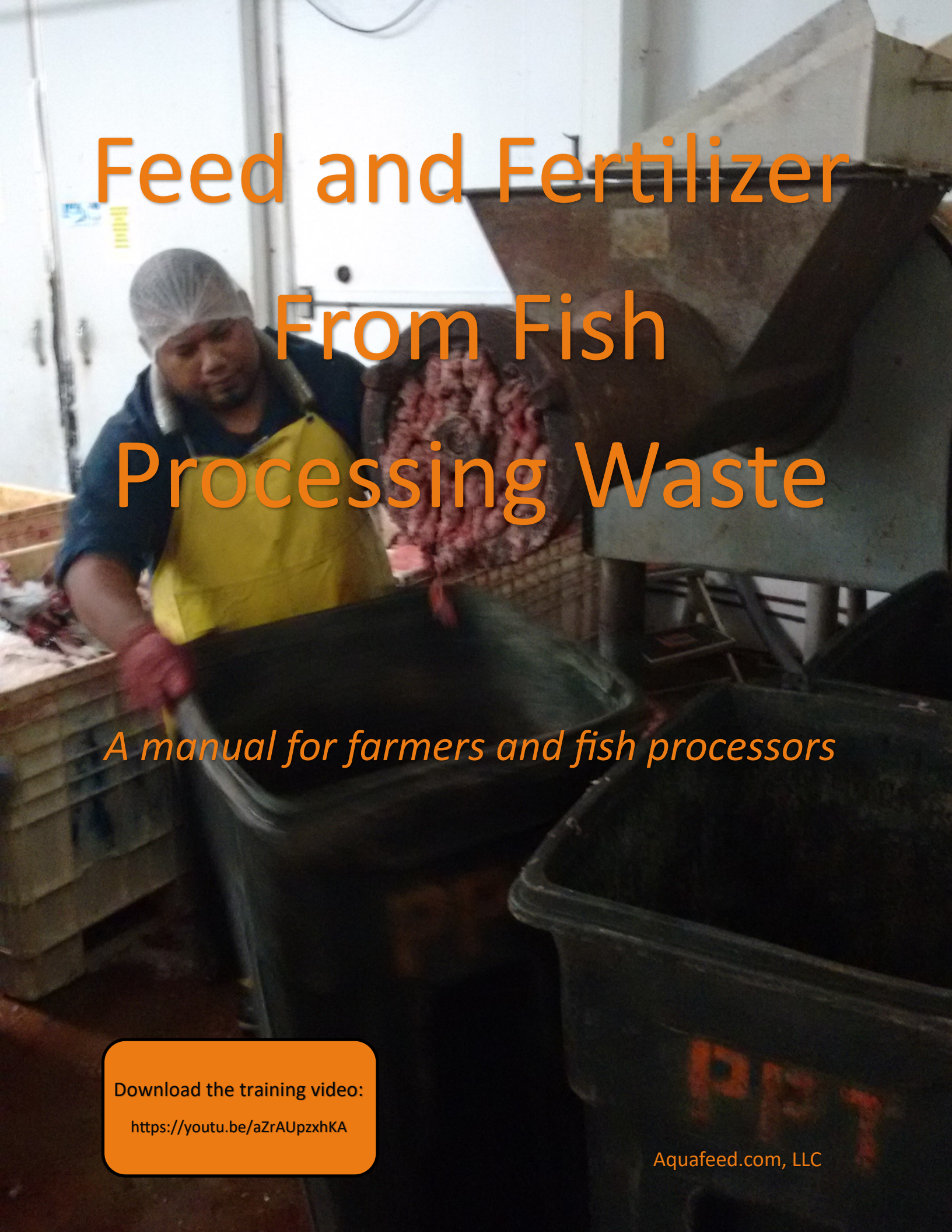

# Feed and Fertilizer From Fish Processing Waste

*A manual for farmers and fish processors*

Download the training video:

https://youtu.be/aZrAUpzxhKA

Aquafeed.com, LLC

# *Contents*

# *Introduction*

Feed and fertilizer are essential but costly inputs for farmers: fish require a high quality, nutritionally balanced diet to grow and maintain health and fertilizers act as soil conditioners, feeding soil, plants, pond, hydroponic and aquaponic systems.

For fish farmers, feed is the single greatest cost of production and in the Pacific Islands the additional cost of shipping makes importing high quality commercial feeds even more expensive. High quality protein is an essential ingredient in aquatic feeds. The inclusion of fishmeal is the main reason for the high price of commercial fish feeds. For many farmers, these costs are prohibitive. Many farmers try to buy less expensive, inferior quality feeds from foreign sources; this results in high mortalities and small fish. Many give up altogether.

Traditionally, agriculture has been the main source of livelihood for the people of the Pacific Islands, where the availability of land is limited, so it is particularly important that the acreage available for crop production is fully optimized. Soil fertility is often poor, and substantial increases in crop yield and quality can be achieved by using fertilizers. Many farmers though are in the position of having to accept low yields because commercial fertilizers are expensive but also can be harmful to the water table. The expense of transporting fertilizers to the region drives up prices to where they are beyond the reach of the poorest farmers. It is also a cost burden for larger agricultural producers that limits their competitiveness in export markets.

Fish Processing Waste comprises the parts of the fish that are discarded by the wholesalers after they have prepared the fish for selling on to retailers and restaurants. This waste is a readily available local protein source, equal in quality to fishmeal, that fish processors are paying to dump. It is available in Hawaii and the Pacific Islands cheaply – or sometimes free.

By employing the simple processing procedures and methods in this manual, using off-the-shelf, readily available equipment, you can make a high protein, high quality, water stable, supplemental feed that will reduce your feeding costs by reducing the amount of imported commercial feed you need to buy. This locally sourced throw-away product can also be made into a high quality, organic liquid fish fertilizer for use on fields, in fish ponds, hydroponic systems, and maybe even added carefully back into the oceans to promote primary productivity for greater harvests from our oceans. You will also help our environment by fully using the wild fish caught, without any waste being dumped in to the landfills or pumped and dumped into the ocean.

Warren G. Dominy, Ph.D.

Aquafeed.com LLC

# FISH PROCESSING WASTE (FPW) SUPPLEMENTAL FEED & FERTILIZER PROCESSING

## Supplemental Feed

### Why A Supplemental Feed VS Complete Feed ?

- The Mixed FPW available from the Fish Wholesaler is highly variable in nutrient content especially in fat because of the composition of the raw materials being supplied on a day to day basis.
- A farmer or a small business can still utilize that variable Mixed FPW raw material source that is now being thrown away, by converting it into a supplemental feed or fertilizer to reduce the cost of imported feed and fertilizer that is used in the islands.
- This supplemental feed or fertilizer does not have a guaranteed nutrient content like a commercial complete feed or fertilizer manufacturers sells to a commercial fish farm or vegetable farm for profit.
- Mixed FPW quality is dependent on handling and the cold chain temperature control of the raw material. High quality FPW = feed, Low quality FPW = fertilizer

### Quality and Nutrient Content of FPW
### As collected from the Fish Wholesaler's plant (<40°F)

| | | TUNA | NON TUNA | MIXED est. |
|---|---|---|---|---|
| | | 100% | 100% | 60 / 40 |
| Feed Ingredient | | FPW | FPW | FPW |
| **Specifications** | | 60% | 40% | |
| | | | | |
| Total Volatile Nitrogen (TVN) - Raw | mg/100g | 58.2 | 52.3 | 62.04 |
| | | | | |
| Protein | % | 57 - 76 | 47 - 64 | 53 - 71 |
| Fat | % | 6 - 18 | 16 - 33 | 10 - 24 |
| Moisture | % | 4.2 | 6.0 | 4.90 |
| Ash | % | 15.7 | 12 - 15 | 14.87 |
| Salt & Sand | % | na | na | na |
| FFA | % | 4.8 | na | 4.8 |
| Histamine | ppm | na | na | na |
| Digestibility | % | pending | na | pending |
| Soluble Protein | % | 15.0 | na | 15.00 |

Making a supplemental feed is essentially the same process that is used to make fish balls for human consumption. In Asia fish balls are made by grinding up fresh, boneless white fish fillets and mixing it with salt and a starch source to make a fish paste, then forms the fish paste into a fish ball and cook it in hot water (not boiling). This is a common, well-known process throughout Asia that can be made with off the shelf equipment that can convert FPW into a fish or crustacean feed.


There are numerous examples of the fish ball manufacturing processes for human consumption in Asia. YouTube videos listed below are processes for small home scale, small scale commercial, and large-scale commercial production of fish ball production.

**Small home scale (Hong Kong)**
https:/ /www.yo utube.co m/ watch?v =pShigxVv AP w

**Small commercial scale (Indonesia)**
https:/ /www.yo utube.co m/ watch?v =e666xjfGh9U
https://www.youtube.com/watch?v=IEcyItI6ZB8

**Large commercial scale fish ball production line (Ding-Han Machinery, Best World Equipment)**
https:/ /www.yo utube.co m/ watch?v =W-eCcv 6Knqw
https:/ /www.yo utube.co m/ watch?v =y uoMb6J_KFM

The Aquafeed.com LLC supplemental fish feed process uses the same process for making fish balls for human consumption, the only difference is that the raw material used is Fish Processing Waste (FPW) that is fresh high-quality muscle tissue, bone, skin, cartilage, ligaments, fins and tail that finely ground. This is mixed with salt and a starch source to form a fish paste, the paste is formed and cooked to denature the fish protein to form a water stable, supplemental fish feed.

The leftover FPW with reduced quality parameters that are not suitable for making a supplemental fish feed is digested with beneficial microbes into a live organic liquid fish fertilizer.

## RAW MATERIALS


## RAW FPW MATERIAL

Mixed FPW (muscle tissue, heads, bone, cartilage, ligaments, tails, and fins) is ground through an Autio 1101 GH, 50 Hp. motor meat grinder w/ a 1” die plate.

## GROUND FPW IS TRANSFERED TO FEED PROCESSING LAB MAINTAINING THE COLD CHAIN AND QUALITY OF FPW



## THE FPW IS REGROUND BY A MEAT GRINDER AND A BONE PASTE GRINDER

This reduces the particle size of bones, head, tail, fins, cartilage, and ligaments, first reduce with a meat grinder, then use a bone paste grinder (colloidal mill) for the fine particle size reduction.


**MEAT GRINDER** **BONE PASTE GRINDER**

# PROCESSING THE FPW FOR FINE PARTICLE SIZE

**RAW FPW GROUND BY A HOBART 4146 5-HP MEAT GRINDER WITH 5/32” DIE HOLE PLATE**

**GROUND FPW AFTER A MEAT GRINDER WITH A 5/32” DIE PLATE**

**GROUND FPW FROM A MEAT GRINDER 5/32” DIE PLATE THEN GROUND THROUGH A 10-HP BONE PASTE GRINDER**

**FPW AFTER A BONE PASTE GRINDER FINELY GROUND FPW**

## CURRENT FEED FORMULATION AND PROCESSING

8 kg of FPW (~20% dry matter) = 1,600 grams

| | | |
|---|---|---|
| FPW | 1,600 grams FPW | 73% |
| | 45 grams salt | 2% |
| | 548 grams wheat flour | 25% |
| | 2,193 grams | 100% |

Wheat flour and salt are added to the ground up FPW and mixed vigorously for 20 minutes until the proper consistency of the wet sticky fish paste mixture is achieved, this will vary according the fat composition of the FPW. The mixture of the FPW and other ingredients will form a fish paste, then it is formed into fish balls by hand or extruded through a meat grinder to form feed pellets or formed through a piping bag or cooked into small granules forms like cooking hamburger for tacos. The fish ball, pellet, or granular form is cooked in hot water (80-90$^{o}$C) which denatures the fish protein and gelatinizes the starch and produces a semi-moist water stable finished product. The semi-moist feed is ambient air dried in a forced air-drying cabinet, targeting a water active level (Aw) of 0.6-0.7.

## MIXERS USED TO CREATE A FISH PASTE


**5-QUART KITCHEN AID MIXER**

**30-QUART THUNDERBIRD MIXER**


Cooked fish balls - Moisture 64.6%, Dry Matter 35.4%  Aw 0.99, prior to air drying. Drying feed down to Aw 0.6-0.7.  As feed air dries color of feed darkened.

# AMBIENT AIR-DRYING CABINET WITH FANS

## SOLAR DRYING FEED

## SOLAR DRYING FEED WITH FAN

# FISH PROCESSING WASTE (FPW) SUPPLEMENTAL FEED & FERTILIZER PROCESSING

## Supplemental Feed Variations

8 kg of FPW (20% dry matter) = 1,600 grams FPW

| | |
|---|---|
| 1,600 grams FPW | 73% |
| 45 grams salt | 2% |
| 548 grams wheat flour | 25% |
| 2,193 grams | 100% |

Wheat flour and salt are added to the ground up FPW shown in the above formula and mixed vigorously for 20 minutes until the proper consistency of the wet sticky fish paste mixture is achieved; this will vary according the fat composition of the FPW. The fish paste is formed into fish balls by hand or form into feed pellets through a piping bag to make a floating feed. Feeds can also be made without making a fish paste: small granules feed forms can be made like when cooking hamburger for tacos. There is also the precooked and semi-dried FPW patties that can be formed into feed pellet strands without sticking together as they are extruded from the meat grinder die plate. All feed - fish ball, pellets, or granular feeds are cooked in hot water (85-95$^{o}$C), which denatures the fish protein and gelatinizes the starch and produces a semi-moist, water stable finished product. The semi-moist feed is ambient air dried in a forced air-drying cabinet, targeting a water active level (Aw) of 0.6-0.7. If water activity (Aw) is higher than this range of 0.06-0.07 refrigerate product.

# ALTERNATE FORMS OF FEED

## FLOATING PELLETS BY A PIPING BAG


Fill fish paste in Ziplock bag cut a small hole and squeeze or use a commercial pipping bag to pipe out a strand of fish paste into the hot water. The longer it cooks the more the pellets expand and get less dense to become a floating feed.

# PELLET WATER STABILITY 60 MINUTES

## (Fish Paste Feeds)

**35% TILAPIA FEED** **40% TROUT FEED** **SUPPLEMENTAL FPW FEED**

**ALTERNATE FORMS OF FEEDS NOT MADE WITH A FISH PASTE BUT WITH THE SAME INGREDIENTS WITH A MEAT GRINDER**

Semi-cooked & semi-dried patties are formed into pellet strands that don't stick together when exiting the die plate.

Meat grinder formed noodle-like strands are dried then broken up into pellets

**ALTERNATE FORMS OF FEEDS NOT MADE WITH A FISH PASTE BUT WITH THE SAME INGREDIENTS WITH A MEAT GRINDER**

Ground FPW cooked into a granular form
like ground beef being cooked for tacos

Cooked FPW granules can be screened to different feed sizes

# PROBLEMS ENCOUNTERED IN FPW

## HIGH OIL CONTENT

**SOLUTION:**

Remove as much of the free pooling oil from raw FPW, the fish paste, or the ground FPW as possible, also remove oil during cooking process.

# PROBLEMS ENCOUNTERED IN FPW

## PARTICLE SIZE REDUCTION OF HARD AND TOUGH FISH BODY MATERIAL; HEAD, TAIL, FINS, CARTILAGE & LIGAMENTS

**SOLUTION:**

For reducing the particle size of hard and tough bones, head, tail, fins, cartilage, and ligaments. First reduce size with a meat grinder ~ half inch die plate hole size for each pass (1” to ½” to ¼”) then use a bone paste grinder (colloidal mill) for the final fine particle size reduction.

# FISH PROCESSING WASTE (FPW) SUPPLEMENTAL FEED & FERTILIZER PROCESSING

## Liquid Fish Fertilizer Anaerobic & Aerobic Digestion

### Commercial LIQUID FISH FERTILIZER


Nutrients

| NPK 5 • 1 • 1 | |
|---|---|
| Total Nitrogen | 5.0% |
| Available Phosphate ($P_2O_4$) | 1.0% |
| Soluble Potash ($K_2O$) | 1.0% |
| Dry Solids est. | 40% |

**Derived from Fish Solubles**

~ 50% dry solids, acidified w/ $H_2SO_4$ and/or $H_2PO_4$ to ~ pH 4.

## Liquid Fish Fertilizer Imported into Hawaii




# Fertilizer made From Fish Processing Waste (FPW)

Consists of fish carcasses, viscera, heads, gills, bone, tail, fins, skin, scales, cartilages and ligaments which are discarded parts from a fish processing plant.

## Sourcing FPW from Small Island Businesses

Fish Wholesaler w/ grinder

Restaurants, Retail Fish Counters

# FPW into a Liquid Fish Fertilizer

**(Anaerobic digestion)**

Ground FPW from Fish Wholesaler

↓

Regrind FPW to reduce particle size with a meat and a bone paste grinder

↓

Mix 3kg FPW + 1-liter extended EM-1 (1:20) + make up to 5-gals with dechlorinated water

↓

Anaerobic digestion generates gas, and container needs to be vented
Stir every other day and in 7-10 days fermentation will be completed and the pH should drop to pH 4
Must mix to break up floating sponge like layer that forms on top of liquid

↓

Sample for NPK , minerals, solids

EM-1 = Effective Microbes

# EM-1® Beneficial Micro-organisms, Concentrated Solution

EM® is made up of 3 main genera: phototropic bacteria lactic acid bacteria and yeast. This specific group of naturally occurring beneficial micro-organisms was formulated over 30 years ago by Dr. Teruo Higa at the University of Ryukyu in Okinawa.


EM-1® Liquid Fish Fertilizer

- 5-gallon bucket
- 3 kg ground FPW
- 1-liter of extended EM-1® (1:20 ratio)
- 1-liter molasses
- 20 grams of WSR
- Make up to 5 gals with dechlorinated water

# FPW into a Liquid Fish Fertilizer

(Aerobic digestion)

Ground FPW from Fish Wholesaler

↓

Regrind FPW to reduce particle size with the meat grinder and a bone paste grinder

↓

Mix 6-7 kg + 1-2 liters molasses +20grams of Keeton Industries, WSR™ microbes
+ add dechlorinated water up to 4-gallons and aerate mixture

↓

Aerobic digestion, air generated needs to be vented
Digestion should be completed in 72 hrs. but leave and aerated for 5-10 days
Must mix to break up the thick emulsified fat layer that forms on top of liquid

↓

Sample for NPK , minerals, solids

WSR ™= Waste Sludge Reducer

## Keeton Industries Beneficial Microbes, Waste & Sludge Reducer (WSR™)

Keeton Industries has identified several special spore forming microbial strains uniquely capable of remediating specific, detrimental water conditions. All beneficial microbes (*Bacillus amyloliquefaciens, Bacillus licheniformis, Bacillus pumilus, Bacillus subtilis) are blended using single species culture to ensure optimum growth and to avoid contaminants, before the different species are blended together*


WSR Liquid Fish Fertilizer

- 5-gallon bucket
- 6-7 kg ground FPW
- 1-2 liters molasses
- 20 grams of WSR
- Make up with dechlorinated water up to 4 gal*
- Aerate 7-10 days

* Space to keep emulsion from overflowing bucket

Aerobic digestion with WSR dry microbes

2 -5-gallon buckets in each of the 50-gallon rubbish bags. Needle holes were made all over the plastic bags to let out air, diffuse any concentrated odor source to inhibit flies from laying eggs and growing maggots on the splattering of any over flow of FPW from buckets.

## RESULTS *


**TOP**
Emulsion of Air, Protein & Fat


**MIDDLE**
Liquid Fish Fertilizer

**BOTTOM***
Undigested Bone, Fins & Ligaments

Middle Layer will settle out into 2 layers a clear dark reddish-brown liquid and a milky opaque bottom layer of undissolved tissue fibers which over time decreases as it is broken down into a clear dark reddish - brown liquid.

* Bone paste grinder not used in the WSR treatments shown above, shows course bone particles.

# CALCULATIONS TO DETERMINE CARBON: NITROGEN (6:1)

## Recommended For 5 Gallon Bucket

| Carbon Source | Available C | Required Organic Carbon |
|---|---|---|
| Molasses* | 24.0% | 5,769.23 mL |
| White sugar | 42.1% | 4,275.53 g |
| Lactose | 42.1% | 4,275.53 g |
| Dextrose | 40.0% | 4,500.00 g |
| Glucose | 40.0% | 4,500.00 g |
| Acetate | 40.0% | 4,500.00 g |
| Glycerol | 39.1% | 4,603.58 L |
| Cellulose | 44.4% | 4,054.05 g |
| Starch | 44.4% | 4,054.05 g |
| Cassava meal | 43.4% | 4,147.47 g |
| Corn flour | 43.4% | 4,147.47 g |
| Rice brane | 43.4% | 4,147.47 g |
| Sorghum meal | 43.4% | 4,147.47 g |
| Tapioca | 43.4% | 4,147.47 g |
| Wheat flour | 43.4% | 4,147.47 g |
| Wheat brane | 43.4% | 4,147.47 g |

* Assuming 24% W/W carbon concentration and specific weight of 1.3 g/ml

**PER 5-GALLON BUCKET**

## ANAEROBIC DIGESTION: EM-1

3 kg FPW wet @ 0.20% DM = 0.6 kg DM
FPW is ~ 50% CP /6.25 = ~ 8 % nitrogen
(0.6 KG FPW DM) * (8 % N) = .048 kg of nitrogen or ~48 grams N
Molasses weight ~ 1.3 grams/ ml. Therefore 1 liter of molasses is 1.3Kg (24% carbon) = 312 grams carbon
Add 1 liter 1:20 extension of EM-1
Carbon to Nitrogen ratio 6.5:1

## AEROBIC DIGESTION: WSR

6 kg FPW wet @ 0.20% DM = 1.2 kg DM (FPW is ~ 50% CP /6.25 = ~ 8 % nitrogen)
(1.2 KG FPW DM) * (8 %) = .096 kg of nitrogen or ~100 grams N
Molasses weight ~ 1.3 grams/ml. Therefore 1-liter of molasses is 1.3Kg (24% carbon) = 312 grams carbon was used in test. However, add 2-liters of molasses for the recommended C:N ratio from Keeton.
WSR add 20 grams and add up to 4 gals of dechlorinated water and aerate vigorously
Carbon to Nitrogen ratio 3:1 w/ 1-liter molasses tested at.
Carbon to Nitrogen recommended, 6:1 per Keeton Industries, with 2-liters of molasses.

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**Volunteers and Supporters:**

Mr. Mark Mitsuyasu, Fisheries Program Officer / Bottom Fish Coordinator, Western Pacific Region Fishery Management Council.

Garden & Valley Isle Seafoods, Inc., Honolulu: Mr. Robert S. Fram, President; Mr. Wendell Bukida, Operations Manager; Mr. Festos Phichiol, Receiving Supervisor; and Mr. William William.

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This manual was developed as part of the project "Development of a Supplemental Feed and Fertilizer from Fish Processing Waste for Island Farmers and Small Businesses for Sustainable Aquaculture and Agriculture" and funded by Fisheries Development and Utilization Research and Development Grants and Cooperative Agreements Program, under a Saltonstall Kennedy award (NOAA-NMFS-FHQ-2016-2004617).

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