

The fish are split open from the back, gutted, dressed, and washed, before salting by the pickling method. After 18–24 hours they are sun dried, cooled, and packed.

Dried white bait, sole, silver belly, and similar fishes

The whole fish are washed thoroughly with clean water, before salting by the pickling method. After 18–24 hours they are sun dried, cooled, and packed.

Spoilage in Cured Fish

Most bacteria and yeast do not grow at water activity (a_w) levels below 0.85. However, halophilic bacteria, xerophilic moulds, and osmophilic yeast can grow at still lower a_w. Table 3 gives the a_w required for growth of different organisms (Francis and Balachandran 1991).

The most common mould growth in cured fish is 'dun', development of chocolate or yellowish-brown spots on the flesh, caused by the halophilic mould *Sporendonema epizoum*. Various kinds of white fungi also impart unpleasant appearance to cured fish. Halophilic bacteria require 10% or more salt in the food medium. Species of the genus *Halobacterium* and *Halococcus* produce pink coloration.

Table 3. Levels of water quality (a_w) required for growth of different organisms.

Organism	a_w level
Bacteria	0.99 to 0.91
Yeasts	0.99 to 0.85
Moulds	0.99 to 0.80
Halophilic bacteria	0.90 to 0.75
Xerophilic moulds	0.85 to 0.65
Osmophilic yeasts	0.85 to 0.60

Oxidised fat imparts the colour of rusted iron, and unpleasant rancid odour and flavour. Fragmentation in dried salted fish arises from preprocess spoilage, subsequent mould/bacterial growth, and insect infestation.

Insect infestation

Blowflies

Blowflies are very common insects found breeding in any dead or decaying animal material that is moist enough to support their development. Their larvae, or maggots, cause physical damage to the dried fish.

Beetles

The most common beetle pests of dried fish belong to the family Dermestidae. If the beetles are left undisturbed for several weeks, they can voraciously consume the flesh and soft tissues of the cured fish until only the bones and some hard tissue remain. The species of dermestids in storage of dried fish are *Dermestes maculatus, Dermestes frisehii, Dermestes ater*, and *Dermestes carnivorus*. Of these, *Dermestes ater* appears to be more prevalent in India and neighbouring countries (Bostock et al. 1987).

Mites

Mites, very small arthropods related to spiders, are frequently associated with dried fish and shellfish that have been in extended storage. Despite their small size they can cause serious damage by consuming or contaminating cured fish. Species belonging to the genera *Lardoglyphus* and *Suidasia* are very common.

Quality Control of Cured Fish

Cured fish vary widely in quality, especially in moisture and salt levels, mainly due to the non-uniformity of processing practices followed at different curing centres. The chemical, bacteriological, and organoleptic quality characteristics of some important varieties of commercially cured fish are given in Table 4 (George et al. 1983, 1986). Chakrabarti (1991) reported that most of the gutted, salted, and dried fish samples he examined contained histamine below 10 mg/100 g of muscle. Histamine content in ungutted salted-dried fish was higher than that in gutted-salted-dried fish. During summer, histamine level in whole sun-dried white

Table 4. Chemical, bacteriological, and organoleptic characteristics (average values) of commercially cured fish.

Fish	Moisture (%)	Sodium chloride (%, dry weight basis)	Acid insoluble ash (%, dry weight basis)	Total volatile nitrogen mg/100 g (dry weight basis)	Standard plate count	Organoleptic score[a]
Sardine	36.01	18.38	5.94	94.09	1.644×10^3	3
White bait	38.72	3.36	9.57	72.69	2.230×10^5	2
Silver belly	41.04	13.74	5.36	89.57	1.264×10^4	2
Sole	37.95	17.69	6.98	104.05	2.987×10^3	1
Ribbon fish	36.85	16.78	14.97	78.40	2.823×10^3	2
Cat fish	41.71	22.91	12.30	83.60	3.485×10^6	2
Lactarius	40.01	19.79	2.97	89.40	4.849×10^3	3
Mackerel	38.32	23.56	2.50	77.73	3.230×10^5	4

[a]Organoleptic score: 0 = poor; 1 = poor-fair; 2 = fair; 3 = fair-good; 4 = good; 5 = very good.

bait exceeded 100 mg/100 g muscle in a few cases, while in winter the level was almost half. Histamine contents of some commercially cured products are given in Table 5.

Many curing yards in India do not have provision for adequate running water of desirable quality, proper buildings, dressing tables, waste disposal, or raised platforms for drying. Imperfect cleaning of fish, inadequate salting, incomplete drying, and general unhygienic handling impair the quality of the products, leading to discoloration, off-odours, excessive extraneous matter, insect infestation, high bacterial counts, fragmentation during storage, etc. Coliforms, *Escherichia coli* and faecal streptococci, are generally absent. Coagulase positive staphylococci were detected in few commercial samples (Sanjeeve et al. 1985). Solanki (1985) reported that uric acid content can be taken as an index of hygienic condition and acceptability of insect-infested fish products.

The Bureau of Indian Standards (BIS) has set quality standards for several cured-fish products. The quality requirements mainly relate to size, moisture, freedom from excessive sand and salt, absence of deterioration, freedom from fungus and mites, etc. Requirements for moisture, salt, and acid insoluble ash are given in Table 6.

Conclusion

Fish curing in India is declining relative to freezing and canning. Availability of ice at or near landing centres, a network of trafficable roads connecting the landing centres with hinterlands, and construction of several new fish landing harbours with modern amenities have stimulated increased consumption of fresh fish, resulting in a decrease in production of cured fish. Nevertheless, curing remains an important method of preservation of fish. Sanitary conditions in handling, production, and distribution systems, although not of the highest order, have recently witnessed marked improvement due to government inputs. As dried fish does not require sophisticated chilled storage systems for preservation it will continue to attract the low-income consumers of fish in India for many years to come.

Table 5. Histamine content in cured fish.

Fish	Histamine content (mg%, wet weight basis)
Seer (*Scomberomorus guttatus*)	10.8 ± 2.28
Mackerel (*Rastrelliger kanagurta*)	19.2 ± 2.56
Polynemus indicus	34.5 ± 16.31
Ribbon fish (*Trichiurus haumela*)	4.1 ± 1.21
White pomfret (*Stromateus sinensis*)	7.8 ± 1.02
Mugil kelaarti	4.4 ± 1.02
Mugil cephalus	4.1 ± 1.72
Sciaenids	6.6 ± 2.67
Chanos chanos	3.2 ± 1.24
Saurida tumbil	4.0 ± 1.56
Oligo sp.	8.6 ± 1.35
Carangid sp.	5.1 ± 1.05
Sole (*Cynoglossus* sp.)	4.1 ± 2.03
Cat fish (*Arius* sp.)	5.7 ± 1.06
Silver bellies (*Leognathus equulus*)	6.4 ± 2.26
Kilimeen (*Nemipterus japonicus*)	8.1 ± 1.14

Table 6. Quality requirements for dried fish products.

Products	Requirements		
	Maximum moisture (%)	Sodium chloride[a] (%)	Maximum acid insoluble ash (%)[a]
Dried prawns/shrimps	20	5 (max.)	1
Dried whitebait	18	2.5 (max.)	7
Dried Bombay duck	15	7.5 (max.)	2
Laminated Bombay duck	15	6 (max.)	1
Dry salted threadfin (Dara)	40	25 (min.)	1.5
Dried salted jewfish (Ghol)	40	25 (min.)	1.5
Dried salted catfish	35	25 (min.)	1.5
Dried salted leather jacket	35	25–30	1.5
Dried salted horse mackerel	35	25–30	1.5
Dried salted mackerel	30	25–30	1.5
Dried salted seer fish	35	25–30	1.5
Dried salted shark	35	25–30	1.5
Dried shark fins	10	–	1.5
Fish maws	8	–	1.5
Dried salted surai (tuna)	35	20–25	1.5
Dried salted dhoma	35	10–15	2

[a]Values are on moisture-free basis.

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Fungi from Indonesian Dried Fish

J. I. Pitt*

Abstract

A survey of fungi occurring on Indonesian dried fish was carried out by purchasing samples showing visible mould from retail markets and drying yards in and around Jakarta. In all, 75 samples were examined, comprising about 500 fish representing 24 species. Most fish were sampled by direct plating from visible mould growth, but some were also macerated and dilution plated. The major fungal genera isolated were *Aspergillus* and its ascosporic state *Eurotium*. The most common *Aspergillus* species was *A. niger*, isolated from 36% of samples. *A. flavus* (27%) and *A. sydowii* (22%) were also common. *Eurotium rubrum* (35% of samples), *E. repens* (26%), and *E. chevalieri* (18%) were widespread. *Penicillium* species were isolated quite frequently, but their incidence was usually attributable simply to the presence of spores rather than to growth. During the course of this study *Polypaecilum pisce* was described as new; it was found on 42% of samples and was the most common species isolated. *Basipetospora halophila*, like *P. pisce* an unusual halophilic xerophile, was found on five occasions. The water relations of several commonly occurring species were investigated and competition between five major species evaluated on media and fish pieces over a range of temperature and water activity.

STUDIES on fungi occurring on Indonesian dried fish formed part of one of ACIAR's earliest ACIAR projects (Project 8304), which studied all aspects of fish drying in that country. In collaboration with staff of the Research Institute for Fish Technology, we carried out a comprehensive study of the occurrence of fungi on dried fish in and around Jakarta. We bought fish from Senen, the main market in Jakarta, and from markets and fish drying yards in neighbouring villages. We looked at about 500 dried fish, in 75 samples each containing up to 12 fish. We specifically selected samples with visible mould on them. The proportion of dried fish production which showed visible mould is difficult to estimate, but comprised perhaps 10% of the samples we saw in the market place. As we were particularly checking the lower end of the marketing system, it seems likely that no more than 5% of fish sold in Indonesia is affected by visible mould growth.

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Fish Species

In all, the samples studied included 24 fish species (Table 1; Wheeler et al. 1986). The most common were sardines, squid, snakehead, mackerel, and anchovies. The water activity (a_w) of the 75 samples ranged from 0.65 to 0.79, with 69 samples lying between 0.70 and 0.76. Only two were below 0.70 a_w and only three above 0.76 a_w. This means that nearly all were of a water activity similar to saturated NaCl, which clearly provides a very strong controlling influence on the a_w. Growth of fungi is, at most, very slow at 0.75 a_w, so the presence of visible mould usually indicates growth when a_w was higher: either during slow drying or under inadequate storage conditions or both.

Mycoflora

Initially, each fish was checked with the stereomicroscope for visible mould growth. Where spots or areas of mould were found, samples were taken with a sterile needle and placed onto suitable growth media. We also pressed pieces of visibly mouldy fish directly

Table 1. Fish species studied.[a]

Latin name	English name	Indonesian name	No. of samples	a_w range
Sardinella fimbriata	Fringe-scale sardine	Tembang	16	0.71–0.79
Katsuwonus sp.	Skipjack	Cakalang	1	0.71
Loligo sp.	Squid	Cumi-cumi	9	0.69–0.76
Rastrelliger hanagurta	Chub mackerel	Kembung lelaki	3	0.72–0.73
Ophiocephalus striatus	Snakehead	Gabus	7	0.73–0.75
Scomberomorus sp.	Spanish mackerel	Tenggiri	4	0.72–0.76
Leiognathus sp.	Slipmouth, ponyfish	Peperek, selar	2	0.72–0.73
Trygon sp.	Ray	Pari	1	0.72
Lutjanus sp.	Red snapper	Ikan merah	1	0.73
Paraplotosus sp.	Catfish eel	Sembilang	1	0.76
Anadara sp.	Blood cockles	Kerang, darah	1	0.76
Chanos chanos	Milkfish	Bandeng	1	0.74
Pseudosciaena sp.	Croaker	Gulamah	3	0.71–0.74
Tachysurus sp.	Sea catfish	Jambal	2	0.75
Saurida sp.	Lizard fish	Beloso	1	0.76
Decapterus sp.	Scad	Layang	2	0.74
Puntius javanicus	Carp	Tawes	3	0.73–0.75
Stolephorus sp.	Anchovy	Teri	5	0.65–0.72
Trichiurus sp.	Hairtail	Layur	1	0.73
Hemirrhamphus sp.	Halfbeak, garfish	Julung-julung	1	0.74
Trichogaster pectoralis	Snakeskin gourami	Sepat siam	1	0.72
Sepia sp.	Cuttlefish	Sotong	1	0.72
Tachysurus sp.	Dried fermented catfish	Jambal roti	1	0.78
Cynoglossus lingua	Tongue sole	Ikan lidah	1	0.72

[a] Wheeler et al. (1986).

onto agar media (Wheeler et al. 1986). Most of the fungi isolated came from visible growth on the fish, but some fish pieces were macerated in peptone water and plated out by dilution plating. In this case, fungi isolated were not necessarily growing on the fish, but may have been present only as spores.

The genera most commonly isolated from fish in this study are shown in Table 2. The most frequently isolated genus was *Aspergillus*, from which we identified 17 species, and which comprised 34% of the isolates found. This number did not include species of *Eurotium* (an ascosporic genus which produces an *Aspergillus* asexual state). If *Aspergillus* and *Eurotium* are considered together, they were the fungi most frequently isolated during this survey.

The most commonly isolated *Aspergillus* species was *A. niger* (Table 3), which was present on 36% of samples. This was not unexpected: *A. niger* is the dominant fungus on Australian sun-dried fruit (King et al. 1981). The black colour of the spores produced by this species undoubtedly account for its very high resistance to ultraviolet radiation and its presence on sun-dried food products. Despite its common occurrence, in my opinion it is unlikely to be important as a cause of spoilage, as it was observed to be actively growing on only an occasional fish. *A. flavus* was also isolated frequently, from 27% of samples. It is discussed further below in the context of mycotoxin production. The third common species of *Aspergillus* encountered was *A. sydowii* (23%), a slowly growing species found mostly in dried foods.

Eurotium species were common on the dried fish samples. This was to be expected; Eurotiums are extremely common on all dried substrates. *E. rubrum* (on 35% of the samples), *E. repens* (26%), *E. amstelodami* (22%), and *E. chevalieri* (18%) were all of common occurrence.

Table 2. Genera of fungi isolated from Indonesian dried fish.[a]

Genus	Percentage of isolates	Number of species
Aspergillus	34.1	17
Eurotium	20.9	6
Penicillium	16.5	20
Polypaecilum	8.5	1
Cladosporium	4.4	2
Chaetomium	3.0	NI[a]
Talaromyces	2.3	1
Monascus	1.6	NI
Basipetospora	1.4	1
Paecilomyces	1.1	1
Syncephalastrum	0.8	1
Trichoderma	0.8	2
Ulocladium	0.8	NI
Absidia	0.6	1
Alternaria	0.6	NI
Eupenicillium	0.6	2
Wallemia	0.5	1
Botryotrichum	0.3	NI
Corynascus	0.3	1
Dactylosporium	0.3	NI
Dreschslera	0.3	NI
Fusarium	0.3	1

[a] Wheeler et al. (1986)
NI = not identified to species level.

Table 3. Species of fungi commonly isolated from Indonesian dried fish.[a]

Species	No. of isolates	Percentage of samples
Aspergillus		
A. candidus	5	6.8
A. flavus	20	27.0
A. fumigatus	5	6.8
A. niger	27	36.5
A. penicillioides	12	16.2
A. restrictus	6	8.1
A. sydowii	17	23.0
A. tamarii	5	6.8
A. wentii	11	14.9
Basipetospora		
B. halophila	5	6.8
Chaetomium sp.	11	14.9
Cladosporium		
C. cladosporioides	12	16.2
Eurotium		
E. amstelodami	16	21.6
E. chevalieri	13	17.6
E. repens	19	25.7
E. rubrum	26	35.1
Monascus		
M. ruber	6	8.1
Penicillium		
P. chrysogenum	6	8.1
P. citrinum	14	18.9
P. smithii	5	6.8
P. thomii	7	9.4
P. viridicatum	5	6.8
Polypaecilum		
P. pisce	31	42.0

[a] Wheeler et al. (1986).

We isolated species of *Penicillium* quite frequently, and saw a wide range of species. However, most were apparently present as spores, or at the most came from very limited growth, and I believe *Penicillium* is of no real importance in the spoilage of dried fish in Indonesia.

Polypaecilum pisce is an unusual species of great interest which we described as new during the course of this study (Hocking and Pitt 1988). It constituted 9% of the total isolates found; more importantly, it was present on 42% of all samples examined. It was indeed the dominant species found in this study, a fact which is the more remarkable because it had not previously been described. Growth on dried fish was often very extensive (Fig. 1). However, whether *P. pisce* can be considered to cause spoilage is debatable. Although Western senses would certainly reject fish such as those shown in Figure 1, the smell generated by *P. pisce* is aromatic and pleasant, and entirely acceptable to Indonesian palates. Perhaps it could be used in a positive fashion as an agent for producing a fermented product, in the manner in which *Penicillium* species are used in the production of fermented sausages in Europe.

A species that was rarely isolated (five isolates), but of great interest to us, was *Basipetospora halophila*. This species occurs only in very salty habitats and is the most salt-tolerant fungus known.

Fungal Water Relations

A major part of this study investigated why particular fungi were present on the dried fish. Water activity studies were carried out using techniques originally described by Pitt and Hocking (1977). That system uses Petrislides (Millipore Corporation, Sydney), a plastic device the same length as, but twice the width of, a microscope slide, with the upper surface formed into a miniature Petri dish. The Petrislide is designed for incubation and microscopic examination of Millipore filters. Petrislides have proved to be very suitable for water relations work. Media are prepared using NaCl, glycerol, or a mixture of glucose and fructose to control a_w over the desired range. In use, small quantities of medium are poured into the Petrislide lids, which are then inoculated with a test fungus, the lids closed and the Petrislides incubated. Incubation conditions are carefully controlled: Petrislides are stacked in plastic food boxes in which the a_w is maintained by small open dishes of saturated salt solutions. At appropriate intervals, the Petrislides are taken out and examined under the low power (100×) microscope. Germination and growth of the fungus can be readily watched in a virtually closed environment.

Typical growth results obtained are shown in Figures 2–7, which plot growth rates against a_w as influenced by type of solute present or incubation temperature. Growth rates at 25°C for two common, xerophilic *Aspergillus* species are shown in Figure 2. The rapidly growing species shown is *A. wentii*, which was quite common on the fish samples. A characteristic of this species is that its growth rates are virtually independent of solute type: *A. wentii* grows almost as well in media containing NaCl as in those where a_w is controlled by glucose or glycerol. It is also very xerophilic, a fact only discovered during this study, with an optimum a_w for growth below 0.95, and a minimum below 0.8 a_w in NaCl. High growth rates (up to 200 μm/hour; nearly 5 mm/day) at a_w around 0.95 indicate an ability to rapidly colonise fish during drying. In contrast, *A. penicillioides*, also shown in Figure 2, grows much more slowly, less than 50 μm/hour under optimal conditions. Growth was again little affected by solute type, with a minimum near 0.75 a_w in NaCl media. This species is therefore capable of continuing to grow, though slowly, on dried fish stored in the range of the samples we examined.

Growth of a representative *Eurotium* species, *E. rubrum*, is shown in Figure 3. Its growth is noticeably affected by solute, with growth rates over a wide a_w

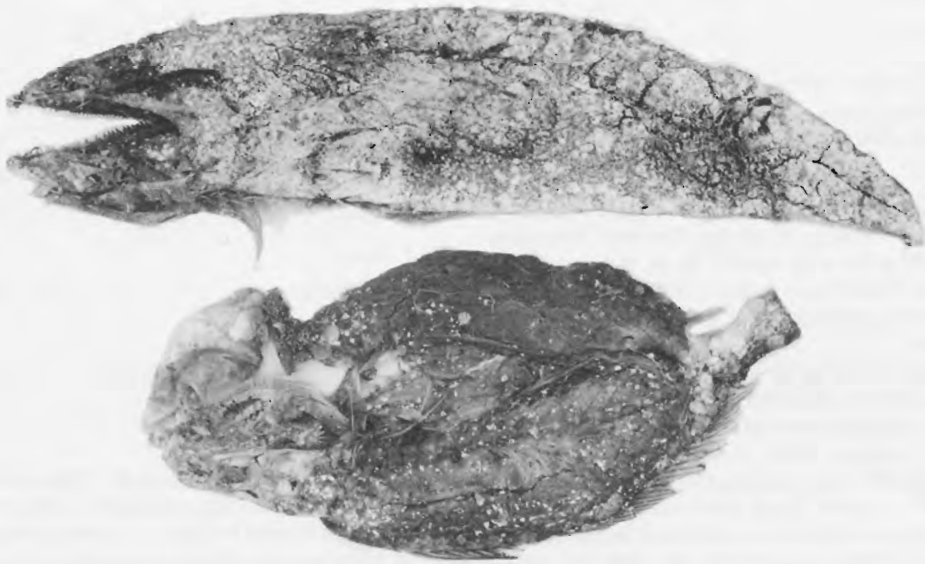

Figure 1. Salted dried fish showing extensive mould growth. The larger fish is 28 cm long and is almost completely covered in mould, predominantly *Polypaecilum pisce*.

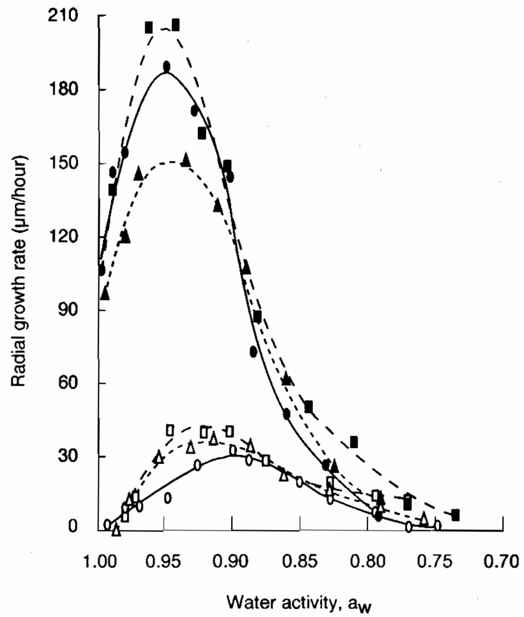

Figure 2. Effect of water activity and solute on the radial growth rates of xerophilic fungi. ●, B, H *Aspergillus wentii;* E, G, C *Aspergillus penicilloides*; J, E NaCl; B, G glucose/fructose; H, C glycerol (Andrews and Pitt 1987).

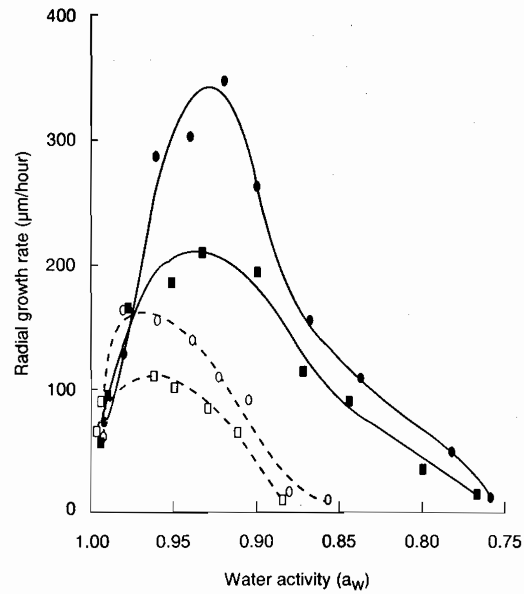

Figure 3. Effect of temperature, water activity and solute on radial growth rates of *Eurotium rubrum*. B, glucose /fructose, 20°C; G, NaCl, 20°C; J, glucose/fructose, 25°C; E, NaCl, 25°C (Wheeler et al. 1988b).

range averaging more than twice as fast in media containing glucose/fructose as in those containing NaCl. Growth continued at much lower a_w levels in glucose/fructose as well. At first glance, dried fish appear to be an unfavourable environment for *Eurotium* species: however, these species grow so quickly under favourable conditions that their growth rates on NaCl media at 25°C are still comparable with those of most other fungi discussed here.

The influence of a_w and solute on growth of *Polypaecilum pisce* is shown in Figure 4. This species is also xerophilic, like the *Aspergillus* species just described, but with one notable difference: growth on media containing NaCl is faster than growth on media containing glucose/fructose. To describe this very unusual characteristic, we coined the term 'halophilic xerophile' for species such as this. The term halophile alone is properly reserved for bacteria which have an absolute requirement for salt environments, in contrast to these fungi which are capable of balanced growth in the absence of NaCl.

In assessing the ability of fungi to grow on drying and dried fish, the effect of temperature is also important, as shown for *P. pisce* in Figure 5. This species grows much more quickly at 30°C than at 25°C, but temperature has little effect on growth rates over the range 30–37°C. The ability to grow strongly in the presence of NaCl at 30°C or more provides an explanation of the colonisation of drying fish by *P. pisce*.

The first notable difference in growth of *Aspergillus flavus* from the other species discussed here is that optimal growth takes place at a very high a_w, at least 0.98 (Fig. 6). The second is that, under the conditions used here, *A. flavus* failed to germinate below 0.85 a_w, indicating little opportunity to grow on drying fish during the later, more prolonged, drying stages. *A. flavus* exhibited much faster growth at 37°C than at lower temperatures, but failure to grow below 0.85 a_w at that temperature also indicated rapid spore death before germination. In other studies (e.g. Pitt and Miscamble 1994), *A. flavus* has been shown to grow near 0.80 a_w under more favourable conditions.

Figure 6 is important. At 30°C, a temperature relevant to tropical fish drying, *A. flavus* grows very quickly in NaCl at high water activities, so if the early stages of drying are prolonged, growth of *A. flavus* may occur on salted fish. However, *A. flavus* grows only slowly below 0.9 a_w and, as shown in Figure 6, is incapable of growth once 0.87 a_w is reached on the drying curve. Further, as all of the

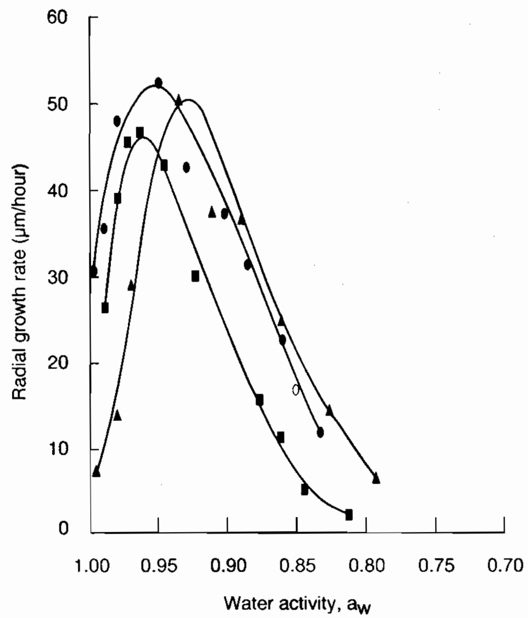

Figure 4. Effect of water activity and solute on the radial growth rates of the halophilic xerophile *Polypaecilum pisce*. J, NaCl; B, glucose/fructose; H, glycerol (Andrews and Pitt 1987).

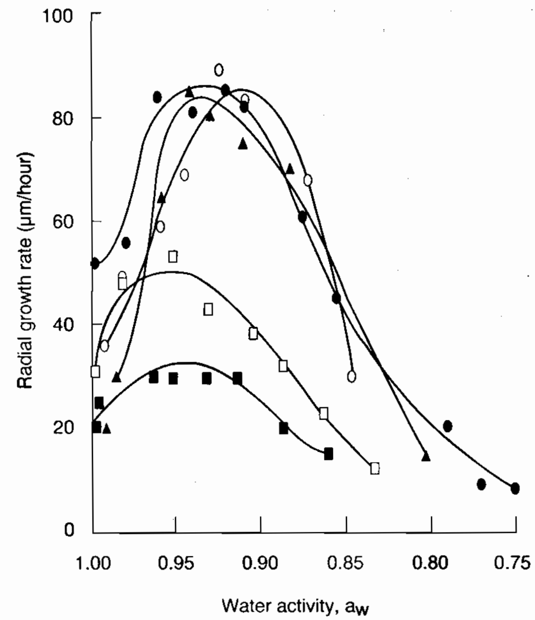

Figure 5. Effect of temperature on the radial growth rate of *Polypaecilum pisce* in NaCl based media. B, 20°C; G, 25°C; J, 30°C; E, 34°C; H, 37°C (Wheeler et al. 1988c).

retail samples examined from Indonesian sources were below 0.8 a_w, no prospect whatever exists of *A. flavus* growing in dried Indonesian fish.

Although of lesser importance in the context of fish spoilage, *Basipetospora halophila* is intriguing because of the great difference between its ability to grow on glucose /fructose and on NaCl-based media (Fig. 7). No set of conditions appears to exist where growth is more rapid on carbohydrate-based media. A carbon source is still needed for growth, but quite low levels of glucose appear to be adequate. Its very high tolerance of NaCl is exceptional amongst terrestrial eukaryotic life forms. Growth still occurs at 0.75 a_w, although very slowly (about 10 µm/hour). An important point is that it does not compete with the other fungi at high a_w, as its maximum growth rate is also very slow (never exceeding 40 µm/hour). However, it is capable of causing eventual spoilage under normal tropical storage conditions.

The other fungus worthy of note in the present context is *Wallemia sebi*. This tiny brown fungus was found many years ago growing on dried fish in the cold temperate zone in the northern hemisphere (Frank and Hess 1941). Before our study began, the literature indicated that *W. sebi* was the main cause of spoilage of dried fish throughout the world. In fact, we never saw *W. sebi* in dried fish from Indonesia. The reason for its absence lies in its inability to grow much above 30°C in this kind of product (Wheeler et al. 1988a). *W. sebi* simply does not compete under tropical conditions with the fungi discussed here.

Competition Experiments

One interesting aspect of our work was to examine the way in which the species discussed above were able to compete with each other for 'space' on dried and drying fish (Wheeler and Hocking 1993). The experimental design used was that pairs of fungi were inoculated onto agar media or fish pieces, 0.5 to 1.5 cm apart depending on a_w, temperature, and species. Five fungi were studied: *Polypaecilum pisce, Eurotium rubrum, Aspergillus wentii,* and *A. penicillioides,* all commonly isolated from dried fish, and *Basipetospora halophila,* included because of its interesting water relations. Three temperatures were used, 15, 25, and 30°C, and a_w from 0.98 to 0.84.

Behaviour of each pair of isolates varied both with species and conditions: the most common interaction was mutual inhibition on contact or inhibition followed by more-or-less unimpeded growth of one species over the other. A numerical scoring system was

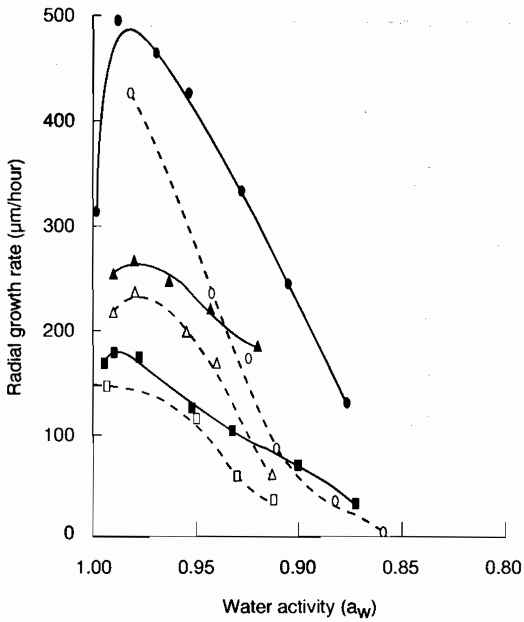

Figure 6. Effect of water activity and solute on the radial growth rate of *Aspergillus flavus*. B, glucose/fructose, 20°C; G, NaCl, 20°C; H, glucose/fructose, 25°C; C, NaCl, 25°C; J, glucose/fructose, 37°C; E, NaCl, 37°C (Wheeler et al. 1988b).

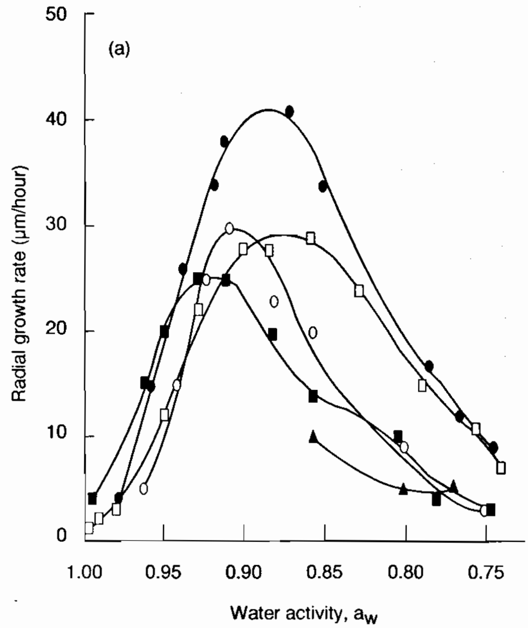

Figure 7. Effect of temperature on the radial growth rate of *Basipetospora halophila* in NaCl based media. B, 20°C; G, 25°C; J, 30°C; E, 34°C; H, 37°C (Wheeler et al. 1988c).

developed in which the reactions between the species were expressed as an 'index of dominance', which described the overall ability of each species to compete. For details see Wheeler and Hocking (1993).

The most interesting results are those for interactions on dried fish pieces at 0.90 a_w (a drying fish) and 0.84 a_w (a nearly dry fish) at 30°C (Table 4).

Results were rather surprising. Comparative growth rates at 30°C (Fig. 8) indicated that *Aspergillus wentii* and *Eurotium rubrum* would be dominant at high a_w (0.90); however, index of dominance scores indicated that *B. halophila* and *P. pisce* were highly competitive under these conditions. Dominance clearly is not only a matter of growth rate. At the lower a_w, all species studied were equally competitive except *Eurotium rubrum*, which was totally noncompetitive (Table 4). This was equally surprising, as in pure culture on NaCl media, only *P. pisce* and *B. halophila* grew (Fig. 8).

Aflatoxins

The topic of aflatoxin in dried fish remains of interest. As shown in Figure 6, *A. flavus* grows very quickly at 30°C in media containing NaCl as the major solute. So during the early stages of drying, *A. flavus* can grow if the time above 0.9 a_w is prolonged (2 or more days). Once the a_w of a drying fish is reduced below 0.9, growth of *A. flavus* slows, and it ceases at about 0.87 a_w. Once a fish has been dried below 0.85 a_w, there is no possibility of *A. flavus* growing at all. All of the samples we examined from Indonesia were below 0.8 a_w, and safe from *A. flavus* growth. *A. flavus* was found quite frequently during the course of this study (Table 2), but visible growth was not observed in any instance. There is no evidence that toxin formation occurs in the absence of growth.

We assayed for aflatoxins each fish on which *A. flavus* was found, and detected none. In Africa, where freshwater fish are dried in the absence of salt, aflatoxin has been reported in quite large amounts (Joslyn and Lahai 1992); however, their results were unquantified and have not been confirmed. In contrast, the occurrence of significant levels of aflatoxin on salted dried fish in Southeast Asia appears to be unlikely.

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Table 4. Interactions between fungi on dried fish at 30°C[a].

aw		Fungal interaction					ID[b]	Media[c]
		Bh	Pp	Aw	Ap	Er		
0.90	Bh	–	2	4	2	5	13	8
	Pp	4	–	4	5	5	18	10
	Aw	2	2	–	2	0	6	8
	Ap	2	0	2	–	0	4	8
	Er	0	0	0	0	–	0	8
0.84	Bh	–	2	2	2	5	11	14
	Pp	2	–	2	2	5	11	14
	Aw	2	2	–	2	5	11	7
	Ap	2	2	4	–	5	13	0
	Er	0	0	0	0	–	0	2

[a] Bh = *B. halophila*; Pp = *P. pisce*; Aw = *A. wentii*; Ap = *A. penicilloides*; and Er = *E. rebrum*.
[b] ID = incidence of dominance score; the higher the number, the more competitive the species (under conditions used here).
[c] Media = ID score from NaCl medium at 30°C for comparison.

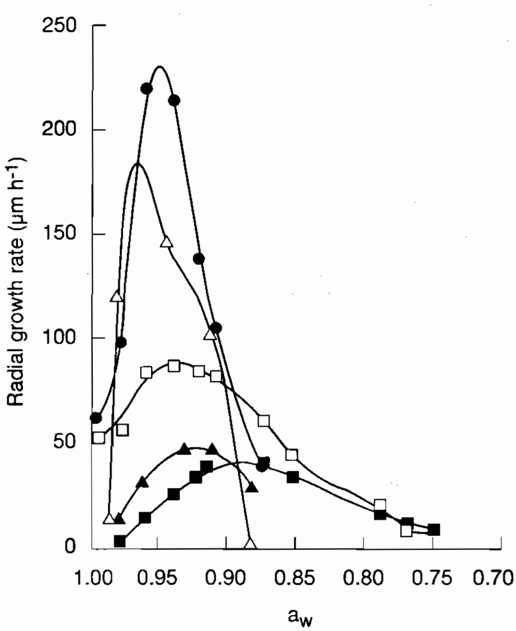

Figure 8. Comparative growth rates of five fungi on NaCl media at 30°C. B, *Basipetospora halophila;* G, *Polypaecilum pisce*; J, *Aspergillus wentii*; C, *Aspergillus penicillioides*; H, *Eurotium rubrum* (Wheeler and Hocking 1993).

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Impact of Insects on the Quality and Quantity of Fish and Fish Products in Indonesia

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Abstract

Entomological studies were conducted in Java from 1984 to 1992 as part of a more comprehensive investigation into the prevention of losses in the quality and quantity of fresh, and dried and salted fish in Indonesia, in a collaborative project sponsored by the Australian Centre for International Agricultural Research (ACIAR) and the Agency for Agricultural Research and Development, Indonesia (AARD).

Initial studies involved training personnel in basic entomology, supplemented by projects on the biology, ecology, and effects of salt on the major insects associated with fish and fish products, notably flies and beetles.

Inspections of fish-landing sites, drying and processing locations, warehouses, and wholesale and retail stores were conducted to assess insect damage and to gain the perceptions of fish handlers and potential consumers on insect presence and/or damage.

Longer term studies evaluated the seasonal abundance of flies and fly-borne bacteria, assessment of infestation in containers, fish loss in commercial stores and warehouses, repellent effects of plant products and insecticides, and the use of screening to reduce losses in retail stores.

Factors influencing the implementation of the research findings are discussed.

THE harvest of marine fish contributes significantly to protein demanded for human consumption in Indonesia. For example, in 1984–85 approximately 300000 fish were landed at the Jakarta ports of Muara Baru and Kalibaru. In the absence of adequate chilling and freezing facilities, salting and drying remain the main methods for preserving fish accounting for approximately 50% of total processed fish (Suparno, these proceedings).

Insects attack fish at all stages of the marketing chain, resulting in accelerated rates of decomposition and direct product loss after processing.

Entomological investigations commenced at the Research Institute for Marine Technology (RIFT), now the Research Station for Marine Fisheries (RSMF), Slipi, Jakarta in 1984 and were concluded in 1992. These activities are discussed under the following categories:

- Strengthening entomological expertise
- Survey of insect (and mite) species associated with fish and fish products
- Research projects in laboratory and field
- Surveys to assess the perceptions of processors, wholesalers, and retailers on the effect of insects on product acceptability and loss.

Entomological Investigations

Strengthening entomological expertise

At the commencement of the project, RIFT staff had no entomological experience, having been trained in fish-orientated disciplines. Informal meetings were held with 4–5 junior staff members assigned to entomological aspects of the general program and the basic features of insects, their life history, ecology, and potential pest significance to fish products and human health, were explained and discussed.

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These activities were supplemented by a series of experiments designed to provide basic training in insect culture and how insect life histories and habits were modified by food substrate moisture content (measured as water activity, a_w) and salt content, and in using Gorham (1987) and, latterly, Haines and Rees (1989) for pest identification.

Survey of insects and mites commonly associated with fish and fish products

All steps in the marketing chain from landing through processing, storage by wholesalers, to retail sale, were studied, to determine the insect species involved and the conditions in which they occurred. Two major groups, the flies and the beetles, were present, involving cosmopolitan species recorded as pests of fresh, fermented, and salted and dried fish (Osujc 1975; Golob et al. 1987; Poulter et al. 1988; Haines and Rees 1989; Awoyemi 1991; Esser 1991). The major species encountered are listed in Table 1.

Observations and preliminary breeding trials indicated that the large green blowfly, *Chrysomya megacephala*, preferred fish of high water activity for oviposition and could tolerate salinities up to 8%. It also preferred illuminated to shaded sites in choice trials. By contrast, *Musca domestica* was as common in shaded as in illuminated sites, and did not prefer high protein and high water activity substrates for oviposition, choosing vegetable wastes of moderate water activity, supplemented with animal protein, fish wastes, or chicken faeces. Moreover, the tolerance of *M. domestica* for salt is less than 2%. As will be discussed later, both species contaminate fresh-fish surfaces with a range of microorganisms.

Fermented fish were commonly infested by the cheese skipper, *Piophila casei*, particularly in warehouses. In preliminary tests, dilute solutions (2%) of butyric, propionic, and acetic acids confined in soft-drink containers fitted with an open-ended inverted cone and hung in a warehouse resulted in maximum catches in butyric and minimum catches in acetic acid traps.

Table 1. Insects and mites commonly associated with fish and fish products in Jakarta, Indonesia.

Diptera	*Chrysomya megacephala* (Fabricius)
	Musca domestica L.
	Piophila casei (L.)
Coleoptera	*Dermestes* spp., notably
	Dermestes carnivorus Fabricius
	Dermestes maculatus De Geer
	Dermestes ater (De Geer)
	Necrobia rufipes (De Geer)
Acari	*Lardoglyphus konoi* (Sasa and Asahuma)

The reduction in water activity following processing renders the fish suitable to attack by dermestid beetles. Although three species were associated with the product in warehouses and particularly retail stores, *Dermestes maculatus* predominated, even though *Dermestes carnivorus* was more tolerant of salt content. A higher reproductive potential, with a moderate degree of salt tolerance, ensured the success of *D. maculatus* in both numbers and distribution. *Dermestes ater* was rare. Maximum dispersal of both adult and larval dermestids occurred at night.

Laboratory and Field Projects

Pest biology

The effects of moisture and salt contents of fish tissue on survival and development of *C. megacephala* were assessed. Batches of 10 newly hatched larvae were transferred to treated tissues using three replicates of each two-factor combination at three levels of each factor. Before each of three runs, tissue moisture content (m.c.), a_W, pH, and salt concentrations of treatment samples were determined. The results indicated that moisture and salt contents singly and in combination significantly affected survival and the weight and size of surviving flies. Optimum survival occurred on unsalted tissue, with 16.7% mortality at 76% m.c. (a_w 0.93) and 77% salt increasing to 80% mortality at 70% m.c. (a_w 0.84) and 8.7% salt. Differences in survival were also reflected in the dimensions and weight of resulting pupae and adults.

Comparison of *D. maculatus* and *D. carnivorus* feeding on unsalted anchovies indicated that *D. maculatus* produced more larvae sooner than did *D. carnivorus*, resulting in greater food losses per unit time, e.g. the average amount of food consumed per larva over 6 weeks was 0.519 and 0.395 g for the respective species. Such differences were minimised when brined anchovies were used.

Ecology

Fly abundance at landing sites

Populations of *M. domestica* and *C. megacephala* were monitored for 18 months at two Jakarta fish landing sites, Muara Angke and Kalibaru. The former site is located on an isolated point, whereas the latter is in a more-populated area. The daily catch ranged from 15–23 and 1–3 t of fish for the respective sites. Monitoring involved the exposure of 8 × 8 cm sticky traps and plain white cards attached in pairs to at least eight fixed sites within the covered reception areas. Traps and cards were exposed for 3 hours on one day at each site at monthly intervals, after which counts of captured flies and faecal spots left by flies alighting on the white cards were recorded. After 6 months, the use of sticky traps was discontinued for the respective counts were highly correlated. However, adult flies were captured by netting in order to obtain relative numbers of each species.

Fly numbers were compared with monthly rainfall and catch of fish (Figs 1, 2). Population indices so obtained indicated that maximum numbers of both species occurred just before and in lesser numbers following the wet season whereas during the wet season population numbers fell (Fig. 3). Populations of *C. megacephala* at both sites remained relatively constant throughout the sampling period, whereas *M. domestica* numbers were comparable to *C. megacephala* at Muara Angke but with two distinctive pre-wet peaks and with the population of *M. domestica* at Kalibaru, on average, three times greater (Fig. 4). These differences reflect the greater adaptability of *C. megacephala* to exploit wet habitats, e.g. drains, with the initial wetting of dry organic wastes favouring temporary increases in *M. domestica* numbers at Muara Angke and the more favourable habitat of the large accumulation of animal and vegetable wastes at Kalibaru producing higher populations of *M. domestica*.

Bacterial loads on individual flies

Twenty Bijoux bottles, each containing 2 mL sterile isotonic saline, were taken in a cool box to the site on each monthly sampling occasion. Five individuals of each of the two fly species were sampled in the following manner. Flies were captured in a clean net and individual flies transferred with sterile forceps to a Bijoux bottle which was recapped and gently shaken for a standard 10 times, the fly removed, and the contaminated saline stored for subsequent serial dilution and a 1 mL aliquot used to establish a pour plate on nutrient agar. Plates were incubated for 36 hours and counts made. Identification of the major bacterial forms was made according to the diagnostic procedure of Lee et al. (1979).

Bacterial counts per fly exhibited a distinctive seasonal pattern which ranged from 10^2–10^3 per fly, irrespective of species, during the dry season, to 10^9 microorganisms per fly during the west season (Fig. 5). The identity of the most common forms of bacteria found is shown in Table 2. The general trend in abundance of bacterial loads clearly reflected the incidence of bacteria within the breeding habitat which, in turn, was related to the moisture content of those habitats. The composition of the bacterial flora on *C. megacephala* was relatively constant throughout time at both sites; *Corynebacter, Acinetobacter* spp. and representatives of Enterobacteriaceae were the major taxa carried by both fly species at both sites.

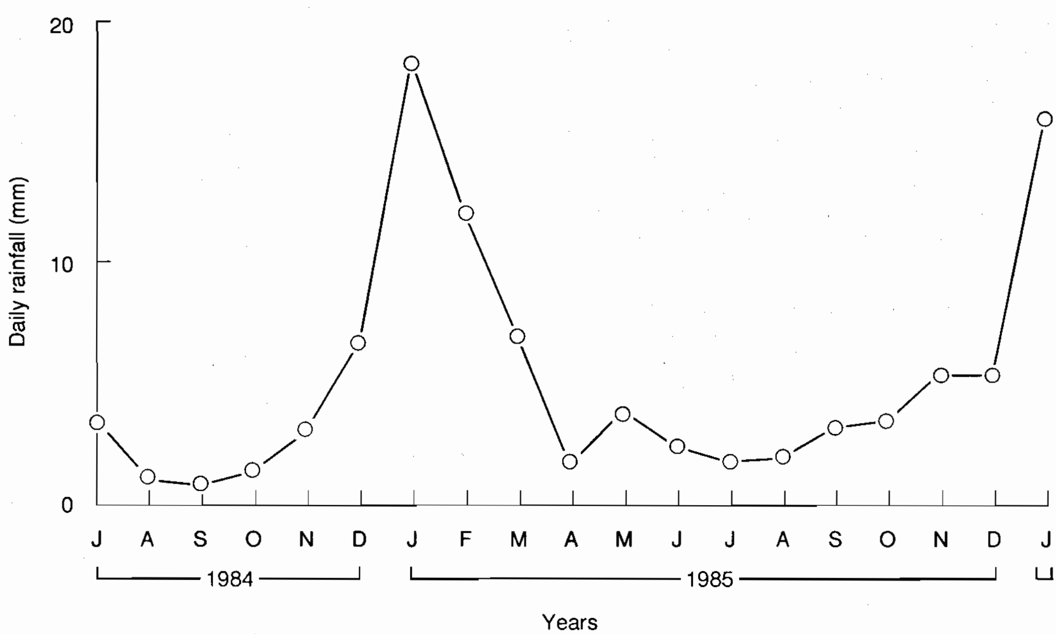

Figure 1. Average daily rainfall per month. Jakarta (Tanjung Priok Meteomaritim Station).

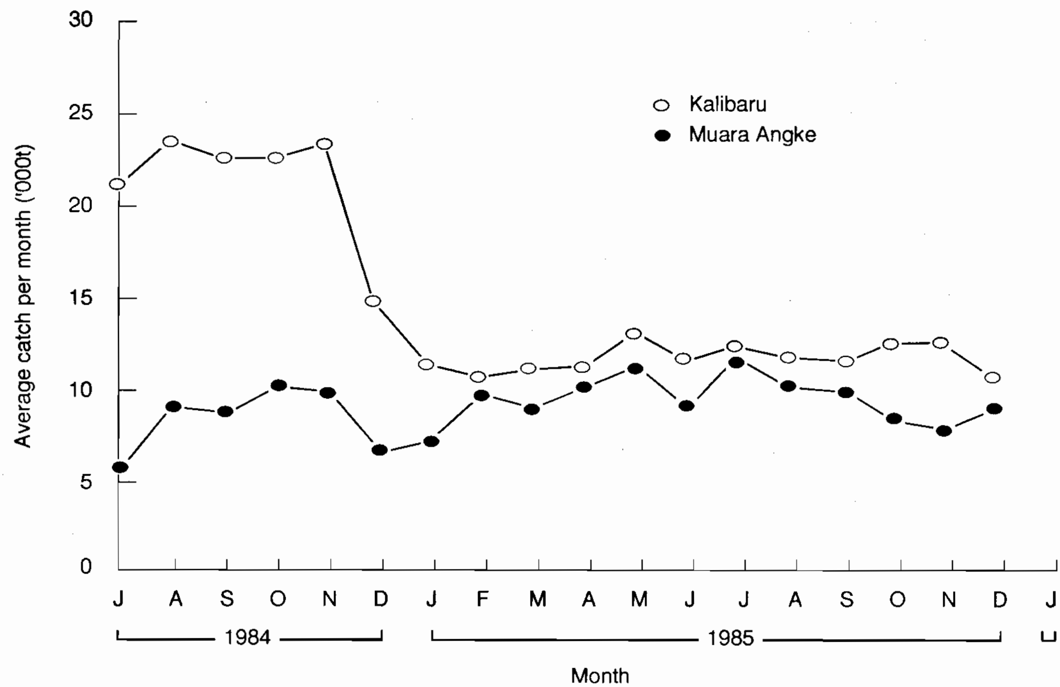

Figure 2. Average catch of marine fish landed per month at Jakarta ports.

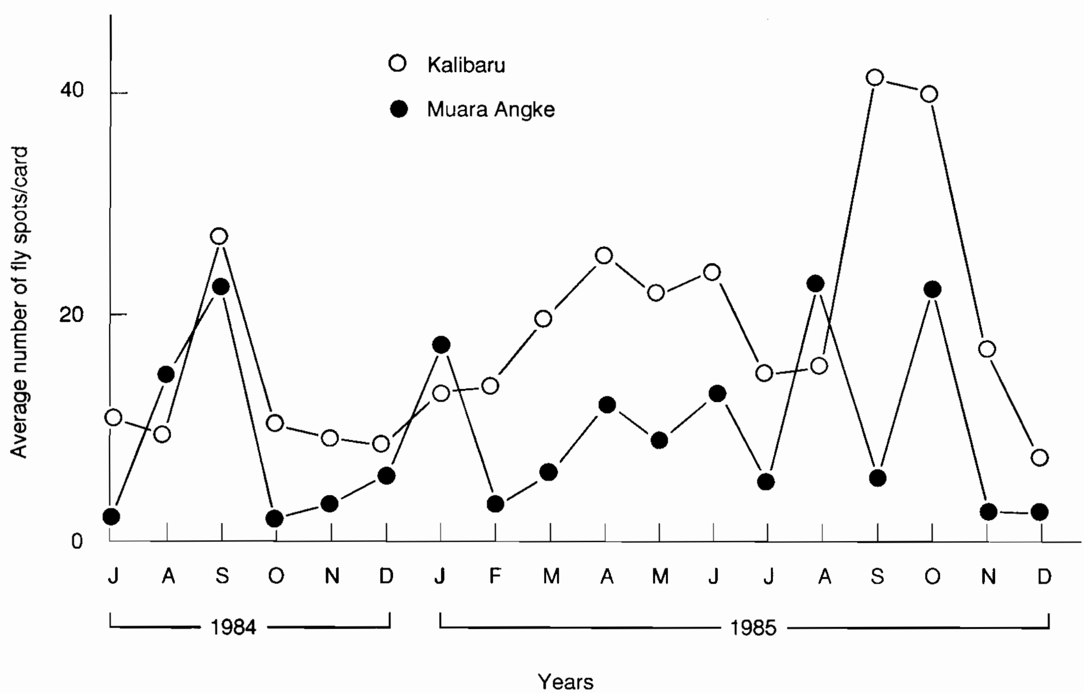

Figure 3. General activity of flies recorded at Kalibaru and Muara Angke fish landing sites.

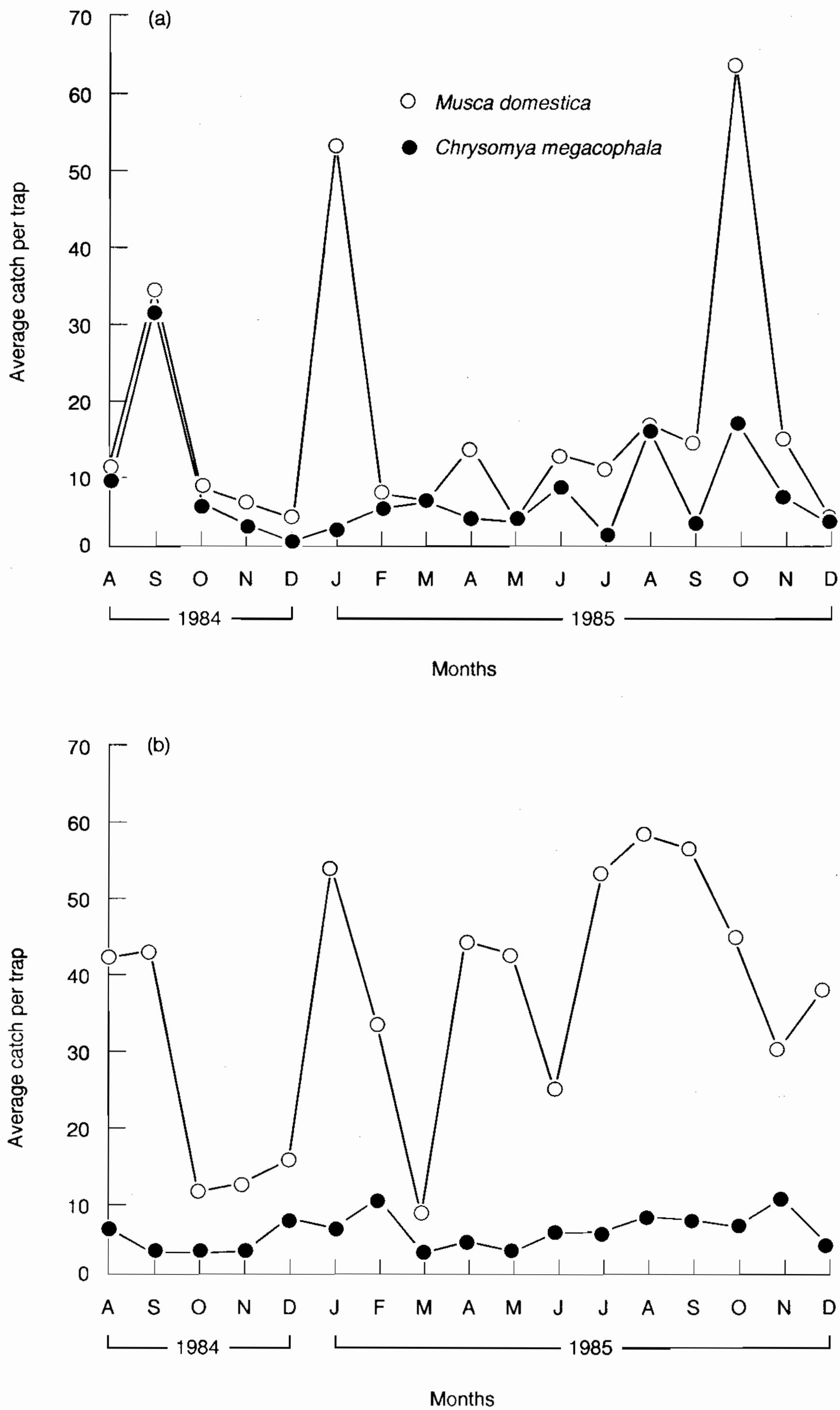

Figure 4. Relative abundance of *M. domestica* and *C. megacephala* at Muara Angke (a) and Kalibaru (b) fish landing sites, Jakarta, 1984–85.

Effect of screening on bacterial contamination of fish surfaces

Fresh fish were either salted in commercial brine, or blanched in boiling water for 4 seconds, and salted in sterile brine for 2 days, then dried at the same location on either open racks or within a screened cage fitted with an elevated floor. After 2 days drying, 4 patches of skin (1.5 × 1.5 cm) were removed along the lateral line of each fish, washed with sterile saline, and bacterial counts made. The results indicated that brining reduced initial counts, with blanching and sterile brine affecting a reduction 100-fold greater than that from commercially brined fish, 10^7 to 10^3 and 10^7 to 10^5, respectively. Drying further reduced loads 100-fold, with screening from flies effecting a further 20–40 fold decrease. Using selective media it was confirmed that enterics, moderate and extreme halophiles, yeasts, and moulds were transferred to fish by flies.

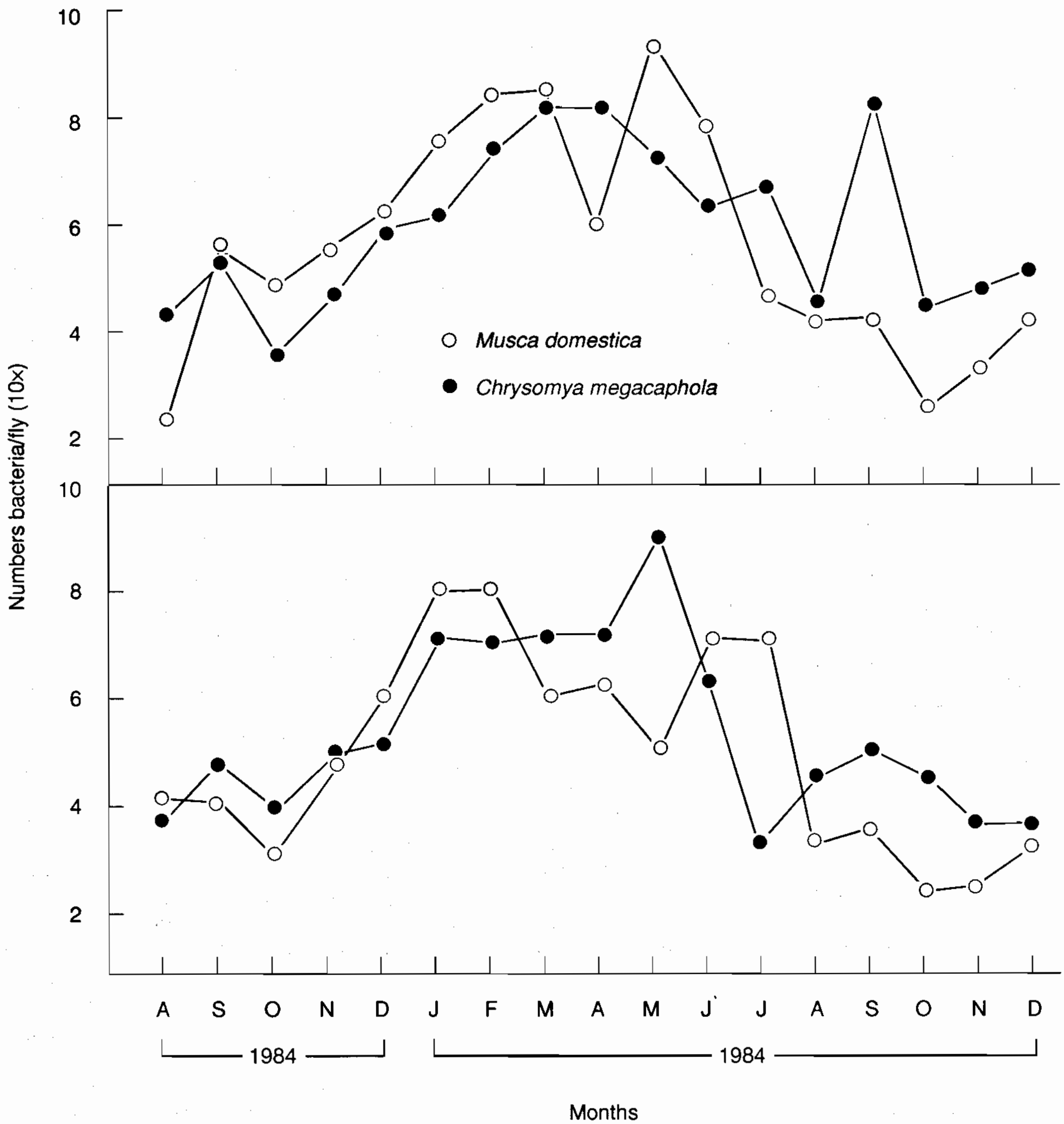

Figure 5. Seasonal trends in the bacterial loads carried by individual *M. domestica* and *C. megacephala* adults at Muara Angke (above) and Muara Angke (below) Jakarta 1984–1985.

Table 2. Composition (%) of microflora carried by flies at fish landing sites in Jakarta, Indonesia.

	Muara Angke		Kalibaru	
Microorganisms/types	*C. megacephala*	*M. domestica*	*C. megacephala*	*M. domestica*
Acinetobacter	10.0	4.3	26.7	9.1
Bacillus	25.0	8.7	–	9.1
Corynebacter	15.0	13.0	20.0	9.1
Enterobacteriaceae	10.0	26.1	33.3	36.3
Micrococcus	–	4.3	–	9.1
Moraxella–like	10.0	8.7	–	9.1
Staphylococcus	30.0	8.7	–	9.1
Vibrionaceae	–	26.1	20.0	9.1

Protection of fish with insecticides and plant extracts

The protective effects of commonly used insecticides and dusts, and a range of commercially available food spices and plant products, were compared.

- Cycloprothrin, a substituted pyrethroid of low mammalian toxicity, was compared with Minawet (pirimiphos-methyl), Decis (deltamethrin), and Startox (allethrin-dichlorvos) by dipping of pieces of catfish (*Arius* sp.) in solutions of each material at recommended dosages. Treated plus untreated control pieces on commercial drying racks in a 6 × 6 Latin square design were exposed to flies for four consecutive days in both the dry and wet seasons.

Some results of these tests have been reported elsewhere (Anggawati et al. 1991, 1992). In summary, Minawet, the only material registered for use on fish in Indonesia, did not prevent *C. megacephala* adults from landing and ovipositing, although no eggs hatched. Cycloprothrin- and Decis-treated fish received significantly fewer visits from flies, had less oviposition and, again, no egg hatch. Startox, which is commonly used by processors, had an effect similar to that of Cycloprothrin and Decis; i.e. the pyrethroid content significantly reduced fly landing rates and settling times. In the wet season, however, when drying was slower, Startox was ineffective, and Minawet- and Startox-treated fish became more attractive to flies than untreated controls. These results were further confirmed when the experiments were conducted in the laboratory using caged flies and standardised fish presentation within agar media confined in cups and covered with polyfoam pads treated with the test insecticides.

- Following the results of the previous study, Cycloprothrin and Decis were evaluated for preventing *D. carnivorus* and *D. maculatus* infestation of 700 g lots of dried anchovies (*Stolephorus* spp.) sealed in triple-walled paper bags (30 × 18 × 12 cm). A tapioca starch solution of each insecticide was prepared and painted over the outer surface of the bags to provide a residue of 0.05 and 0.5 g/cm^2 for Decis and Cycloprothrin, respectively. Painted bags were allowed to dry for 24 hours before placing them in containers with 10 pairs of adults and 75 fourth stage larvae. An equivalent number of unpainted packages was added to each species replicate. In addition, Dryacide®, a sorptive silica dust, was evaluated by dusting the inner surfaces of the three paper layers with 0.5 g/bag.

Dryacide® was ineffective in preventing the invasion of bags by dermestids and caused no significant mortality. Deltamethrin (Decis) inhibited penetration of the bags for 90 days and Cycloprothrin for 60 days (Table 3).

- Many processors use insecticides, e.g. Startox, Baygon, or Minawet, to suppress insect infestation in processing and storage. As indicated above, Startox and Minawet have been shown to be ineffective in preventing flies from alighting and ovipositing on fish products, whereas the pyrethroids, deltamethrin and cycloprothrin, do reduce oviposition and reinfestation. A study was initiated to assess whether aqueous (hot and cold) alcohol and hexane extracts of a range of spices, condiments, and citrus peels could repel insects when sprayed on fresh, acceptable fish. Twelve substances were evaluated at 15 minute intervals against untreated and pyrethroid sprayed controls in a 5 × 5 Latin square design in which the most repellent of three test substances was progressively compared or rejected through 20 runs each of one hour duration.

Following analysis, the test substances fell into four groups—repellency equivalent to pyrethroid control, intermediate, no different to untreated control, and promoting visits greater than to untreated controls. White pepper, garlic, and star fruit (*Averrhoa bilimbi*) belonged to the first, and tamarind and turmeric to the last groups. White pepper alcohol extracts were the most active, whereas aqueous extracts were effective for star fruit and garlic.

- Screening was shown to significantly reduce bacterial loads on the surface of exposed fish. To assess the effect of screening on invasion and damage of fish, two 500 g lots of anchovies were left for 72 hours in a Tawah Abang market retail store. In one box 50 g of fish was held on the screen floor of a four-sided 2 cm deep frame which closely fitted the box with the remaining fish. The results are shown in Table 4. On final inspection, fish in the unscreened container were dull and brittle and extensively damaged whereas fish below the screen remained bright and in good condition despite some invasion through human inquisitiveness. Furthermore, it was evident that confining access to the bulk of food by screening, limited larval invasion into the upper, more-illuminated layer (Table 4).
- Levels of insect infestation of dried salted fish at different times of the year can provide information on species and stage of insects involved and a measure of resident population parameters essential to the quantification of actual loss. This project aimed to develop a rapid method to determine the incidence of insects (and bacteria and fungi) relative to the number of fish items in commercial containers.

Permission was obtained from retailers/wholesalers to fully inspect individual containers of fish by removing individual layers and recording for each the number and identity of any insects and other contaminants. Fifty containers were examined over 12 months and, irrespective of the size of fish and the type of container, e.g. wood, cardboard, rattan, etc., infestation levels ranged from 5–30%. Examination of the data indicated that the correlation between the incidence of insects in the top four layers was positively and significantly correlated to the total incidence within the container; i.e. $Y = 2.52 + 1.10X$ ($r^2 = 0.94$) where Y = total incidence (per cent) and X = incidence (%) in the top four layers (Fig. 6). This relationship can then be partitioned with respect to individual insect species, e.g. *Piophila casei* ($r^2 = 0.78$) and *Dermestes carnivorus* ($r^2 = 0.82$), and for the mould *Polypaecilum pisce* ($r^2 = 0.62$). Knowledge of this relationship has provided an effective method for rapidly (5–10 minutes) determining differences in the risk of damaging populations within and between stores (Indriati et al. 1985, 1991).

Insect infestation and loss of fish in distribution and marketing

Assessments of insect, bacterial, and mould infestation were made at 24 locations in Jakarta, including processing sites, warehouses, and stores. Details of this project are reported in Indriati et al. (1991). Levels of infestation by different pests varied

Table 3. Dermestid invasion of 250 g lots of anchovies sealed in paper bags painted with either tapioca paste alone or paste plus insecticides.

		Numbers of bags invaded and total dermestids on anchovies					
		30 days		60 days		90 days	
Treatment	Rate g/m^2	Bags	Dermestids	Bags	Dermestids	Bags	Dermestids
Deltamethrin	0.05	0/4	0	0/4	0	0/4	0
Cycloprothrin	0.50	0/4	0	2/4	31	2/4	18
Control	–	4/4	91	4/4	17	4/4	181

Table 4. Effect of screened trays of anchovies (50 g) on the invasion of anchovies (450 g) contained in boxes and exposed for 72 hours at Tanah Abang November 1–3, 1991.

	Number of dermestids		Amounts of frass (g)	Fragments (g)
	Adults	Larvae		
Test				
screened tray	24	3	–	4.0
container	6	1	1.1	–
Control				
container	180	107	8.0	7.0

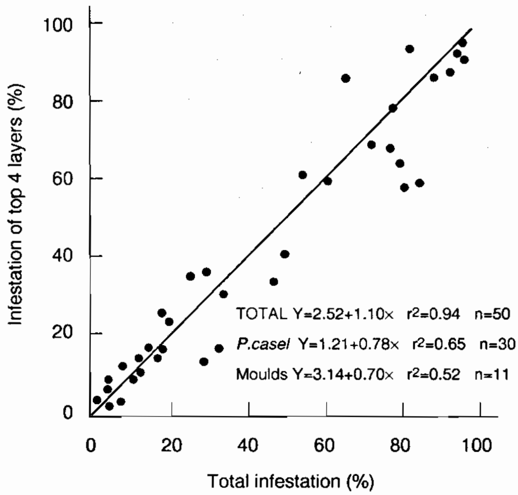

Figure 6. The relationship between the incidence of insects and moulds in the top four layers of dried salted fish and their incidence in the total package.

according to the stage the product had reached in the marketing chain. Thus, utilising the four-layer method described above, infestation levels of 30% were recorded during processing and transport, 5% at wholesalers, and 60 and 35 % at large and small retail outlets, respectively. These levels were closely related to time of storage at each step of the market chain. At least seven transfers were recorded for containers of fish from initial processing to ultimate sale as food, with individual retailers increasing turnover by reducing prices as quality declined. Dipping, spraying, or painting fish with both recommended and non-food grade insecticides was commonly adopted, particularly in the processing of large fish, with some processors adding insecticides to the brine used for salting. Alternatively, higher levels of salt were commonly employed in brines. Large wholesalers and retailers commonly use chill rooms (5–10°C) to hold fish. In addition, retailers may reprocess the product or sort containers before repackaging. Inadequate roofing and ventilation were major factors affecting the water activity of stored fish during the wet season, rendering them prone to fly infestation. Small retailers tended to be more concerned with their goods than large markets and cleaned their stores daily, but when located within large markets, reinvasion by insects resident in general wastes occurred. Attempts to suppress mites in anchovies packaged in plastic bags and subjected to high humidities during transport, involved winnowing and sun drying the product. Many personnel handling such products were affected by allergic reactions and skin sensitivities.

Conclusion

In order to overcome losses due to insects it is imperative that local authorities establish regular systems in the disposal of rubbish and wastes, the major breeding sites for flies, as part of general public health programs. This can be the only permanent solution and is preferably addressed at a national level.

There is a need for active extension advice on hygiene and related matters to be given to fish processors, wholesalers, and retailers to ensure that premises are kept free of wastes, in sound repair, and that coding or marking systems be implemented so that the source and date of shipment of containers received can be easily identified. This last point would provide a basis for sound warehouse and stock management.

The AARD–ACIAR program is the first broad investigation which has addressed the question of losses in quality and quantity of harvested marine fish in Indonesia. Much has been learnt but it is only a beginning and in order that extension advice be relevant and meaningful, research should be targetted and widely encouraged and supported.

Drawing from our experience, the overall objectives of any program can be achieved only if the following conditions are met:

- there is recognition and active support for the work within national priorities for human health and welfare
- project objectives are clearly identified and achievable
- key researchers have appropriate research expertise and experience
- all workers have a scheduled commitment of time to individual projects
- researchers are actively encouraged to establish links with persons with similar or specialist expertise in local and outside organisations
- researchers are encouraged to publish the findings of their research in international journals
- if practical, local research sites must be within a reasonable distance of office location to avoid excess time spent in travel.

For most people the choice of fish products is determined by price. The use of screening, etc., while minimising infestation, interrupts the movement of the product along the marketing chain. Small changes can have large effects. The challenge to researchers is to ensure that individual efforts are carried out within the larger socioeconomic context of providing food of increasingly better standard to the people at large. Sanitation, education, and extension are essential for the common good.

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