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Fish By-Catch... 
Bonus from the Sea 

Report of a Technical Consultation 
on Shrimp By-Catch Utilization held in 
Georgetown, Guyana, 27–30 October 1981 

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Fish Silage from By-Catch

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Small fish in the by-catch and by-products from industrial processing of fish (heading, gutting, and mechanical deboning) have been used in the production of fish silage — by the addition of 2.5% (by volume) of formic acid at ITESM. The product has been tested in diets of pigs in nearby swine-raising farms. Experimental biologic tests have shown that pigs receiving the diets have higher growth rates and better feed conversion efficiencies than do pigs fed fish meal. Results were especially encouraging for a dry mixture of silage and cereal, which was fed to suckling pigs.

The great diversity of species and available volumes of by-catch make it an attractive source for the production of acid-hydrolyzed products (fish silage). The process is not new. It was developed in the Scandinavian countries during the 1920s. Poland and Denmark produce fish silage on an industrial scale for livestock feeds. In recent years, the production of fish silage using by-products from the processing of tuna (Jones 1976, unpublished data) and white fish (Tatterson and Windsor 1974) has attracted much attention.

In the manufacture of fish silage, the raw material is ground so that the proteolytic enzymes in the intestinal tract and skin are spread throughout. Adding acid lowers the pH of the mixture, promotes enzymatic breakdown of protein, and prevents bacterial decay. This process has been used at ITESM to convert shrimp by-catch to silage, and the product has been tested in diets of pigs. By-catch unloaded at Guaymas Harbour was used. In most instances, the raw material had been stored on the vessels' decks in plastic ice-filled boxes, or in refrigerated holds, for 6–12 hours.

The preparation of silage from finfish was straightforward (addition of 98.5% formic acid at 2.5% by volume). At 2% formic acid, the samples decayed within the first 98 hours after processing. However, fish silage could be prepared with concentrations of formic acid as low as 1.5% if enough hydrochloric acid were added to lower initial pH to 3. It was not possible to produce fish silage from either the by-catch crustaceans or the elasmobranchs alone; however, mixtures of these with finfish kept well. In addition, fish wastes from heading, gutting, and deboning were suitable for inclusion in silage. In general, when enough acid is added in the preparation of fish silage, stored mixtures are quite stable (Crean et al. 1979).

An LFP 300 semi-industrial plant (BP Nutrition Ltd) was evaluated for the production of fish silage from the by-catch and wastes from heading, gutting, and cleaning. The material was processed in a 1-t container, a pump grinding and recirculating the mixture; 85% formic acid was automatically added to the mince until it constituted 3.0% of the mixture. The product was stored in plastic containers. This system worked well.

Differences in hydrolysis time and final consistency of the silage depend on temperature. In the LFP 300 plant, a perfectly liquid silage can be produced in 3–4 hours during the summer months when temperatures reach 30–40°C, whereas, during winter months, when temperatures drop to 16–20°C, hydrolysis takes up to 24 hours and silage is thicker.

The liquid silage was tested for chemical composition, storability, and efficiency as feed. It was also dried and mixed with cereals for tests with suckling pigs. The second product has some advantages as all dried feeds: it is a more complete food, transportation costs are reduced, and handling on the farm is simplified.

The drying of mixtures of fish silage with cereals such as sorghum and corn in ratios as high as 1:1 (original weight) proved to be successful. The liquid silage was mixed with
cereal, spread into thin layers on concrete trays, and sun dried to about 10% moisture. Drying ranged from 4 to 8 days, depending on the season.

Protein and fat content in the silage was 17.3–24.5% and 1.4–4.1%, respectively. After 7 months’ storage, only minor changes could be detected in the chemical composition, and the essential amino acids were well represented.

**Biologic Tests**

A series of tests were undertaken to determine the value of fish silage as a protein supplement in swine feed, in both prestarter and fattening stages.

In the first test, conducted in Guaymas, finishing swine were used. Fish silage used in this test was manufactured only from by-catch finfish; 85% formic acid was added to make up 3.0% of the volume of mince. The mixture was stirred regularly by hand for the first 24 hours. After 4 days’ storage, during which it was stirred occasionally, the silage was poured into plastic containers and transported to the site of the experiment. Tests for growth rate were based on diets that incorporated fish silage as 5%, 10%, and 15% of weight. Fish meal was added to the control diet to ensure an equivalent level of fish protein. Sorghum, soybean meal, wheat germ, phosphoric rock, calcium orthophosphate, and salt were added. A commercial vitamin-mineral premix was also added. In this experiment, 40 swine, averaging about 20 kg each, were used. Animals were divided by sex and weight into eight groups, fed once a day, and weighed once a week. The test went on until every animal reached 90 kg (slaughter weight).

In this test, the inclusion of fish silage in the diets of the pigs clearly affected growth rates. Rates of live-weight gain were higher among all swine receiving the three diets to which fish silage had been added (P <0.05) than among those fed the control diet. The feed-conversion efficiency increased with amount of fish silage added (Table 1). However, the differences in weight gain at the three levels of silage were not significant, nor was sex a determining factor. Odour and taste of the meat from these animals were not altered by the addition of fish silage, as shown by sensory tests.

In a subsequent test, dehydrated samples of a silage–sorghum mixture were used as a source of protein to supplement prestarter diets for suckling pigs. (Drying the product increases protein concentration and is essential for pigs at this stage.) The silage was prepared in the LFP 300 plant. It was poured on concrete trays, mixed with ground sorghum (1:1) to form a thin layer, and sun dried for a few days.

Two diets were used: the control diet, identical to that used on swine-raising farms in this region (basically sorghum, soybean meal, calcium, phosphorus, and a commercial vitamin–mineral premix) and an experimental diet in which 67% of total protein was supplied by a sorghum–silage mixture. The remainder was soybean meal, calcium, phosphorus, and the vitamin–mineral premix. Both diets contained 22.0% protein and had equivalent usable energy, lysine, methionine, calcium, phosphorus, and salt. A total of 40 Hampshire pigs were used (20 boars and 20 sows), each having an average initial weight of 4.75 kg. Animals were divided by sex and weight into four groups; water and food were supplied ad libitum. Animals were weighed once a week and amount of feed consumed was recorded. The experiment lasted 6 weeks.

No significant differences were found in live-weight gain from the two diets. However, sharp differences were found in amount of

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Silage (% of diet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Average initial group weight (kg)</td>
<td>21.2</td>
</tr>
<tr>
<td>Average final group weight (kg)</td>
<td>94.3 ± 7.6</td>
</tr>
<tr>
<td>Daily weight gain (g)</td>
<td>519 ± 54</td>
</tr>
<tr>
<td>Food consumption (kg, dry weight)</td>
<td>296.2</td>
</tr>
<tr>
<td>Feed-conversion efficiency (kg live-weight gain/kg food)</td>
<td>0.245</td>
</tr>
</tbody>
</table>
food consumed and, thus, in conversion efficiency, which was significantly higher in boars receiving the experimental diet (Table 2).

The sows receiving a diet to which fish silage had been added showed the highest live-weight gain of the four groups. Live-weight gain of boars receiving the experimental diet was the lowest of the four groups. The low growth rate of boars may have been caused by age differences, as this was the youngest group. They were probably too young to use feed efficiently. Also, there are always some pig litters that show a lag in growth.

Silage produced from the finfish portion of by-catch is an effective supplement to animal feeds. Although it is not possible to manufacture fish silage solely from the crustacean or elasmobranch portion of the catch, satisfactory results can be obtained when these groups are mixed in proportions less than 50% with finfish. Also good-quality silage can be prepared from by-products from the manufacture of fish products for human consumption (i.e., fish heads, viscera, and bones).

Dried with cereals, the silage can increase the protein content (per unit of weight) of animal feed, and the resulting mixture is suitable for use in the diets of suckling pigs. In tests at Guaymas, growth rates were equal to, or higher than, those usually obtained with diets common in the region.

Table 2. Growth, food consumption, and feed-conversion efficiency of suckling pigs fed silage supplements.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control</th>
<th>Experimental</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Average initial group weight (kg)</td>
<td>5.1 ± 0.91</td>
<td>4.15 ± 0.47</td>
</tr>
<tr>
<td>Average final group weight (kg)</td>
<td>12.75 ± 3.88</td>
<td>11.60 ± 1.79</td>
</tr>
<tr>
<td>Daily weight gain (g)</td>
<td>184.5 ± 86.9</td>
<td>172.6 ± 30.4</td>
</tr>
<tr>
<td>Food consumption (kg, dry weight)*</td>
<td>403</td>
<td></td>
</tr>
<tr>
<td>Feed-conversion efficiency</td>
<td>0.377</td>
<td></td>
</tr>
<tr>
<td>(kg live-weight gain/kg food)*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Data recorded without regard to sex.