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Evaluation of the environmental impacts of a Cleaner Production Agreement by frozen fish facilities in the Biobío Region, Chile

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ABSTRACT

The six biggest frozen fish processing companies in Chile signed a Cleaner Production Agreement with the Regional Cleaner Production Secretary, supported by several public institutions related to health, labor risk, and environment. The overall objective of the Agreement was the incorporation of cleaner production measures for frozen fish installations in order to increase production efficiency, to reduce pollution at source, to improve the management of industrial liquid and solid waste, as well as to incorporate upgrading and recycling measures. The implementation phase took two years, in which three audits were carried out, whose results are analyzed in this work. The most important achievements of the implemented measures were the reduction of water consumption (28%), solid waste generation (40%) and energy consumption (24%). Especially important was the implementation of sound management systems that encouraged employee participation, which had a strong effect on diminishing the accident rates of all partner companies (18%) during the study period. Finally, after establishing the basis of quality standards in the processing facilities, it is suggested that the forthcoming renewal Agreements should include further improvements such as incorporating more steps of the products value chain, following a lifecycle approach (e.g. fishing, packaging, transport), into the sectorial evaluation.

1. Introduction

1.1. Historical development of the Chilean seafood industry

Since 1978, Chile has become home of one of the first major fishing industries worldwide due to the abundance of marine resources – especially pelagic fish such as mackerel – and the investments made by the private sector and promoted by the government. In the 1980's and early 1990's, fishmeal was the flagship product, not only by volume but by quality. The upper range of its protein content (67%) opened the doors of fish flour's most demanding markets of the day: the Federal Republic of Germany, Japan and South Africa. After the consolidation experienced in the early 80s, the fishing industry in the south central area experienced a period marked by sustained growth. However, from the second half of the 1990's, the industry was affected by a crisis caused by the reduced availability of mackerel and a lack of tools to control the species over the long term with adequate regulation of the fishing processes. The regulatory framework established with the enactment of the Fisheries Act of 1991 and based on the control effort was insufficient and needed to be adapted to the new reality.

In 1997 it became clear that there was an imbalance between fishing capacity and available resources in Chile, since in those years there was an oversized fleet; the industry faced closures and "El Niño" phenomenon for the first time. At that time, it was imperative to introduce a new way of managing resources; jobs were cut and catches dropped by half. Against this, the industry adopted a method of adding value to products, and the export of frozen goods became one of the best options. Nation-wide there are currently ca. 480 frozen fish processing plants, from which 13 plants manufacture frozen products in the Biobío region with Quality Assurance Programs for exporting these goods.

1.2. Analysis of the production processes of the frozen fish industry and identification of sectorial environmental aspects

Most companies in the Biobio region have frozen jack mackerel (*Trachurus murphyi*) as their main product. The production of

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frozen jack mackerel is intended for direct human consumption, sold in 20 kg-boxes mainly to international markets such as East Africa (Nigeria, Cameroon, Ivory Coast), as well as Peru, Cuba and Russia. Frozen jack mackerel processing consists of the following steps (Fig. 1):

1.2.1. Reception of raw materials

Raw materials are pumped from the storage tanks of refrigerated ships (where the fish is kept at 0 °C) into the plant storage rooms. Given the means of transportation, it is possible to use cold water contained in the ship, as well as sea water filtered, ozonated and cooled to 0 °C (prepared and stored in an isolated pond at the harbor's ground level) to store the fish. Fish can be continuously discharged using a recirculation loop to keep the water cool throughout the discharge process. Raw material can also be received in trays or bins with ice, maintaining a proper temperature to prevent quality degradation.

1.2.2. Screening

Inside the plant the catch is drained, and transported to the weighing zone for classification. Prior to classification, the fish are cleaned of any residue likely to hinder the flow (by-catch). After cleaning, the fish are deposited on a conveyor belt and separated by size. All the out-of-specification catch is left outside the process and used alternatively in the fishmeal or canned fish processing lines. Cleaned and proper-sized fish are received in transfer tanks and temporarily kept in water at 0 °C.

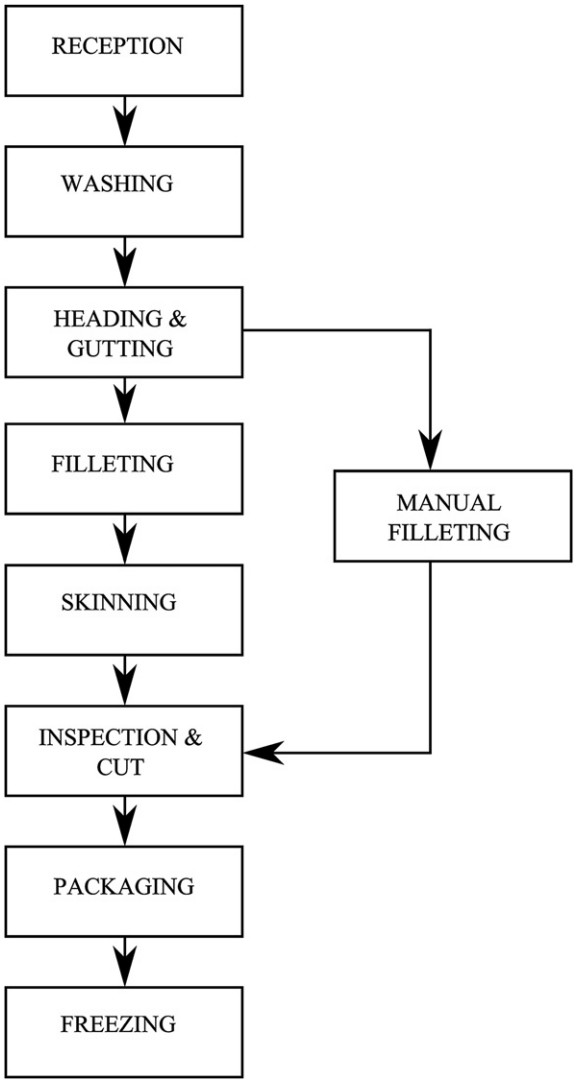

Fig. 1. Simplified flowsheet for the preparation of frozen fish in the studied facilities.

1.2.3. Processing

HG (without head and guts), HGT (without head, gut and tail) and WR (whole): From the transfer tanks, classified fish are carried via a semi-continuous conveyor system to cutting and/or packaging, according to the fish size and the processing requirements. In the packing room HG, HGT or WR fish are drained prior to weighing, where 20 kg batches are packed in sealed boxes according to the procedures of each company. Boxes are labeled and finally arranged in the freezing tunnels.

1.2.4. Tunnel freezing

Using crane forklifts, the packed fish are continuously stored inside the tunnels until the latter have reached their capacity. Once completed, the tunnel is closed and the freezing process is started, where air cooled to −40 °C is circulated, usually by a forced convection system. Freezing can take from 18 to 20 h, during which the product temperature must reach −18 °C at its thermal center. After this, the tunnels are unloaded and the boxes are stored on pallets in −25 °C storage rooms.

The various processing lines generate a series of solid wastes, which are divided mainly into two groups:

1) Waste generated mainly at the stage of cutting and gutting, consisting of heads, tails and entrails of processed fish. Disposal of these wastes in landfills is minimal, as they are reused as raw materials by fishmeal producers;
2) Waste composed of plastic or paper bags, cardboard boxes containing pigments, pigment powder residues, packaging bags, used filters, hardened concentrated sludges, and in some cases sludges from the wastewater treatment plants and sludges from solvent distillation plants. This type of waste is accumulated in containers to be sent ultimately to the authorized sanitary landfill.

For decades, wastewaters were the main environmental problem of the fishing industry, because of the high composition of organic matter, protein, fats and suspended solids they contained (IPPC, 2006).

ASIPES (which in Spanish stands for Association of Industrial Fisheries) has worked for over a decade to produce with cleaner processes, thus reducing pollution levels and increasing the efficiency of natural resource use. In the late nineties, ASIPES partner companies began to spend time and significant amounts of money to reduce the generation of wastewater and to optimize the treatment of it.

1.3. Cleaner production in Chile

In 1997, Chile started the development of its national cleaner production strategy, first under the responsibility of the Ministry of Economy and later, since 2001, led by the National Council on Cleaner Production (CPL). In 2001, the CPL established the Cleaner Production Policy 2001–2005 (CPL, 2001), and continues nowadays with a second strategy, 2006–2010 (CPL, 2006), whose main objective is to systematically and effectively implement cleaner production practices in conjunction with public and private stakeholders at the national level in order to achieve greater sustainability, modernization of production, and competitiveness of enterprises (CPL, 2006; CPL, 2008). In this line, a major impact