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Joint UNIDO/FAO Expert Group Meeting on the
Production of Fish Protein Concentrate

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TECHNICAL DESCRIPTION OF OPERATIONAL FISH PROTEIN CONCENTRATE PLANT[1]

by

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[1] The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

The potential volume production capabilities of a single solvent process has been presented by others at the meeting. As you are all aware, the other process approved by the U. S. Food and Drug Administration uses two, solvents. My experience has been with the two operational FPC plants in the U. S. today which use the VioBin process. The plants are: 1) Alpine Marine Protein Industries Inc., New Bedford, Massachusetts (for which I was formerly the president and major stockholder). That plant is capable of processing in excess of 100 tons per day of whole wet fish; 2) the Cape Flattery Company, Neah Bay, Washington. This plant is capable of processing 200 tons per day of whole wet fish. This plant is mounted on a converted 198 foot landing craft "barge."

The New Bedford plant is currently producing FPC for an AID contract. The Cape Flattery plant is committed to a long term contract to produce an animal food supplement of high biological value. Both of these plants use the VioBin process deweloped by Ezra Levin of Illinois.

The only limitation imposed at these two plants is the supply of fish (hake) for producing FPC. On November 25, 1969 supplementary data to petition 121.1202 approved February 2, 1967 was submitted to the U. S. Food and Drug Administration.

This petition contained the basic data supporting the request to approve menhaden, herring, anchovy and thread herring as fish used for the production of FPC. The VioBin Process has not encountered any difficulty processing oily fish.

The basic process combines solvent extraction and azeotropic distillation for the effective separation of water and oil from proteinaceous fish tissues. The solvent is ethylene dichloride (EDC). The extraction occurs at a temperature of 159F and thus does not destroy the high quality amino acids of animal protein. Product yield is much higher than conventional methods of fish reduction because there is no loss of water-soluble proteins. The biological value is higher when the broadly catagorized "unidentified growth factors are retained. As an example, a recent evaluation was run using a single solvent process requiring 5 extraction stages, and the VioBin process using ethylene dichloride (EDC) in the first stage and 3 extractions using 91% isopropyl alcohol. The increased loss in the single solvent process occurs primarily because of the solubility of certain proteins in the dilute alcohol extracts in stage 1 and 2 of that process.

With an FPC plant of 200 tons per day input (in this instance, herring) the daily yield difference is 3.56 tons per day of FPC. At 30¢ per pound on a 200 day operational year, this difference amounts to $427,200 in that year! The extractor is the primary vessel in the system and maintains the proper temperature for separating liquids from most proteins. Water removed from fish tissue forms a heterogenous azeotrope with the solvent. This in effect separates water from fish oil so effectively that no water-oil emulsion is formed. (Preliminary work on the problem of removing oil from fish processed by the alcohol method has been done. At present it is reported that the removal of fish oil from a water-alcohol-fish oil emulsion is a costly process.) The remaining liquid is called Miscella and contains a solvent-oil solution.

This solvent is reccvered and oil separated by evaporation, filtering, and finally steam stripping. Losses are indicated at less than one percent of solvent in process. The residue oil may be of tremendous value if considered for use in the ethical drug industry.

As water and oil are continuously removed in the extractor, the density of EDC is reduced. Proteinaceous fish solids drop to the bottom as the specific gravity increases and are then conveyed to an agitated washer for a similar operation with fresh solvent. After this washing process, the wet meal is conveyed to rotary steam jacketed vacuum dryers. This process removes residual EDC solvent by several applications of purge steam and evaporation. The FPC is then either milled, screened and stored, or conveyed to the 2nd stage process, an isopropyl alcohol extraction unit, for further deodorizing to meet the U. S. Food and Drug specifications.

Solvent vapors (EDC or alcohol and steam) from the dryers, evaporaters and extractors are condensed on their way to the decanter, which discharges the water and recycles the solvent for further use. Vented vapors from the vacuum pump and from various process vessels are sent to a solvent recovery system for further recovery of small amounts of solvent that would otherwise be lost.

The second stage process is very similar to the process described by others and that which is in use at the plant in Agadir. The alcohol extracting unit installed at the New Bedford plant operates essentially by contacting the output FPC from the first stage with IPA-water solvent to extract flavor and aroma producing materials. The FPC flows from chamber to chamber countercurrent to the flow of solvent.

Desolventizing is conducted in much the same manner as in the first stage. Several desolventizors are used to conduct the drying operation. While one unit is on the line the others are inoperative but accumulating the continuous flow of drained FPC.

As in the first stage process, the alcohol and some EDC is recovered through the specially designed solvent recovery system.

The VioBin process, particularly the continuous separation of fat from wet tissue and the apparatus utilizing such continuous process is based on the following premise:

> Many substances, particularly of animal origin, contain relatively high proportions of water which are present either in the form of intracellular fluid, or are present in the cell tissue as intercellular fluid. The presence of a moisture content in tissue in excess of 20 percent greatly impairs, or prevents use of a conventional solvent extraction process for the removal of fat from the tissue.
>
> An azeotrope has the property of boiling at a lower temperature than the boiling point of either of the liquids which form the zeotrope.
>
> The body of solvent must form an azeotrope with water preferably at atmospheric pressure. The solvent should be selected to form an azeotrope, which will remove substantial portions of water in relation to the amount of solvent distilled at the operating temperature selected. Among the solvents of this class, we prefer ethylene dichloride. Ethylene dichloride (EDC) has a boiling point at atmospheric pressure of 83.5 C. A water-ethylene dichloride azeotrope boils at 70.5 C.

> The solvent must not be reactive with the tissue constituents under operating conditions, and must be capable of being removed by evaporation from the fat without leaving harmful or toxic residues.

It is noted that the sale of FPC in the U.S. and to markets funded by the U. S. Agency for International Development requires a manufacturing process approved by the previously mentioned Food and Drug Administration. Review of the overall FPC manufacturing experience available today indicates that the VioBin process is the one best suited for large scale production.

Since 1958 the VioBin Process has been in a continuous program of development. Only since mid 1967 have we moved from the laboratory to the economical large-scale production plant.

The production plants were based on a large enough processing capability to make the individual processes economical. By optimizing each process and fully utilizing the whole wet fish, the various solvents and the utilities, we now have operating proof that fish protein concentrate may be economically produced on a large scale.

Considerable effort has been expended by Marine Protein Inc. toward establishing design criteria for a 200 ton per day input shore-based plant and 200 ton per day incremental shipboard based plants. I must emphasize here that the design of these plants are based on a dual solvent process, but could very well have been designed for a single solvent process if that process were well enough established.

The benefits of a shipboard plant are numerous. The most significant are the increased days of production per year, and the reduced cost of landing fish at sea versus a stationary shore based plant.

However, before comparing the relative merits of shipboard versus shore based plants a feasibility study would be recommended. Such a study would consider all factors such as site location, fish harvesting, product utilization, labor supply, transportation, and so forth.

The specific business of MPI is to perform such studies and to do the necessary engineering commensurate with the dictates of the study.

A sample of a statement of work for such a study is available.


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