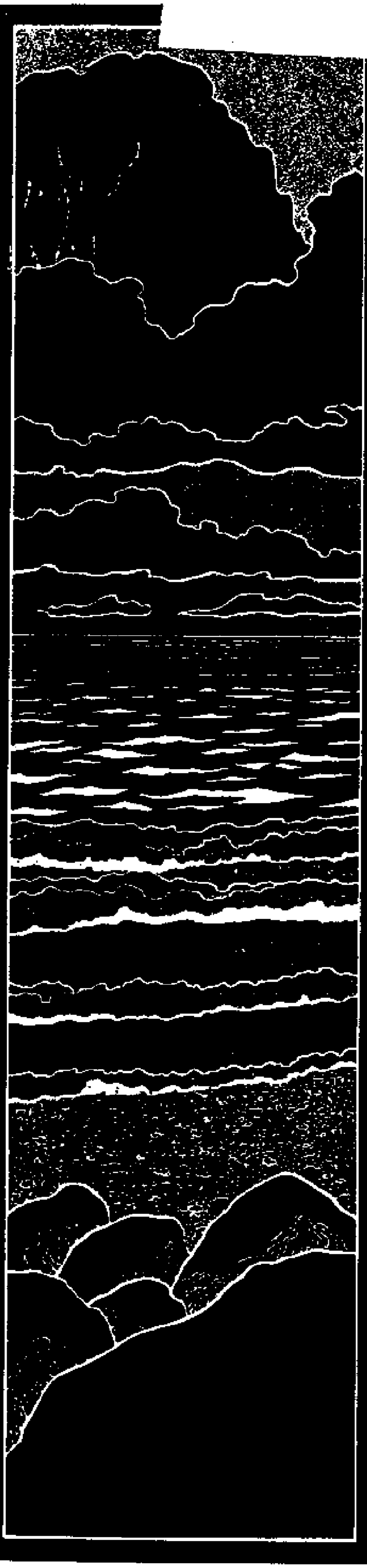

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Handling Fishery Wastes and By-Products

David A. Stuiber, Robert C. Lindsay and Richard Vilstrup

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HANDLING FISHERY WASTES AND BY-PRODUCTS

Fish Liquification:

An Alternative to the Present Waste Handling Practices

of the Great Lakes Fishing Industry

Departments of Food Science

and Meat & Animal Science

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PREFACE

This publication is a product of the cooperative effort of the Wisconsin fishing industry, state and federal agencies, and University of Wisconsin research and Extension personnel, working together in an attempt to find a solution to one of the many problems facing the Great Lakes commercial fishing industry.

The efforts of this group focused on the task of developing economic, marketing and technical information on simple fish liquifaction systems. Field interviews, laboratory investigations, and field pilot liquifaction operation have firmly established the necessity of refining the liquifaction process for the use in a wide variety of individual situations encountered in Great Lakes fish processing facilities.

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Fish Liquifaction:

An Alternative to the Present Waste Handling Practices

of the Great Lakes Fishing Industry

Introduction

In the past, the problems of fish waste disposal were of a minor nature. The waste material was dumped into sanitary landfills, picked up by rendering plants, ground and introduced into the sanitary sewage system of dumped back into the lakes. With the advent of regulation changes promulgated by the Environmental Protection Agency (EPA), Wisconsin Department of Natural Resources (DNR) and county and municipal governments restricting some of the former practices, the disposal of fish processing wastes is no longer a minor issue for some of the fish processors, but has become a serious problem.

In 1975, fishermen and fish processors were interviewed as part of an Upper Great Lakes Regional Commission study to determine the magnitude of the present fish waste disposal problem and assess disposal practices now in use.

As a means of estimating the quantities of waste material which have to be dealt with by any given processor, information gathered from individual firms and commercial fish statistics was analyzed. Using this information as a base, it was estimated that the total waste produced in Wisconsin ranged from 2 to 3 million pounds annually. Because of the scattered nature of the industry, no more than several hundred thousand pounds were produced in any one particular location. However, with the increasing emphasis and promotion of the use of underutilized species such as suckers, burbot, alewives and carp, this situation may change and a trend developed toward an increase in waste production.

As a result of the evaluation of information available, the following alternatives were identified as possible methods which would provide a means of handling fish wastes and meet the present regulations:

1. Forming waste into frozen blocks for sale as raw material for canned and fresh animal feeding;
2. Increase the sale of this material for rendering or other by-product use;
3. Use basic raw material for fish meal;
4. Convert the fish processing wastes into liquid fish fertilizer.

Of the above-mentioned alternatives, the conversion of the wastes into fish fertilizer seems to hold the greatest promise.

The production of a liquid fish product is not a new idea. Work in this area had been carried out in Finland in the 1920's with the emphasis on the use of the resultant product as an animal feed ingredient. The Finnish product was called fish silage. However, since that time, other products of a similar nature have been developed such as liquid fish, fish hydrolysate and others.

Regardless of the intended use of any of the mentioned products, the process involved in producing them is similar, and makes use of an enzymatic reduction of the fish flesh with the concurrent release of water until the material becomes fluid. This is achieved by the addition of a sufficient amount of acid which enhances the hydrolytic action of the native enzymes present in the flesh and gut of the fish. In addition to enhancing enzymatic activity, the low pH achieved through the addition of acid dissolves bones and reduces the possibility of degradative bacterial growth and consequently putrefaction and putrefactive odors.

The odor factor is of importance both from the standpoint of odor produced during production and odor of the finished marketable product. Odors associated with the process of fish liquification are dependent upon the nature of the starting material. If the starting material is reasonably fresh, there may be a noticeable, fishy odor during the initial stages of the digestion process. As the process continues, a malty plus fish-oil odor combination is observed. This odor combination will continue to persist for at least six months. If the starting material has already begun to break down and putrid odors are apparent, these odors will remain throughout the life of the product unless successfully masked by an odorous perfume-like compound.

Methods and Materials

The fish liquification process can be described as a combination of specific steps which include:

1. Grinding (mechanical reduction)
2. Acid addition (lowering pH)
3. Digestion (accomplished with agitation and heat);
4. Screening (removal of undigested bone particles);
5. Standardization (maintaining a consistant, guaranteed analysis);
6. Storage (either large bulk storage or warehousing of bottled product).

Grinding:

The grinding of waste material is a necessary step in the process. This step mechanically reduces the particle size of fish wastes such as bony frames, scrap fish, offal and fish trimming to a semisolid mass which can be mixed and blended. The smaller the particle size, the more rapid and efficient the digestion process.

Grinding was accomplished during this study using a Hobart food chopper, Style 201, equipped with a 3/4 horsepower motor and a Number 12 size head. The grinding head was fitted with a grinder plate having 1/4 inch holes.

It is recommended that a grinder plate having holes less than 1/4 inch not be used. Because of the nature of the waste material being ground, bone chips, scales and fish skin particles have a tendency to plug up grinder plates with smaller holes. This resulted in down time for grinder disassembly, cleaning and reassembly. By using a plate with 1/4 inch holes a good portion of these problems were overcome.

It was also observed that skins from large fish such as lake trout and salmon were difficult to grind. This problem can be partially overcome by partial freezing before grinding. If frozen fish waste is to be used, the material should be partially thawed before grinding. Complete thawing will result in water loss which will have to be replaced to produce a reasonable semifluid mass which can be stirred and handled in the equipment. It is recommended that fish or fish scraps be used as soon as they become available rather than freezing them for use at a later time.

Acid Addition:

The semisolid mass resulting from the fish waste grinding step is acidified at a rate of 6.96 pounds of 85% phosphoric acid or 7.96 pounds of 75% phosphoric acid per 100 pounds of fish waste. The added acid is thoroughly mixed either by stirring with a mechanical agitating device or hand mixing with a paddle. If a particularly solid batch of flesh is obtained, the material is difficult to pump initially. A more fluid system will result if a few gallons of a previous batch of liquid fish are added and mixed thoroughly.

Acid addition accomplishes the following objectives:

a) the pH is lowered to a sufficient level which hinders most microbial growth;

b) the lower pH enhances enzymatic digestion of the ground fish mass;

c) dissolves calcium from bones and disintegrates bone particles;

d) increases the phosphorus level of the resulting finished product.

Adding the amount of acid indicated will provide a 4% phosphorus level in the finished product, and a required pH of less than 4.0.

Digestion:

The digestion of the mixed, acidified semifluid mass is accomplished enzymatically. The natural enzymes present in the flesh and gut of the macerated fish waste serves as the enzymes source.

Raising the temperature and maintaining it at 140°F while continuously agitating the mass by means of a recycling pump produces a finished digested product during a 12-hour processing period. Cartilage, scales and most small softer bones will also be dissolved during this period.

The digestion rate is very dependent upon two important factors: temperature and agitation. In the laboratory studies, small batches of liquified fish could be produced in a matter of 4 to 6 hours using high speed blenders and a temperature of 140°F. Reduction of either temperature or agitation resulted in a lengthening of the digestion period.

Screening:

The liquid obtained from the digestion processing step is screened to remove the larger undigested bone particles. Screening is accomplished by passing the digest through a 18 x 14 mesh screen. It was found that some large bone fragments had a tendency to persist in the digest after the recommended 12-hour digestion period when scrap from large boned fish such as sucker, salmon, lake trout or carp were used as starting raw material. If the active digestion time were increased beyond the recommended 12-hour period, the large bone fragments would eventually dissolve and not present a problem. However, this process was designed to accommodate wastes generated daily during normal fish handling and filleting. Such operations require that rapid waste disposal techniques be employed (waste handled with 24 hours) to prevent accumulations of several days processing wastes which can quickly spoil causing foul odors as well as fly and health problems.

If space is available for installation of several holding tanks, the fish digest can be pumped into storage and held for two to three weeks where digestion will continue and the large bone fragments digest. If this is possible, the screening procedure can be eliminated.

Standardization:

By law, a fertilizer product must carry a minimum quality guarantee for nitrogen (N), phosphorus (P) and potassium (K) on the product label. The N, P and K values present on the label represent percent total nitrogen, available phosphorus measured as percent phosphorus pentoxide (P_2O_5), and soluble potash measured as percent potassium oxide (K_2O). This type information enables a consumer to select a product which will provide the nutrient requirements for his or her plants.

To ensure that indicated labeled amounts of the plant nutrients N, P and K are present in the product despite source and variability of the starting material, a liquid fish fertilizer producer can supplement the mixture with nitrogen, phosphorus and potassium containing chemical compounds. By using specific chemical compound additions a producer can obtain any specified N, P, K grade desired for the product. A listing of some of the chemical compounds which are sources of N, P and K and have been used in fertilizer applications is given in Table 1. It is possible to calculate and add appropriate amounts of the N, P, K yielding compounds presented in Table 1 and produce a fertilizer product of any given grade.

Odor Masking:

In addition to supplementing the liquid fish product with N, P and K containing chemical compounds an odor masking compound and citronella oil are also added. When fish of high lipid content are used as the source of basic raw material in the digest, a characteristic fishy odor is associated with the product.

Table 1. Partial Listing of Chemicals Commonly Used as Fertilizer Supplements

Essential Nutrient	Chemicals
Nitrogen	ammonium nitrate, anhydrous ammonia, organic materials, ammonium sulfate, sodium nitrate, ammonium nitrate-limestone, urea, calcium nitrate, calcium cyanimide
Phosphorus	ordinary superphosphate, triple superphosphate, ammonium phosphates, phosphoric acid
Potash	mine run (muriate) salts, muriate of potash, sulfate of potash, sulfate of potash magnesia, potassium nitrate, potassium hydroxide, potassium carbonate and bicarbonate, potassium metaphosphate

To overcome this fishy odor problem, a fish deodorant was used. The fish deodorant used in this study was "fish odor mask #402067-00," available from Crompton and Knowles Corporation, Flavor and Fragrance Division, 17-01 Nevins Road, Fairlawn, New Jersey 07410. The deodorant was added at the rate of 0.05% w/w with good success.

Citronella oil addition is optimal. Citronella oil was used because it is believed to deter dogs and cats when the fish fertilizer is used in gardens and around yard plants. It also has a rather pleasant citrus-like odor. This material is also available from Crompton and Knowles Corporation and is used at a 0.15% w/w level.

Storage:

The screened liquid fish digest can either be bottled immediately or pumped into bulk storage and held for future treatment or bottling and labeling. The digest is relatively stable at this point. However, further desirable digestion will occur during storage although at a much slower rate due to variation in temperature.

If the liquid fish digest is to be marketed as a fertilizer having a specified N, P, and K value different from that of the starting raw material, it may be advantageous to have bulk storage capacity to hold material for a length of time. In addition to producing a more fluid uniform digest, the standardization and odor mask additions could be postponed until a large quantity of the digest were available thus giving the producer more control over the standardization procedure. The more fluid product produced under these circumstances would also facilitate bottling and handling. It should be emphasized that the liquid fish digest is corrosive, and the storage vessel selected should be capable of withstanding attack from the highly acidic mixture.

Bottling:

The bottling and labeling of the product can be accomplished mechanically or done by hand. Equipment is available for these purposes. The containers used in this study for bottling the fertilizer were gallon, quart and pint polyethylene screw top bottles. These containers proved satisfactory for this purpose.

The use of glass containers is not recommended for this product. During the initial experimentation period of the study, one batch of liquid fish was produced with an insufficient amount of acid. After being placed in bottles, a fermentation took place which produced large quantities of gas. As a result, the plastic bottles swelled and stretched until pinhole leaks developed releasing the pressure. If a similar situation were to arise and the product were packaged in glass containers a dangerous situation would have existed which could have resulted in personal injury to anyone handling such bottles when and if they were to explode.

Procedures and Discussion

This study involved the processing of a variety of fish wastes. This included separate digestion runs on whole fish scrap, bony filleting wastes, heads, scales, offal and combinations of each material. In each instance, the starting material was ground using a food chopper to reduce particle size and the mascerated fish waste introduced into a jacketed stainless steel mixing tank. Practical experience gained in the field has shown that a corrosion-resistant, jacketed digestion tank would be the tank of choice for use in digesting the type of waste material generated during fish processing. Such a vessel affords ease of mixing and good heat transfer characteristics which combine to aid in maintaining process control over the digestion procedure.

To size a tank for use in the digestion process, the following points should be taken into consideration:

1) Ten (10) pounds of fish waste will occupy approximately one (1) gallon of tank volume;
2) the tank selected should be capable of handling the quantity of fish waste generated during any 24-hour fish processing period plus a reasonable percentage safety margin for periods of flush processing activity.

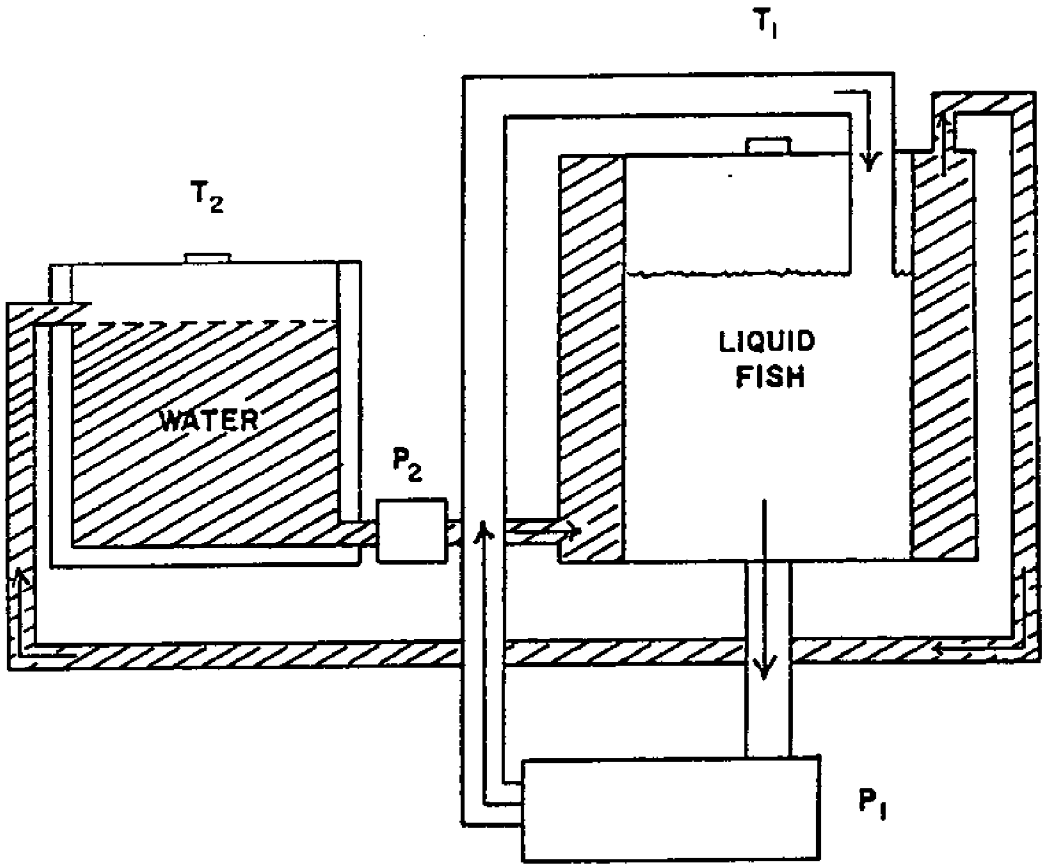
A diagram showing flow patterns and pump positions for the laboratory digestor developed during this study is presented in Figure 1. Ground waste material is placed in digestion tank (T_1) indicated and then is acidified. The slurry is mixed and agitated to obtain even distribution of the added acid by means of manual stirring and a circulating pump (P_1).

The temperature of the digesting mixture is raised and maintained at 140°F by means of heated water circulating in the jacket of the digestion tank (T_1). The water is heated in a hot water reservoir (T_2) using thermostatically controlled 500 and 1000 watt heaters. The water is circulated within the systems by the water pump, marked P_2 in the diagram.

The temperature at which the digestion is allowed to proceed will have a marked effect upon the digestion rate. Digestion rate experiments were conducted at temperatures ranging from 100 to 140°F. Using the digest obtained at 140°F as the standard digestion, processing times were found to range from 96 hours at 100° to 12 hours at 140°F. It was also found that temperatures above 140°F should be avoided due to the risk of denaturing (inactivating or destroying) the digestive enzymes in the mascerated fish mixture.

FIGURE I

FLOW PATTERNS AND EQUIPMENT POSITIONS OF FISH DIGESTION APPARATUS



T_1 : DIGESTION TANK

T_2 : HOT WATER RESERVOIR

P_1 : CIRCULATING PUMP

P_2 : WATER PUMP

The pump, labeled P_1 in diagram (1), is necessary to facilitate agitation and circulation of the digesting material, and for removing the finished liquid fish product from the tank. A one horsepower centrifugal pump having a 2-inch feed and exit proved to give satisfactory performance. When less than 2-inch diameter pump and pipes were used in the system, a problem developed with clogging prior to any noticeable liquifaction of the semifluid mass. A lack of agitation and mixing will lead to putrefaction and incomplete digestion.

After a 12-hour digestion period standardizing materials are added directly to the digestion tank and given an additional half hour to completely mix. The fortified fish emulsion was then passed through an 18 x 14 mesh screen and put directly into polyethylene bottles.

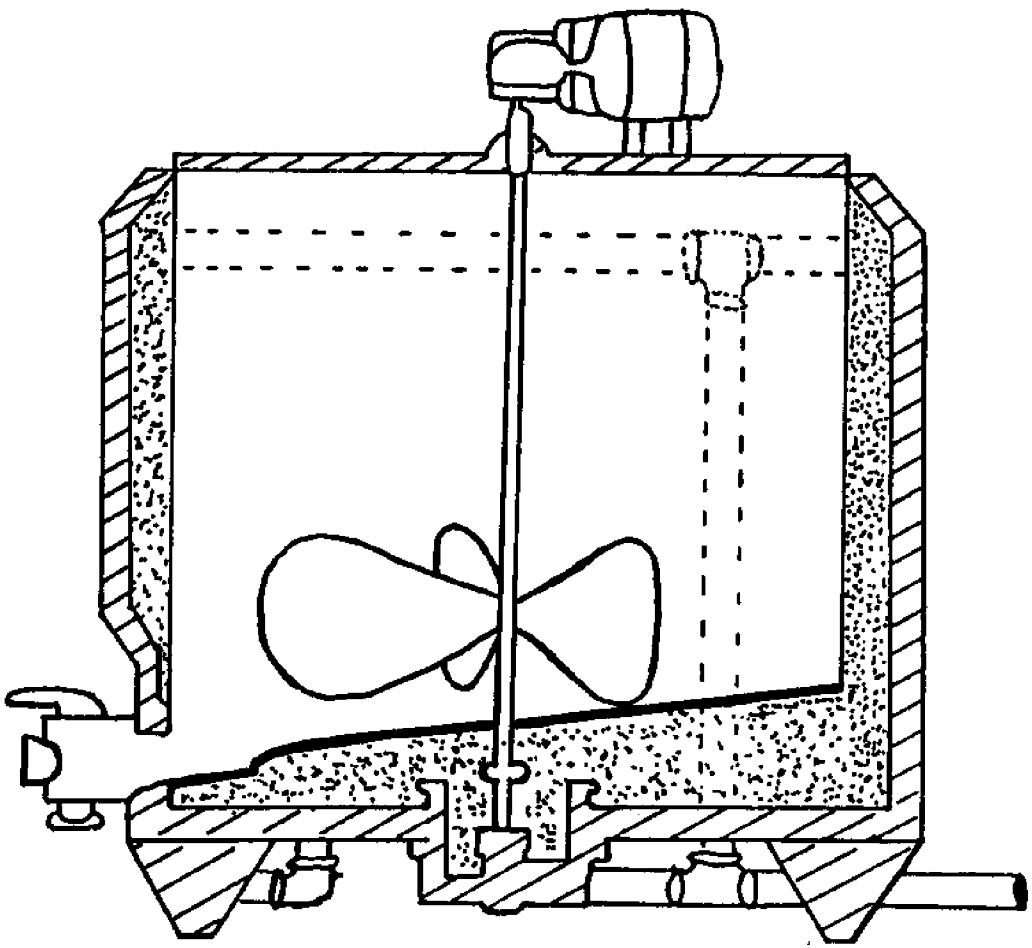
For the fish processor wanting to make fertilizer without a large initial capital outlay, used stainless or fiberglass-lined tanks are available. Dairy equipment dealers handling used dairy equipment are sources of tanks which can be readily adaptable to fish fertilizer manufacture. Figure 2 shows a proposed fish digestion tank modified from a "batch-type" milk pasteurizer. The pasteurizer contains all the essential features:

1. Jacketed tank;
2. Propeller-type agitation;
3. Drain.

Such tanks are designed to use either hot or cold water from an external source and do not have a self-contained heater. The heat source in this case may be any suitable hot water source already present in a plant such as a hot water heater or the condensate from refrigeration compressors. In any event, it must be remembered that the temperature should be maintained at no greater than 140°F no matter what the source of heat may be.

Figure 2

"Batch-Type" Milk Pasteurizing Vat



Standardizing Liquid Fish Fertilizer

Data from the analysis of the liquid fish products produced in the laboratory from waste material of varying composition are presented in Table 2. Data from the analysis of a liquid fish fertilizer currently produced commercially in the State of Wisconsin are also included in Table 2.

A fertilizer is graded according to the percent nitrogen (N), phosphorus (P), and potash (K) it contains. The compositional analyses of the various liquid fish fertilizers presented in Table 2 show that the commercially marketed fertilizer sample rates higher in percent N, P, and K than all of the experimental liquid fish products. This is due to the standardization of the commercial sample through the addition of nitrogen, phosphorus, and potash containing compounds. The data presented in Table 1 also indicate a general decrease in the percent nitrogen of samples produced from bony frame and offal material when compared with a liquid product produced from whole fish. This results from the removal of nitrogen containing protein flesh during filleting, and leaves a lower nitrogen containing material which is processed into the liquid fish product.

A fertilizer producer must indicate a minimum guaranteed analysis of N, P, and K on the product label. To ensure that labeled amounts of plant nutrients are present despite variations in starting material, a liquid fish fertilizer producer may have to supplement the mixture with nitrogen, phosphorus, or potash containing compounds in order to obtain a desired specified N, P, K grade for the product. Some chemical compounds used for fertilizer application have been presented in Table 1. However, when choosing a particular chemical component there are some considerations worth noting:

1) The final N, P and K content desired in the fertilizer;
2) the potency or % N, P and K in the particular chemical constituent;
3) the cost and availability of the chemical;
4) the suitability and compatibility of the chemical component with the organic fish emulsion.

Table 2. Plant Nutrient Content of Liquid Fish Fertilizer Samples

Sample Description	N%	P%	K%	P_2O_5[a] %	K_2O[b] %	NH_4-nl ppm[d]	NO_3-nl ppm	Solids %	Crude Protein %
Commercial liquid fish fertilizer	5.66	1.950	3.170	4.466	3.804	2825.0	238.8	44.2	35.4
Liquid Alewife	3.20	1.010	0.245	2.313	0.294	1275.0	61.3	50.1	20.0
Eviscerated Coho Salmon (50% Solids Basis)	5.62	1.42	0.610	3.25	0.732	1190.8	326.4	50.0	33.5
Whole White Sucker	2.70	1.56	0.39	3.57	0.47	--	--	31.3	16.9
2-1 Viscera-Frame[c]	2.17	1.34	0.275	3.07	0.33	572.0	20.3	36.9	13.6
1-2 Viscera-Frame	2.27	1.34	0.323	3.07	0.39	592.6	30.6	36.1	14.2
1-0 Viscera-Frame	1.98	1.39	0.248	3.18	0.30	594.3	37.1	37.3	12.4
Alewife Viscera and Heads	1.66	1.31	0.224	3.00	0.27	362.1	12.1	31.2	10.4
80% Racks 20% Viscera Commercial Plant	1.37	1.13	0.400	2.59	0.48	198.8	19.9	38.3	8.5
Viscera Commercial Plant	2.00	1.59	0.243	3.64	0.29	275.6	19.9	28.4	12.5

(a) $\%P_2O_5 = \%P \times 2.29$

(b) $\%K_2O = \%K \times 1.2$

(c) Samples 5-7 were run to observe compositional variations by varying the proportions of viscera and frames in the starting material.

(d) 1000 ppm = 0.1%

Using the above criteria, urea, phosphoric acid and muriate of potash were selected as the respective sources of nitrogen, phosphorus and potash.

Nitrogen. Unstandardized liquid fish may contain from 1 to 3 percent nitrogen depending upon the composition of the starting material, see Table 2. After obtaining an analysis on the normal base liquid mixture, a simple procedure can be used to assure a minimum guaranteed amount of nitrogen in the liquid product.

Using urea as the source of available nitrogen, the addition of 2.17 pounds of this material per 100 pounds of liquid fish product will result in a one percent increase in the percent nitrogen of the finished product. Therefore, if the liquid fish digest contains 3 percent nitrogen, the addition of 4.34 pounds of urea per 100 pounds of digest will provide 5 percent nitrogen in the finished product.

Phosphorus. If phosphoric acid is used at the recommended levels, an analysis of 4 percent phosphorus will result in the product. To increase the phosphorus level, phosphoric acid or a phosphate salt may be added. When 75% phosphoric acid is used to increase the phosphate level, the addition of 1.9 lbs of 75% phosphoric acid per 100 lbs of liquid fish product will result in a one percent phosphate increase in the final product.

Potash. The standardization of the fish digest potash level is accomplished through the addition of muriates of potash (KCl). For each percent increase in potash content required, add 1.62 pounds of KCl per 100 pounds of liquid fish digest.

To compensate for the change in constituent percentages due to the change in total product weight, it would be advised to add all constituents (plant nutrient additives) in slight excess.

Equations 1, 2, and 3 presented below are used to calculate the amount of supplemental nitrogen, phosphorus, and potash required to convert whole fish or fish waste to a specified desired analysis liquid fish fertilizer.

Equation (1) -- Equation for the determination of nitrogen in liquid fish.

$$\frac{\text{lb Nitrogen}}{\text{lb liquid fish}} = \frac{\frac{\text{lb nitrogen}}{\text{lb fish waste}}(\text{wt. fish waste used}) + \frac{\text{lb nitrogen}}{\text{lb urea}}(\text{wt. of urea to be added})}{\text{wt. of fish waste used} + \text{wt. urea added} + \text{wt. potash added} + \text{wt. acid added}}$$

Equation (2) -- Equation for the determination of phosphorus in liquid fish.

$$\frac{\text{lbs Phosphorus}}{\text{lb liquid fish}} = \frac{\frac{\text{lbs Phosphorus}}{\text{lb Phosphoric Acid}}(\text{wt. Phosphoric Acid added}) + \frac{\text{lbs Phosphorus}}{\text{lb waste}}(\text{wt. of fish waste used})}{\text{wt. of fish waste used} + \text{wt. urea added} + \text{wt. potash added} + \text{wt. acid added}}$$

Equation (3) -- Equation for the determination of potash in liquid fish.

$$\frac{\text{lbs Potash}}{\text{lbs liquid fish}} = \frac{\frac{\text{lbs potassium}}{\text{lb waste}}(\text{wt. of fish waste used})(1.2) + (.5245)\frac{\text{lbs potassium}}{\text{lb potassium chloride}})1.2)}{\text{wt. of fish waste used} + \text{wt. urea added} + \text{wt. (potassium chloride added)} + \text{wt. acid added}}$$

A complex but more precise method for standardizing the liquid fish product involved the solutions of simultaneous equations. This is accomplished by making use of the equations provided above. To start, it is necessary to know how much nitrogen, phosphorus and potash are being contributed (to the final total of each constituent) by the starting raw material. Data of this type have been obtained on a number of fish and fish waste combinations and is presented in Table 2.

To solve for the quantities of supplements required to produce a fertilizer having a specified analysis using this method, it is convenient to establish the objective of the exercise along with limits within which the problem must be solved. The objective of this exercise was to produce a liquid fish fertilizer which would have a final analysis of 5% N, 4% P and 4% K from 2,000 pounds of fish waste having the following analysis:

1. Nitrogen in waste = 0.02 lbs N/lb waste;

2. Phosphorus in waste = 0 lbs P/lb waste;

3. Potassium in waste = 0.004 lbs/lb waste;

and the operator was limited to the use of urea, 75% phosphoric acid and muriate of potash (KCl) as his source of supplemental nitrogen, phosphorus and potash. It was also known that urea contains 47% nitrogen, 75% phosphoric acid contains 23.7% phosphorus and muriate of potash contained 52.45% potassium. It was also noted that the phosphorus content of a fertilizer is expressed as the percent P_2O_5 present in the product. Thus, when the phosphorus concentration of the fertilizer sample had been determined, multiplying the weight of phosphorus present by the factor 2.29 gave the weight equivalent of P_2O_5 for the sample and the factor 1.2 is used to convert the weight of potassium present to the weight equivalent of potash.

The calculations involved in the solution of this problem are presented in Appendix I. The calculated amounts of supplements obtained from solution of the problem were:

Pounds of Urea to be added: 182.0

Pounds of 75% Phosphoric Acid to be added: 185.0

Pounds of Potash to be added: 144.35

Total wt of 5,4,4 fertilizer produced from 2,000 lbs of waste: 2444.75

The information and methods on standardization presented here are to give a potential producer of liquid fish fertilizer a brief look at some of the complexities involved in this process. However, a producer would be best advised to consult a professional laboratory for analysis of the product and help in establishing standardizing procedures to make sure when producing and marketing the product it meets all requirements under the law.

In addition to helping a processor establish standardizing procedures, professional guidance should also be obtained as to developing labeling instructions concerning the safe use of the product and methods of dilution and application.

Trace Element Content of Liquid Fish

The importance of nitrogen, phosphate and potash for use in increasing crop yield and maintaining plant health has been firmly established. However, micronutrient or trace element requirements of plants is still a relatively new concept and still being documented. It has been demonstrated through plant tissue analysis techniques that certain trace elements are essential to good plant health. At present however, more research is needed in this area to establish general recommendations on trace element amounts and specific elements for soil type and geographic region. Agronomists are currently working to better define the trace element requirements for specific plant species such as corn, cotton, rice, and small grains.

Liquid fish is a source of some of the trace elements now under study. The trace element composition of various liquid fish samples has been determined and the analytical data are presented in Table 3. Along with other elements, liquid fish contains trace amounts of iron, copper, zinc, and manganese. The value of liquid fish as a good trace element source for plants has yet to be determined. However, a potential for the use of the product in this regard does exist.

Summary of Costs Involved in Production of Liquid Fish

In this section, an attempt is made to establish some of the primary costs involved in producing a 5,4,4 analysis liquid fish fertilizer product from fish processing wastes. Items not included in the cost summary are costs of waste product and labor. Because of the variability of fish processing waste material, it is assumed that the uses of this material are negligible and thus has no

Table 3. Trace Elemental Analysis of Liquid Fish Fertilizer Samples

Sample[a]	Ca%	Mg%	Na%	Al[b] ppm	Fe ppm	B ppm	Cu ppm	Zn ppm	Mn ppm	Ba ppm	Sr ppm	Cr ppm
1	0.555	.0252	.3220	202	103	4.24	1.85	35.5	3.71	1.050	7.09	2.42
2	0.485	.0116	.4290	12.3	106	2.59	1.70	36.1	2.34	0.522	3.10	1.24
3	0.380	.0335	.1531	43.4	13.6	3.8	1.4	14.2	<1.4	<1.4	2.2	<2.1
4	0.723	0.0338	0.1080	16.6	63.25	5.23	3.66	209.78	4.98	<8.00	2.30	<12.00
5	0.424	0.0207	0.0863	121.0	23.36	3.84	<4.00	16.24	<8.00	<8.00	<4.00	<12.00
6	0.401	0.0250	0.0848	134.3	20.04	4.58	<4.00	16.25	3.31	<8.00	<4.00	<12.00
7	0.291	0.0202	0.0884	271.9	121.60	3.88	<4.00	22.38	6.56	<8.00	<4.00	<12.00
8	0.390	0.0196	0.0889	159.4	76.75	4.55	<4.00	29.42	9.45	<8.00	<4.00	<12.00
9	0.278	<0.0400	0.0766	214.9	32.56	1.60	7.24	51.32	3.63	<8.00	<4.00	<12.00
10	0.210	0.0164	0.1153	225.5	60.21	3.15	5.17	53.68	4.37	<8.00	<4.00	<12.00

(a) Sample ID same as in Table 1.

(b) 1000 ppm = .1%

monetary value. It is also assumed that the labor required for overseeing and handling the process will be an added responsibility of an individual already on the payroll. However, if costs were to be included in the summary for starting raw material and labor, their effect upon the total finished product costs would not be difficult to compute.

A summary of costs for materials, equipment and energy needed to produce a liquid fish product are presented in Table 4. Items listed in the table under the heading Equipment, are available either new or used from restaurant and dairy equipment dealers. The remaining items are available from most scientific supply companies or local hardware supply outlets.

Materials such as phosphoric acid, fish deodorant and citronella oil are available from many chemical supply companies. The fish deodorant used in this study was "fish odor mask #402067-00," obtained from Crompton and Knowles and was added at the rate of 0.15% w/w.

Table 5 is presented to aid in clarifying the production and material costs involved in producing a gallon unit of 5,4,4 liquid fish fertilizer product. The table shows that a gallon of fertilizer product can be produced for $0.72 a gallon, excluding costs for labor and waste raw material.

The $0.72 per gallon production cost figure is based upon small volume materials purchased. If items such as acid, urea, potash bottles, labels, etc., were to be purchased in large quantities, the $0.72 per gallon production figure could be reduced. However, this method, as described, was designed to appeal to those members of the fishing community having limited financial resources and faced with the problem of high cost waste disposal. With that in mind, the method presented outlines a simple procedure to not only eliminate the waste disposal problem but in addition, provides a potential source of added revenue for the existing business.

Table 4. Summary of Equipment, Materials and Energy Costs for Processing Fish Wastes into Liquid Fish Fertilizer

Equipment			Materials		Energy	
Grinder	New:	\$1,200- \$1,400	Acid	Approx. 33¢/lb	Elect	\$ .78/day
Stainless Steel			Urea	9.25¢/lb		
Digestor Tank	New:	\$8,000				
2,000 lb capacity	Used:		Potash	4.75¢/lb		
Cost of modifying tank for agitation and heat			Citronella Oil	\$2.00/lb		
			Deodorant	\$7.60/lb		
Pump (if bulk storage is desired)			Bottles			
	New:	\$400.00	gallon	\$25/100		
	Used:	\$ 50.00	pint	\$12/100		
			quart	\$11/100		

*These costs are the best estimates available as of February 1977.

Table 5. Estimate of Production and Material Costs to Produce 1,000+ Gallons of Liquid Fish Fertilizer

Material	Quantity	Unit Cost	Total Cost	Cost/Gal.
75% Phosphoric Acid	737 lb	$ .33/lb	$ 243.13	$ 0.24
Urea	725 lb	0.0925/lb	67.06	0.07
Muriate of Potash	575 lb	0.0475/lb	27.31	.03
Fish Deodorant	5 lb	7.85/lb	39.25	0.04
Citronella Oil	15 lb	4.00/lb	60.00	0.06
Gallon Bottles	250 cases/4 each	1.00/case	250.00	0.25
Labels	1,000	0.02 each	20.00	.02
Energy	--	--	3.90	.01
Raw Material	--	--	--	--
Grand Total			$ 710.65	$ 0.72

Marketing Liquid Fish Fertilizer

The questions most frequently asked by potential producers of liquid fish are: "Can the product be sold, at what price, and through what outlets?" Additional questions arise as to product specifications, use of middlemen, packaging, labeling and promoting the product. Studies of plant fertilizer markets were conducted in 1975 to provide answers to these marketing questions. Fertilizer retailer questionnaire results appear in Appendix II.

Fertilizer Market Segments

Fertilizer users can be classified into three main groups: farmers, professional growers other than farmers, and nonprofessional home users. Within each group are sub-segments as shown in Table 6.

Table 6. Plant Fertilizer Market Segments

Farmers	Professional Growers	Home Users
row crops	florists	vegetables
forage crops	greenhouses	flowers
pasture	seed companies	lawns
orchards	nurseries	shrubs
vegetables	landscapers	trees
		house plants

The categories listed should be of interest to liquid fish producers because of the variation in fertilizer requirements of each group. While liquid fish could be sold as a general, all purpose fertilizer, a better approach is to aim at a particular market segment, adapting price, packaging, and outlets to meet the needs of the target group.

Farmer's Fertilizer Needs

Farmers use fertilizer in large quantities. For example, corn cropland may receive over one hundred pounds of nitrogen per acre. Because of the cost involved in extensive fertilizer use, the main factor considered by farmers when purchasing fertilizer is the price per unit of N, P, and K. Since production costs of liquid fish are higher than those of commercially available inorganic fertilizers at present, price is a barrier to sales for farm use.

Application equipment for liquid fertilizer is not a limitation factor since many Wisconsin farmers own liquid manure or other liquid fertilizer equipment, or irrigation systems suitable for application of liquid fish. However, the expense of handling large volumes of liquid fish required to obtain high nutrient levels would further limit liquid fish's usefulness to most farmers.

Farmers most likely to use liquid fish are probably fruit and vegetable "specialty" crop growers with irrigation systems. The high per acre value of these crops, lower total nitrogen requirements, and desire of some growers to use "organic" methods, are reasons this type of use may be a possibility.

Professional Growers

Growers such as nurserymen, florists, and landscapers tend to be sophisticated and cost conscious in their fertilizer purchases. For example, some nurserymen use individual pot watering tube systems to meter exact quantities of nutrients to plants. For this purpose, most growers would choose the less expensive inorganic products over liquid fish.

A survey did find limited use of liquid fish by some professional house plant growers. These growers explained that certain plants are "tender rooted" and sensitive to overdoses of inorganic fertilizer. For these plants, liquid fish is preferred.

Home Uses of Fertilizers

Unlike farmers and professional growers, home users are likely to spend only a few dollars per year on fertilizer. The home user can usually readily afford to pay slightly more for products he considers likely to give better results.

The variety of fertilizer prices and products found in retail stores shows that price competition is often less important in stimulating sales in this market segment than other factors such as packaging and advertising (Table 7). 1975 prices of inorganic products found in Madison retail home fertilizer outlets varied from $1.40 to $57.00 per pound of nitrogen. Liquid fish fertilizers were offered at from $5.00 to $60.00 per pound of nitrogen.

Most of the cost of fertilizer products intended for home use covers packaging, marketing, and distribution, with only a relatively small percentage of the cost due to the bulk fertilizer. Liquid fish is, therefore, able to be competitive in price with many inorganic products in retail home use outlets.

Liquid fish fertilizer provides slow release of nutrients over a period of a year or more through natural breakdown of the product in the soil. The resulting "sustained feeding" of plants is an advantage in many home uses where maintaining plants in good condition over a period of time is desired. Even more important, the slow release of nutrients makes it impossible for the inexpert home user to "burn" plants. When used in excess, or improperly, some inorganic products can damage plants, a danger avoided with liquid fish.

Liquid fish contains several "micronutrients" such as boron, copper, and manganese. While UW horticulturists state that these nutrients are only rarely deficient in soils, consumers may, nevertheless, be attracted by the fact that liquid fish is a more complete plant food than inorganic products.

Table 7. Sample of Analysis, Package Sizes, and Prices of Home Fertilizers Available in Madison Retail Stores, December, 1975

Brand/Company	Stated Analyses (Use)	Package Sizes Quoted	Retail Price Listed
Precise/3M	12-6-6 (general)	3.7 oz.	$1.59
		6.5 oz.	$1.99
		20 oz.	$4.19
	9-12-6 (vegetables)	20 oz.	$3.79
	6-12-6 (flowers)	20 oz.	$3.79
	6-18-6 (tomatoes)	20 oz.	$3.79
	8-12-4 (roses)	20 oz.	$3.79
	8-11-5 (African violet)	3.7 oz.	$1.19
Ortho/Chevron	12-6-6 (liquid)	32 oz.	$2.69
		16 oz.	$1.69
	5-15-5 (liquid)	16 oz.	$1.69
	*5-2-2 (fish emulsion)	7 oz.	$1.19
	*5-2-2 (fish emulsion)	16 oz.	$1.59
	*5-2-2 (fish emulsion)	32 oz.	$2.69
Rapid Grow	23-19-17	8 oz.	$1.19
	23-19-17	2 lb.	$3.49
	23-19-17	4 lb.	$6.95
Milorganite	6-2-0	50 lb.	$4.29
Scotts Turfbuilder	34-5-5	20 lb.	$9.95

*Composed of fish products.

(continued)

Table 7. Sample of Analysis, Package Sices, and Prices of Home Fertilizers Available in Madison Retail Stores, December, 1975 (continued)

Brand/Company	Stated Analyses (Use)	Package Sizes Quoted	Retail Price Listed
Sterns Miracle Grow	15-30-15	24 oz.	$2.98
	15-30-15	8 oz.	$1.29
Schultz	10-15-10	5.5 oz.	$0.69
Atlas Fish Emulsion	*5-2-2	4 oz.	$0.75
Follete	8-8-8	32 oz.	$3.50
Blood Meal/Oasis	12-0-0	5 lb.	$4.97
Northrup King	5-20-20	5 lb.	$1.99
Corel/Dramm Co.	18-6-12 (slow release)	3 lb.	$9.25
Eeesy Grow	16-8-16 (slow release)	1 lb.	$3.45
Mag Amp	7-40-6	1 lb.	$1.89

*Composed of fish products.

Marketing Strategies for Fish Processors Producing Liquid Fish

Potential producers of liquid fish fertilizer should begin by reviewing their goals and capabilities. Is the main goal to get rid of processing wastes, even if this must be done at a net cost? How does liquid fish production compare with present and alternative methods of waste disposal? How much time and effort can the company devote to marketing a fertilizer product? What level of profit is desired from a fish fertilizer? Once these questions are considered, tentative planning of production and marketing can begin. Alternative marketing arrangements include:

1. Bulk Sales to large users. Applying liquid fish at a rate of ten pounds of nitrogen per acre (20 gallons/acre) would, for example, require only five hundred acres to use liquid fish produced from 100,000 pounds of fish wastes. A few farmers could conceivably buy a fish processor's entire production of liquid fish. Although there would be no bottling costs, and low marketing expenses with this method of selling, prices would probably be low.
2. Bulk sales to a manufacturer's representative. Distribution and sales of liquid fish might best be handled by firms familiar with hoem fertilizer markets. Manufacturers' representatives may be used to bottle and label the product, or to distribute a product bottled by the processor. It is possible that existing liquid fish companies would buy a bulk product for sale under their own label. A list of manufacturers' representatives can be found in the Home and Garden Supply Merchandiser Annual Buyer's Guide. Information supplied by manufacturers' representatives suggests that their distribution and sales services may cost about a 40 percent markup above the manufacturer's bottled price for liquid fish. Use of this approach could give a fish processor access to fertilizer mrrkets with a minimum of his own time required for marketing.

3. Salesmen or jobbers. Instead of a single representative, the marketing problem could be approached by using several salesmen in various areas--for example, major urban markets. By operating on a commission system, this method could keep marketing expenses directly proportional to sales.
4. Direct sales. The present producer of liquid fish in Wisconsin has served as his own sales force. This individual has succeeded in gaining acceptance for his product in parts of the state, with most sales occurring through supermarket outlets. Direct selling may bring the producer greatest dollar amounts per unit sold, but it also demands much more time and effort spent on marketing. A larger fish processor might wish to organize a fish fertilizer operation as a subsidiary or division with a person responsible for sales of the product.
5. Mail order sales. Several liquid fish manufacturers advertise in gardening publications to develop mail order sales. A west coast firm sells liquid fish through a catalogue of a midwestern seed supply company. A mail order offer would also serve as an advertisement that might assist sales through other outlets. Shipping costs present a drawback to mail odder sales since they would account for a good portion of the unit price.
6. Sales program using a combination of methods. Maximum sales might be obtained by a combination of methods that could reinforce each other. Direct sales might be possible to retail outlets located near the processor's plant. Mail order sales could provide an additional market and expose the product to a wider public. Manufacturers' representatives or jobbers could stimulate sales throughout a wider region. Any surplus produced might be sold at a low price to farm or professional growers.

Promotional Activities

Firms selling in bulk could give less attention to promotional activities, but for sales through retail garden stores, supermarkets, or similar outlets, promotion would be very important. The main promotional device in such outlets are the product's packaging and appearance. Other devices include point-of-sale displays, posters, or advertising through local media. The product's name and package label deserve careful attention. Some liquid fish packages emphasize the potent growth factors of the sea, while others have capitalized on the story of the Indians teaching the pilgrims to bury fish as a fertilizer.

Aspects of liquid fish fertilizer which are important to consumers identified by a survey of retailers (see Appendix) included its sustained feeding, non-burning characteristics and "ease of application." These could be emphasized on labels and in advertising or sales materials. To give ease of application, bottles might include a measuring cap. For outdoor use, sale with a siphon for direct dispensing with a garden hose would provide ease of application. In all cases, clear instructions for use should be included.

Targeting to Sub-markets

Liquid fish should be offered in package sizes appropriate for intended uses. Coastal liquid fish products sold in Madison seem to be aimed at indoor house plant growers. The products are sold in four and eight-ounce bottles and labels stress "no odor," which is considered important for indoor use. It would make little sense to offer liquid fish for indoor use in gallon sizes or for outdoor use in the smaller sizes.

In contrast to inorganic products which may be sold as "tomato food," "lawn food," or other specialized uses, no liquid fish product tried to identify itself with a sub-segment of the outdoor home use market. The slow release character of liquid fish would make it seem ideal for a "transplanting fertilizer." Labeling could identify the product as "vegetable" or "flavor" fertilizer. Examination of the analyses of inorganic fertilizers now on the market suggests that very similar products can be sold for different purposes simply by changing the label.

Another suggestion is to aim specifically at the organic grower. By emphasizing the organic character of liquid fish on the label and distributing through outlets identified as organic such as "whole earth stores" or Organic Gardening magazine mail order sales, this market segment could be reached. The organic "movement" actually cuts across all market segments since there are organic farmers, professional growers, as well as home users. Organic growers claim that high potency synthetic fertilizers damage soil and produce foods having lower nutritional value. These claims are largely discounted by soil scientists who have shown that plants use nutrients in the same fashion regardless of source. However, University soil scientists do see merit in organic fertilizers as "soil conditioners" which may help hold water and stimulate beneficial bacteria, especially in poorer sandy or clay soils.

It is not our purpose here to evaluate the merits of organic methods. What is important to the liquid fish producer is that many consumers prefer organic products such as liquid fish. As an indication of the extent of interest in organic methods, Organic Gardening magazine claims a circulation of 3/4 million copies monthly.

The great variety of home fertilizer products now on the market as shown in Tables 7 and 8 means a new liquid fish product faces considerable competition. Not only consumers, but also wholesalers and retailers, must be given incentives to shift to the new product. Different incentives may be important at each level. Retailers may want to fill a "gap" in their fertilizer product line and offer better service to customers. Manufacturers' representatives may desire high sales volume and attractive profit margins at the wholesale level. Consumers may be motivated more by packaging, price, or advertising.

Marketing Costs

To the price of bulk liquid fish, the manufacturer must add marketing costs necessary to get the product to the consumer. According to manufacturers' representatives, a total of 40 percent over the manufacturer's price for a bottled product would be required to cover wholesale distribution costs. Retailers would typically mark the item up by 30 to 40 percent over the wholesale price. If a manufacturer wanted to push the product, he would have to include a marketing budget of his own to aid in promoting liquid fish to wholesalers, retailers and consumers. These costs would vary depending on marketing methods used, but might include cost of designing labels or other materials, salesmen's commissions, or advertising in trade or popular publications.

Sales Potential

Most consumers interviewed who had used liquid fish think it is "the best." This positive attitude makes for repeat sales and suggests that by offering the product in more outlets sales could be expanded. Use in Wisconsin during 1975 was estimated to be about 10,000 to 20,000 gallons, mostly sold in the smaller 4 to 16-ounce containers for indoor use.

Trends favoring development of expanded markets for liquid fish include, in addition to the interest in organic gardening, the rise in food prices which makes vegetable gardening more attractive, and the tremendous boom in indoor house plant growing which has occurred during the past five years. These trends are important in creating a market opportunity for liquid fish.

Table 8. Fish Fertilizer Products Sold in the Midwest, November, 1975

No. of Firms Selling	Product	Price Listed
10	Atlas Fish Emulsion	
	4 oz.	$0.75
	8 oz.	--
	pint	$1.69
	quart	$2.69
	gallon	$6.25
8	Ortho	
	16 oz.	$1.29, $1.15
	quart	$2.69
	gallon	$4.95
	8 oz.	$1.19
	1/2 gallon	
2	MerMaid	
	8 oz. (also sold in all sizes up to 55 gal)	$1.19
2	Toots	
	pint	$1.09
	quart	--
	gallon	$3.09
1	Black Magic	
	6 oz.	$0.89
	12 oz.	$1.49
1	Fish-It	
	8 oz.	$1.20
	pint	$2.00
	quart	$3.20
	gallon	$7.95
1	New Plant Life	
	8 oz.	$2.19
1	C-Food	--
1	Alaska Fish Fertilizer	--

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APPENDIX I

Solution to Liquid Fish Standardization Problems Using Simultaneous Equations

Solution to the Problem of Determining Required Amounts of Urea, Phosphoric Acid, and Muriate of Potash Needed to Produce a Liquid Fish Fertilizer Having a Final N,P,K Analysis of 5,4,4 Using Simultaneous Equations.

Data Provided:

1. Urea contains 47% nitrogen;
2. 75% phosphoric acid contains 23.7% phosphorus;
3. Potassium is added in the form of muriate of potash and converted to potash equivalents by multiplying by the factor (1.2);
4. Starting waste material is 2,000 lbs of fish waste having an analysis of 2.0% nitrogen, 0% phosphorus and 0.4% potash;
5. %P is measured as the % P_2O_5 present in the sample; by multiplying the quantity of phosphorus present by the factor 2.29, the representative quantity of P_2O_5 is obtained.

The first step is to devise three equations containing the three unknown quantities N, P, and K. This is done by substituting the known information about the waste starting material and the supplemental materials into Equations 1, 2, and 3 provided in the text (page 36) and reducing them to their lowest form.

Equation (1) -- Equation for the determination of nitrogen in liquid fish.

$$\frac{\text{lb Nitrogen}}{\text{lb liquid fish}} = \frac{\frac{\text{lb nitrogen}}{\text{lb fish waste}}\text{ wt. fish waste used)} + \frac{\text{lb nitrogen}}{\text{lb urea}}\text{ (wt. of urea to be added)}}{\text{wt. of fish waste used + wt. urea added + wt. potash added + wt. acid added}}$$

Equation (2) -- Equation for the determination of phosphorus in liquid fish.

$$\frac{\text{lbs Phosphorus}}{\text{lb liquid fish}} = \frac{\frac{\text{lbs Phosphorus}}{\text{lb Phosphoric Acid}}\text{ (wt. Phosphoric Acid added)} + \frac{\text{lbs Phosphorus}}{\text{lb waste}}\text{ (wt. of fish waste used)}}{\text{wt. of fish waste used + wt. Urea added + wt. Potash added + wt. acid added}}$$

Equation (3) -- Equation for the determination of potassium in liquid fish.

$$\frac{\text{lbs Potash}}{\text{lbs liquid fish}} = \frac{\frac{\text{lbs potassium}}{\text{lb waste}}\text{ (wt. of fish waste used)1.2} + \frac{\text{lbs potassium}}{\text{lb potassium chloride}}\text{(lbs potassium chloride)}1.2}{\text{wt. of fish waste used + wt. Urea added + wt. potassium chloride + wt. acid added}}$$

Substituting into Equation (1) gives:

$$.05 = \frac{0.02(2000) + 0.47\ (\text{Urea})}{2000 + \text{Urea} + \text{Acid} + \text{Potash}}$$

reducing and collecting terms gives Equation (4).

$$0.42\ \text{Urea} - 0.05\ \text{Acid} - 0.05\ \text{Potash} = 60 \quad \text{-------------} \quad (4)$$

Substituting into Equation (2) gives:

$$.04 = \frac{0.237(\text{Acid})\ (2.29) + 0.0\ (2000)}{2000 + \text{Urea} + \text{Acid} + \text{Potash}}$$

reducing and collecting terms gives Equation (5).

$$-.04\ \text{Urea} + 0.503\ \text{Acid} - 0.04\ \text{Potash} = 80 \quad \text{-------------} \quad (5)$$

Substituting into Equation (3) gives:

$$0.04 = \frac{0.004(2000)(1.2) + (.5245(P)(1.2)}{2000 + \text{Urea} + \text{Acid} + \text{Potash}}$$

reducing and collecting terms gives Equation (6).

$$-0.04 \text{ Urea} - 0.04 \text{ Acid} + 0.5894 \text{ Potash} = 70.4 \quad \text{- - - - - - - - - (6)}$$

There are now three equations, (4), (5), and (6), each containing three unknowns, Urea (U), Acid (A), and Potash (P). Multiplying both sides of Equation (4) by 0.04 yields:

$$0.0168 \text{ U} - 0.002 \text{ A} - 0.002 \text{ P} = 2.4 \quad \text{- - - - - - - - - - - - - - - (7)}$$

and multiplying both sides of Equation (5) by 0.42 yields:

$$-0.0168 \text{ U} + 0.21126 \text{ A} - 0.0168 \text{ P} = 33.6 \quad \text{- - - - - - - - - - - - (8)}$$

Adding Equations (7) and (8) together, the unknown U drops out and you have:

$$0.0168 \text{ U} - 0.002 \text{ A} - 0.002 \text{ P} = 2.4 \quad \text{- - - - - - - - - - - - - - - - - (7)}$$

$$-\ 0.0168 \text{ U} + 0.21126 \text{ A} - 0.0168 \text{ P} = 33.6 \quad \text{- - - - - - - - - - - - - - (8)}$$

$$0.20926 \text{ A} - 0.0188 \text{ P} = 36 \quad \text{- - - - - - - - - - - - - - - - (9)}$$

To generate a second equation containing two unknowns, both sides of Equation (6) are multiplied by -1. This yields:

$$0.04 \text{ U} + 0.04 \text{ A} - 0.5894 \text{ D} = -70.4 \quad \text{- - - - - - - - - - - - - - - - (10)}$$

By adding Equations (5) and (10) together, the unknown U drops out of the equation and you have:

$$0.04 \text{ U} + 0.04 \text{ A} - 0.5894 \text{ P} = 70.4 \quad \text{- - - - - - - - - - - - - - - - - (10)}$$

$$-0.04 \text{ U} + 0.503 \text{ A} - 0.04 \text{ P} = 80 \quad \text{- - - - - - - - - - - - - - - - - - - (5)}$$

$$+\ 0.543 \text{ A} - 0.6294 \text{ P} = 9.6 \quad \text{- - - - - - - - - - - - - - - - - - (11)}$$

There are now two equations, (9) and (11), containing two unknowns. Multiplying equation (9) by the quantity (0.6294) will give:

$$+ 0.131708244 A - 0.01183272 P = + 22.6584 \quad \text{- - - - - - - - - - - - - -} \quad (12)$$

and multiplying equation (11) by the quantity 0.0188 will give:

$$-0.0102048 A + 0.01183272 P = -0.18048 \quad \text{- - - - - - - - - - - - - - - -} \quad (13)$$

Adding Equations (12) and (13) gives:

$$0.121503444 A = 22.47792$$

$$A = 184.998 \text{ lbs of 75\% phosphoric acid}$$

Then, substitute 184.998 for A in Equation (11) and solve for P.

$$(0.543)(184.998) - 9.6 = P$$

Therefore, P = 144.35 lbs of muriate of potash

Then, substitute 184.998 for A and 144.35 for P in Equation (10) and solve for U.

$$.04 U + (.04)(184.998) - (.5894)(144.35) = -70.4$$

$$.04 U = 7.27997$$

<u>U = 181.999 lbs of Urea</u>

Substituting the following answers back into Equations (1), (2), and (3):

Urea to be added = 181.999

75% Phosphoric Acid to be added = 184.998

<u>Muriate of Potash to be added = 144.35</u>

The final % of N, P, and K in the liquid fish fertilizer calculates to be:

4.9989 or 5% N
3.99801 or 4% P
and 4% K

APPENDIX II

Fertilizer Retailer Questionnaire Results

A questionnaire was mailed to 209 firms, including garden stores, supermarkets, florist shops, discount stores, and farm supply companies in 20 Wisconsin and Illinois communities. Eighty-three were returned (40 percent) and tabulated. The following is a summary of results:

1. Fertilizer Market is Seasonal

   Fertilizer sales for outdoor home uses were heavily concentrated in spring. Three-quarters of respondents indicated over two-thirds of fertilizer sales occur in spring. Organic Gardening magazine's editors reported that several liquid fish manufacturers use mail order advertising only during late winter and early spring to take advantage of this seasonal emand. Outlets selling fertilizers for indoor use, such as florist and similar shops are more likely to report steady but limited sales of fish fertilizer the year round. Because of seasonal demand, liquid fish products intended for outdoor use would need to be stockpiled for the spring rush.

2. "What users are the best market for liquid fish fertilizer?"

   In response to the above question, seeking to identify a target sub-market, the retailers split about evenly between suggesting indoor and outdoor home uses. Liquid fish can apparently be sold for both indoor and outdoor home use depending on size of container, type of retail outlet, and labeling. This suggests that a virtually identical liquid fish product could be sold to several sub-segments of the fertilizer market by offering a variety of sizes and labels.

3. What attracts customers to liquid fish fertilizer?

   Advertising, labels, and personal sales contacts would want to focus on the aspects of liquid fish which are most appealing to customers. Retailers were presented with a list of "customer attracting features," and asked to check the three most important items. Responses were:

29 percent	Slow release of nutrients, non-burning
27 "	Ease of application
13 "	Competitive price
12 "	Advertising, promotion and packaging
8 "	Acceptaole odor
7 "	Micronutrients
2 "	N, P, and K analysis
2 "	"Organic"

It is interesting that N, P, and K analysis is not considered important by retailers. Apparently home users do not calculate the cost per unit of nitrogen as the farmer does. Clearly, if the retailers are correct about what their customers want, labels should stress the slow release, nonharmful nature of liquid fish. Ease of application may be partly a matter of perceptions, since pouring from a bottle is not difficult. Instructions emphasizing how easy use of liquid fish really is should be included. Retailers' responses show that characteristics of the product itself make it desirable for home use.

4. Present Market Penetration

Only 35 percent of questionnaire respondents currently sell liquid fish products. In Madison, garden centers and some florist shops catering to house plant growers stock liquid fish products. Supermarkets and chain stores, in general, did not display or offer the product. This would suggest that promoting liquid fish through such outlets may be one method of increasing sales of the product.

5. Sales Trends

No survey respondent reported declining liquid fish sales. Two-thirds indicated that sales have increased slowly, while most of the remainder reported constant sales of such products.

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[1]"Organic" was not on the list presented and was volunteered by respondents in the "other" category. Therefore, "organic" is probably more important than several other items on the list.

6. Price

Retail price of liquid fish during 1975 was typically 75¢ for four ounces and $1.69 for pints. Gallon quantities were priced from $2.50 to $11.50, with most sales in the $3.50 to $6.50 range. The fact that prices can vary suggests that distributors can choose among alternative prices. Should prices be raised to support more marketing and promotion, or higher margins for wholesalers and retailers, is a question to consider since consumers are apparently not very sensitive to price in home fertilizers. On the other hand, if the producer's marketing strategy aimed for a wider market, after concluding that liquid fish use is now confined to a narrow group of avid growers, price might become more important.

7. Total Sales Volume

Total sales of liquid fish fertilizer by respondents to the survey was approximately 1,400 gallons in 1974. However, most outlets sold only a few cases per year, often in smaller size bottles for indoor use. A few firms sold larger quantities. Several hundred gallons, for example, were sold through one retail outlet, mostly in spring for outdoor use in gallon size containers. An educated guess of Wisconsin's total current liquid fish sales would be about 10,000 to 20,000 gallons annually, with a moderate increase each year. Expanding the market area to major population centers such as Chicago and Minneapolis-St. Paul would surely increase this total substantially.

Conclusions

Since there are already a number of liquid fish products on the market and since the product is still a small volume seller in most places, manufacturers would need to build markets up over a period of years, start on a fairly small scale, or allocate most production to low profit bulk sales.

The increased interest in house plants, vegetable gardening, and the organic movement, together with generally positive reactions of consumers who have used liquid fish, and its real advantages for home use, may indicate a real market opportunity for Great Lakes fish processors. Firms that have waste disposal problems, especially, may wish to consider experimenting with liquid fish sales. If initial investment can be kept low, and the firm is willing to take a long-term view of building markets, liquid fish fertilizer could become a reasonably profitable by-product of fish processing.