FISH SILAGE TRIALS IN HONG KONG

by

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Abstract

Production of silage for animal feed by acidification of whole fish or offal was investigated as a means of utilizing periodic gluts including small purse-seined fish. Fifty-three samples, each of 4-10 kg, were selected over 14 months and subjected to various degrees of comminution. Samples were hand-mixed in a plastic bucket with quantities of 85 percent formic acid, usually 3.5 percent by weight, and kept indoors in covered buckets at ambient temperatures of 10–30°C. All whole fish liquefied satisfactorily; offal tended to liquefy at a slower rate, have a more pungent odour and appeared to need more than 3.5 percent acid. Comminution was unnecessary for small fish, e.g. anchovies (*Stolephorus* spp.), but filefish (*Monocanthus* spp.) and offal needed mincing. Scads (*Decapterus* and *Trachurus* spp.) and similar fish of 10-15 cm length needed mincing in the winter, but a coarser comminution, or none at all, was adequate in the summer. Stirring facilitated liquefaction, which varied in speed from 12 h to five weeks. Final viscosity varied; scads producing a glutinous product in the winter, anchovies a watery liquid. Whole fish silages maintained a pleasantly malty smell for one to six months. Deterioration involved the formation of a mould (*Aspergillus*) or infestation with a small dipterid fly. Crude protein was assayed at 15.6-17.0 percent and fat at 1.2-7.0 percent for whole fish. A limited trial showed that whole fish silage supported adequate growth in weaner pigs when incorporated in a cereal-based feed. Possible lines of future development including a small-scale plant for mechanized batch production are discussed.

INTRODUCTION

Fish silage, or liquid fish protein as it has been called, has been widely studied in temperate areas (Tatterson and Windsor, 1974) and 25,000 tonnes were produced annually in Denmark by 1972 (Disney, Tatterson and Olley, 1977). Recently the Tropical Products Institute, London, has developed a dried silage product for use in the tropics, utilizing cheap local vegetable products, e.g. cassava, as a source of energy in the preparation of simple animal feed at the village level (Disney, Tatterson and Olley, 1977). Hong Kong has an inshore purse seine fishery for small pelagic fish andthe catch serves a variety of uses, the majority nondomestic and including bait fish, aquaculture and pig feeds. Periodic gluts occur, the surplus goes either to waste or for use as cheap fertilizer. Trials were initiated to determine whether a better return could be achieved by using the fish to produce fish silage. These were subsequently extended to include demersal fish and fish offal.

MATERIALS AND METHODS

Small pelagic fish landed chilled from purse seiners within 12 h or capture were the original target of the trials but other chilled pelagic species from trawlers and offal from demersal and pelagic fish, used in the manufacture of fish balls, were also used, as shown in Table 1.

The offal comprised either heads and guts removed by hand or the skin and frames remaining after treatment in a meat/bone separator. Following U.K. practice (Tatterson and Windsor, 1974), commercial-grade formic acid (85 percent) was used exclusively.

The raw material was mixed with acid in batches of 4-10 kg in 20 1 low-density polythene buckets. Initial comminution, when carried out, was either by chopping with a butcher's knife or by mincing using a domestic hand mincer on a coarse setting. Acid was gradually added to the raw material from a 500 ml measuring cylinder and the mixture was stirred with a wooden paddle for about 5 min or until thorough mixing was considered to have been achieved. Generally, a quantity of acid equivalent to 3.5 percent by weight of the raw material was used to produce a pH of 3.5-3.9 in whole fish silages but other percentages ranging from 2.5-4.5 percent were also tested.

Table 1

Raw material used in silage treatments

Family	Common name	Scientific name	Number of samples	(Treatments)
Clupeidae	Gizzard shad	*Clupanodon punctatus*	1	(2)
	Sardine	*Sardinella jusseui*	1	(1)
	Sardine	*Sardinella perforata*	2	(3)
	Sardine, mixed	*S. jussieui/perforata*	1	(1)
	Round herring	*Dussumieria basseltii*	1.5	(3)
Engraulidae	Anchovy	*Stolephorus* spp.	6	(10)
	Long-jaw anchovy	*Thrissa dussumieri*	3	(3)
Apogonidae	Cardinal fish	*Apogon quadrifasciatus*	1	(1)
Carangidae	Scad	*Decapterus maruadsi*	4.5	(7)
	Scad	*Trachurus japonicus*	5.5	(8)
	Scads, mixed	*Decapterus* and *Trachurus*	2	(3)
	Scads, mixed	*D. maruadsi* and *Caranx kalla*	1	(1)
Leiognathidae	Slipmouth	*Leiognathus bindus*	1	(3)
	Slipmouth	*Leiognathus insidiator*	4	(5)
Scombridae	Slimy mackerel	*Scomber japonicus*	1	(2)
Balistidae	Filefish	*Monocanthus* spp.	2	(5)
Tetraodontidae	Puffer fish	*Tetraodon* spp.	1	(1)
Fish offal	Mixed fish		2	(2)
	Yellow belly	*Nemipterus bathybius*	5	(6)
	Croakers	Sciaenidae	1	(2)
	Lizard fish	*Saurida* spp.	3	(3)
	Crevalle	*Caranx equula*	1	(2)
	Sea bream	*Evynnis cardinalis*	1	(2)
	Hairtail	*Trichiurus haumela*	1	(1)
Total			53	(77)

The mixture was stored in the mixing bucket covered with a loose-fitting lid and allowed to stand in a well-ventilated, non-air-conditioned room. An alternative form of storage, in filled airtight polyethylene containers of 3.5 l total capacity held in an air-conditioned room at 25°C, was investigated halfway through the trial.

Only subjected tests were used to assess the degree of maturity, freshness and palatability of the silage. Table 2 shows the criteria used to determine the four stages of maturity. Freshness was generally tested by smell, a pleasant malty odour being typical of a sterile, palatable product, although offal silage was generally more pungent. Putrefactive odours were seldom detected in isolation from other signs of deterioration, but generally followed the appearance of dipterid maggots or the growth of an *Aspergillus* mould. Quantities of fat in the raw material induced a slightly rancid smell in the silage. Measurements of pH were carried out infrequently, initially by pH paper and later by meter. Proximate analyses were carried out by the Government Laboratory, Hong Kong. Fat content was assayed more extensively by staff and undergraduates of the Chemistry Department, University of Hong Kong. Two methods of fat assay were used. For mature silage, the sample was homogenized in saturated aqueous sodium chloride and petroleum ether, and the fractions were separated physically, the aqueous layer being re-extracted with petroleum ether. The organic extract was dried over anhydrous sodium sulphate, filtered, and the solvent removed under reduced pressure. For raw fish, a sample of minced fish was blended with a 2:1 mixture of methanol and chloroform and the resultant mixture was allowed to equilibrate before being subjected to a similar extraction process. Differences in results from the two methods are attributable to differences in the polarity of the respective solvents used and to the polarity of the lipids thereby extracted.

Table 2

Maturity stages of silage

Stage	Description
1	Most fish bodies without obvious sign of disintegration (applies to whole raw material only)
2	A few fish bodies still basically undigested (applies to whole raw material),or skeletal parts still with some flesh adherent (applies to comminuted raw material)
3	Slurry with most skeletal parts undigested
4	Material homogeneous, when stirred, except for a few eye lenses and other hard parts. Viscosity variable

Air temperature were taken either from the records of the Royal Observatory, Hong Kong, or from a minimum-maximum mercury thermometer installed at the storage site.

RESULTS

Degree and speed of liquefaction

All samples of whole fish liquefied satisfactorily before deterioration occured, except for samples of filefish (*Monocanthuss* spp.) that had been given little or no initial comminution. Salted anchovies ((*Stolephorus* spp.) also failed to liquefy but both genera liquefied satisfactorily when treated differently. The viscosity of the prepared silage has not been considered in the arbitrary classification of liquefaction. It ranged, however, from an almost watery consistency when derived from anchovy to that of a heavy, jelly-like slurry when produced from scads (*Decapterus* or *Trachurus* spp.) in the winter. Besides manifesting interspecific variation, viscosity also varied according to season and to the degree of initial comminution, although few objective observations were made. In the early stages, some silage yielded a clear supernatant (up to 10-15 percent of silage volume) above a dense settled mass of semi-digested material; other silages even of the same species were almost homogeneous and showed little sign of separation.

The time taken for each sample to undergo complete liquefaction varied from two to over 90 days, as indicated in Fig. 1. Whole fish treated in winter or spring took longer to liquefy than in summer, e.g., from one to two months in spring but only from one to two weeks in May-July 1977. Chopped or minced fish liquefied slightly faster than whole fish of the same species except in the case of smaller pelagics, such as anchovies or young scad, which did not require comminution. Interspecific differences in the speed of liquefaction may be the result of differences in body size rather than in chemical composition. However, whole fish with tough or scaly exteriors such as filefish took longer to liquefy than other species. Fish offal took longer to liquefy than whole fish; one month was the shortest period. Furthermore, the resultant silages often had a much stronger odour, due in part to the semi-digested gut contents of some of the larger species involved. Several offal silages tended to putrefy before liquefaction was complete, possibly because the volume of acid used (3.5 percent as for whole fish) was insufficient to cope with the large proportion of the raw material that was calcareous, resulting in a pH greater than 4.0.

Storage life

The storage life of silage as measured from the date of its preparation is shown in Fig. 2. The period of freshness or palatability shows seasonal changes similar to that for liquefaction (Fig. 1). Spoilage occured more rapidly during the warn, humid summer months; in June-July some samples of scad spoiled within two weeks. On the other hand, samples of sardines maintained a good condition for over 12 months, retaining a good odour to the end, apart from a rather greater rancidity than in the initial stages. Anchovy silage was notable in not becoming infested with dipterids. These insect larvae were tolerant of a pH as low as 3.0. Besides dipterid infestation, the most common cause of deterioration of quality was the growth of *Aspergillus* mould, initially on the exposed internal surfaces of the container and in later stages as an encrustation on the silage itself.

Promixate analysis

The results of the proximate analyses conducted on fully liquefied silages are shown in Table 3. As expected, the values were similar to those of raw whole fish or offal.

Crude protein content was remarkably constant at 15.6-17.3 percent; only anchovy at 11.8 percent fell outside this range. Protein percentage for offal sillages were close to the bottom of the range for whole fish.

Table 3

Proximate analysis of silage at periods of 21-90 days after preparation[a/]

Common name	Sample month	Composition in silage by weight (%)				pH	Scientific name
		Crude protein	Fat	Ash	Water		
Sardine	September	15.98	3.83	3.21	74.14	3.91	*Sardinella jussieui*
Sardine	October	15.81	1.23	3.66	77.01	3.91	*Sardinella jussieui*
Long-jaw anchovy	November	15.99	10.39	8.76	67.89	3.96	*Thrissa dussumieri*
Anchovies	June	11.76	1.45	2.95	81.25	3.80	*Stolephorus* spp.
Scads	July	15.59	3.39	3.43	75.74	3.76	*Trachurus japonicus*
Scads	August	16.64	5.65	3.41	74.09	5.75[b/]	*Trachurus japonicus*
Scads	August	17.28	2.59	3.59	73.76	4.05	*Decapterus maruadsi*
Slipmouth	October	16.64	2.87	3.34	83.38	3.93	*Leiognathus insidiator*
Slipmouth	November	16.69	1.61	3.95	78.00	3.93	*Leiognathus insidiator*
Slimy mackerel	April	16.60	2.25	2.80	76.80	3.90	*Scomber japonicus*
Offal from lizard fish	May	15.10	3.49	5.40	72.70	4.20	*Saurida* spp.
Offal from yellow belly	June	15.70	4.41	8.20	69.50	4.40	*Nemipterus bathybius*

a/ Analysis carried out by the Government Chemist, Hong Kong

b/ 2.5 percent acid in original mixture

Fat content was more variable than protein content, ranging from 1.2-5.7 percent in nine of the ten samples of whole fish and in the upper half of this range for offal. A sample of long-jaw anchovy (*Thrissa dussumieri*) had a fat content double that of the next highest value. A more intensive screening of 48 samples for fat content was carried out, the results of which are shown in Table 4. The highest fat contents recorded for fish offal were 6.9 and 8.1 percent respectively, although for raw fish one sample (of scad) was assayed at 9.3 percent. In general the highest fat values occurred between July and September, and the lowest between April and June.

Temperature

Hong Kong undergoes marked seasonal changes in temperature despite its maritime location. Five-day minima, maxima and means of air temperature at two locations are shown in Fig. 3. The longest series of data available is that from the Royal Observatory in the centre of the urban area. Records are also available for part of the duration of the trials from the experimental site at the Aberdeen Fisheries Office; this site has less extreme values with a maximum of 31.5°C in June and July but values are not available for the coldest period, which the Royal Observatory records demonstrate was January and February, with minima of between 5.5 and 7.0°C. Five-day mean values correspond closely for the two sites and range from 9.5°C in February to 30.5°C in August.

DISCUSSION

Only with offal was there any difficulty in achieving liquefaction and preservation using 3.5 percent of 85 percent formic acid. This probably resulted from the substantial proportion of calcareous matter contained in the offal and was improved considerably by mincing. James, Iyer and Nair (1977) found that 5 percent of 98 percent formic acid was required to maintain a pH of no greater than 4.0 in silage produced from *Leiognathus* sp. Present trials, however, including those on the same genus, suggest that even 3.5 percent of 85 percent formic acid is excessive for whole fish and that a concentration of 2.5-3.0 percent may be adquate. On the other hand, for some offal a concentration of up to 4 percent or greater may be necessary.

It must be presumed that the marked seasonal changes in temperature shown in Fig. 3 are responsible for the seasonal differences in the rate of liquefaction (Fig. 1), final viscosity and tendency to spoil (Fig. 2). Rigorous comparison of changes in such parameters with temperature is made difficult by variation in the raw material and degree of comminution; Table 5 summarizes the speed of liquefaction and deterioration of two important groups of raw material at different times of the year and temperatures. It would appear that the critical temperature for liquefaction is about 25°C; below this point it takes several weeks, above it only a few days.

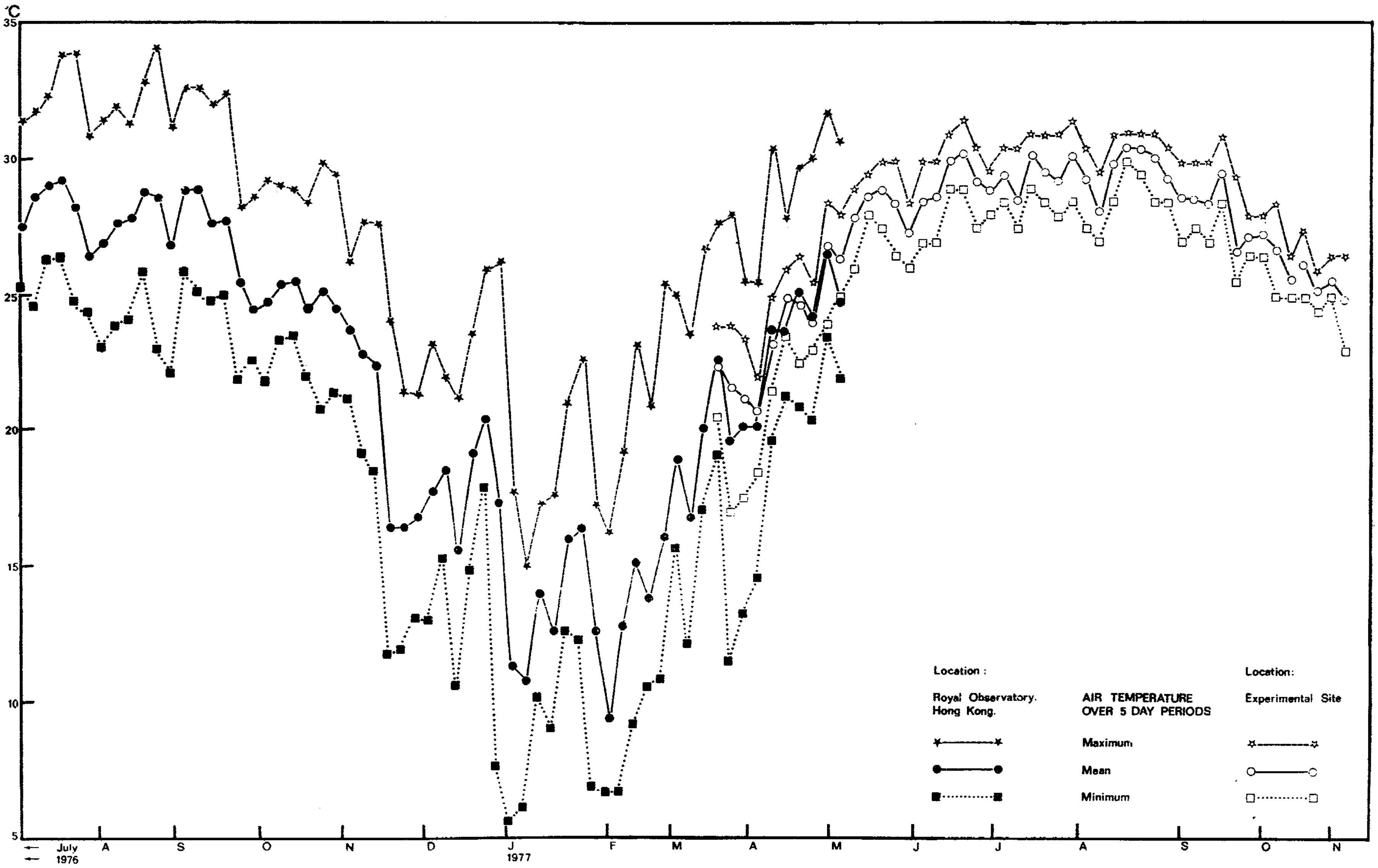
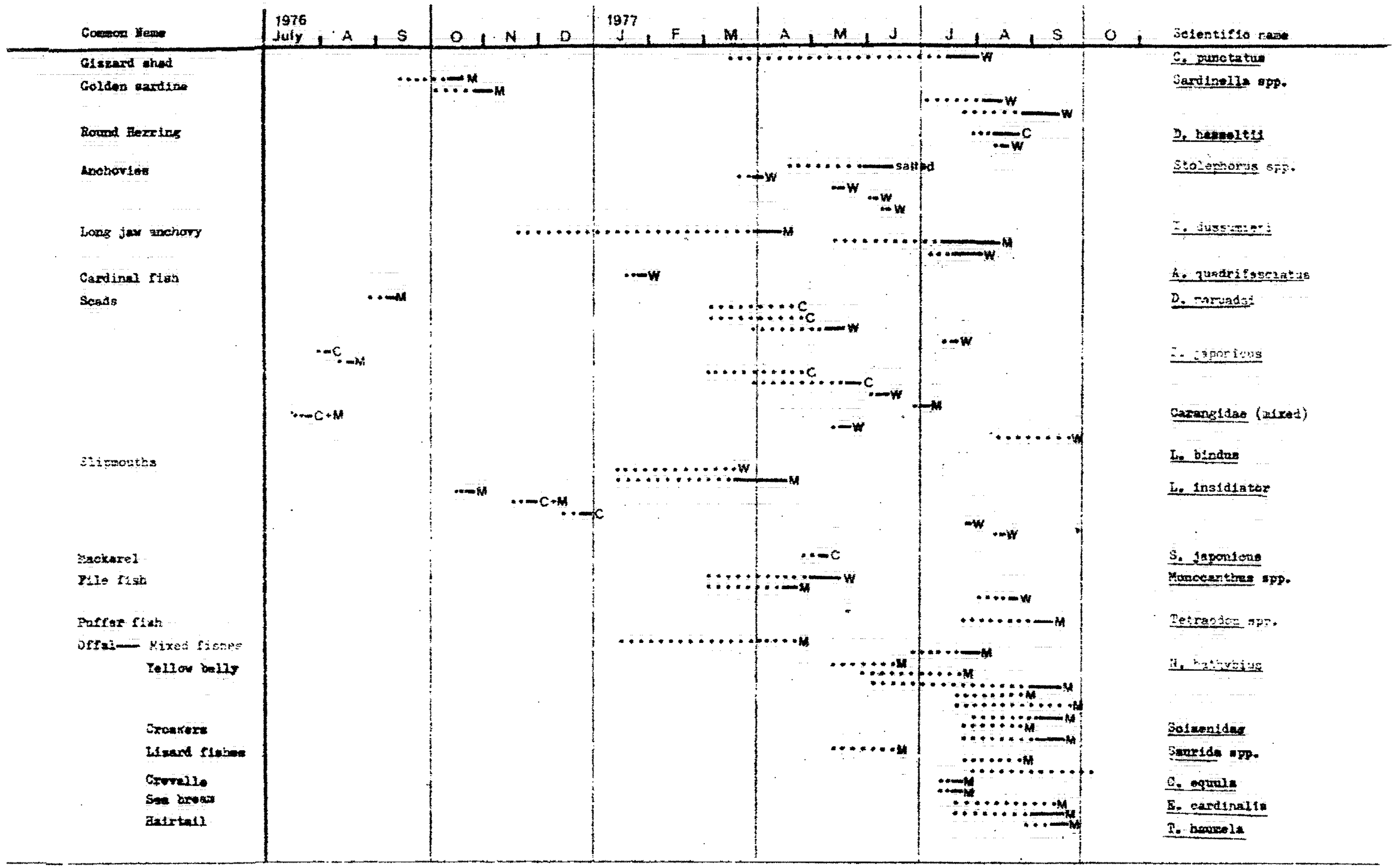
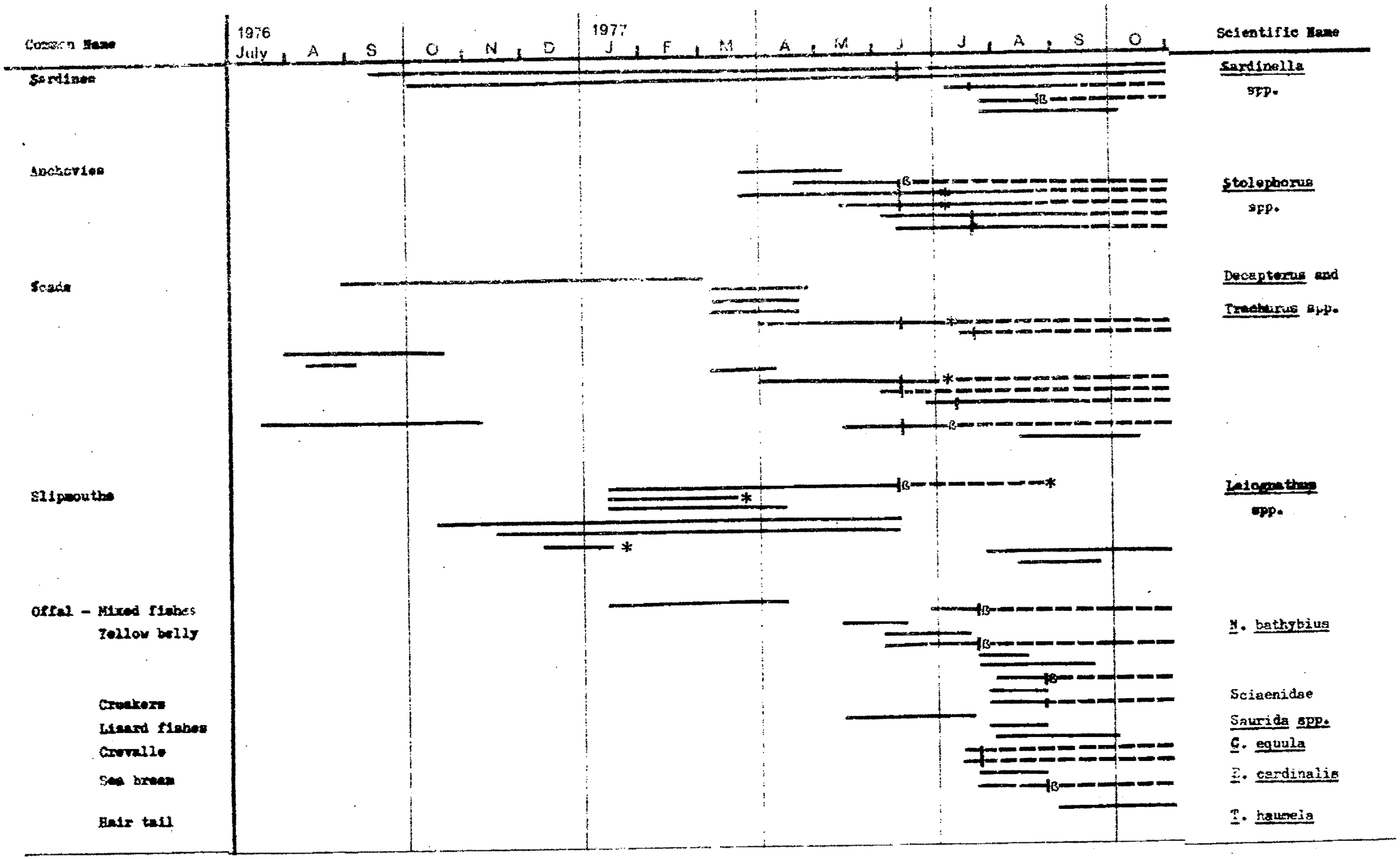


Figure 3 – Five-day means, minima and maxima of air temperature at two locations in Hong Kong



*W, C, or M after each record denote that treatments were on Whole(not comminuted), Chopped or Minced material respectively

Figure : The time taken for material to reach partial (Stage 1-3: dotted line) and full (Stage 4: solid line) liquefaction in silage treatments by species, season and degree of initial comminution.



Vertical line indicates that a sub-sample was transferred to an air tight container,

ß that deterioration had begun at the time of transfer,

* that the sample was withdrawn for use before deterioration had begun.

Figure 2 — The duration of storage of fish silage in good condition in loosely covered (solid line) or air tight (dashed line) polyethylene containers

Table 4

Fat content of silage by species[a/]

Common name	Range of fat content	Number of samples assayed	Month of highest fat content	Remarks	Scientific name
Gizzard shad	3.0–4.9	2	September		*C. punctatus*
Sardines	1.2–4.5	5	July	2 samples also assayed raw	*Sardinella* spp.
Round herring	1.9–2.6	2	August	Samples also assayed raw: one at 5.4% (July)	*D. hasseltii*
Anchovy	1.2–3.1	5	March	–	*Stolephorus* spp.
Long-jaw anchovy	0.77–4.6	2	July	3 samples also assayed raw: onc at 6.6% (July)	*T. dussumieri*
Cardinal fish	4.6	1	January	–	*A. quadrifasciatus*
Scads	0.9–6.9	13	March	1 sample also assayed raw: 9.3% (July)	*Decapterus* spp./ *Trachurus*/*C. kalla*
Talang	5.1	1	September	–	*Chorinemus lysan*
Slipmouth	1.3–3.8	6	September	1 sample also assayed raw: 4.2% (September)	*Leiognathus* spp.
Slimy mackerel	2.1	1	April	–	*Scomber japonicus*
Filefish	1.2	2	–	1 sample also assayed raw: 1.9% (August)	*Monocanthus* spp.
Puffer fish	1.8	1	July	–	*Tetraodon* spp.
Offal from:					
Yellow belly	3.3–5.9	5	May	–	*Nemipterus bathybius*
Croakers	2.6	1	July	Heads and guts only	*Sciaenidae*
Lizard fish	0.6–3.8	2	May	–	*Saurida* spp.
Crevalle	6.3	1	July	–	*Caranx equula*
Sea bream	2.4	1	July	–	*Evynnis cardinalis*
Hairtail	6.5–8.1	2	August	–	*Trichiurus haumela*

a/ Analysis carried out by the Chemistry Department, University of Hong Kong

Table 5

The time taken for fish samples to liquefy and the storage life of he resultant silage as related to the date of preparation and ambient temperature

Fish material		Modal length (cm)	Date of preparation (1977)	Number of days to reach			Mean ambient temperature		
				liquefaction stage 3	liquefaction stage 4	onset of deterioration[a/]	at date of preparation	after 1 week	after 1 month
Anchovy (*Stolephorus* spp.)	whole	9	21/03	7	12	84+	22	22	24
	whole	4	13/05	3	6	32+	29	29	30
	whole	4.5	3/06	1	3	36–47	28	31	29
	whole	5	11/06	2	4	9+	31	30	30
Scad (*D. maruadsi*)	whole	17	30/03	21	47–70	16	20	24	26
	whole	15.5	13/07	2	7	7+	30	29	31
Scad (*T. japonicus*)	chopped	19	30/03	21	47–70	21–26	20	24	26
	whole	8	2/06	3	12	12+	28	30	29
	minced	8	2/06	1.5	4	12+	28	30	29

a/ A number followed by + indicates that after that number of days the silage had not begun to deteriorate but was thereafter withdrawn for use

As regards spoilage, it should be noted that the summer months are also marked by a much higher humidity and this encourages spoilage. Fig. 2 indicates a marked difference in perishability between silage stored in loosely-covered and airtight containers, due perhaps, in part, to differences in ambient temperatures at the respective storage sites. However, it is more likely that the longer storage life in the airtight containers is attributable to the lessened opportunity for contamination by mould spores and dipterid adults and the prevention of water vapour and acid exchange with the atmosphere, which would lead to an increase in pH on the unsubmerged inner surfaces of the container. Such surface was more limited in area in the (smaller) airtight containers which were invariably filled to the top.

Utilization of fish silage

Table 3, which shows the proximate analysis of several silages, indicates the value of silage as a high animal-protein feed supplement. Apart from the anomalous sample of anchovy, for which there is no ready explanation as yet, protein values are constant at about 16 percent of wet weight or 60 percent of dry matter. Fat content at 1.3-6.9 percent (4.25 percent of dry matter) is probably not high enough to cause a serious taint problem except at the higher level but may be sufficient to provide a good source of energy in a feed. Bacteriological tests did not indicate the presence of any important pathogens in silage of pH 4.0 or less. *Aspergillus,* however, is apparently tolerant of a fairly low pH and could prove a nuisance in an animal feed. The inhibition of its development in airtight containers indicates that, with careful storage, the problem can be minimized.

A limited palatability and growth trial was carried out over 137 days at Ta Kwu Ling Pig Breeding Centre, New Territories, Hong Kong. Four local-breed weaner pigs with an initial weight of about 8 kg were reared through to about 20 kg; two were on a control diet based on maize with a soybean and meat/bone-meal high protein supplement, and two on a similar diet with silage completely replacing the high protein supplement. Despite not being neutralized, the silage feed was acceptable but growth rate was less than with the control diet. More rigorous trials are planned. Intensive local pig farming yields about 15 percent of Hong Kong's demand for fresh pork and a significant proportion of the industry uses restaurant waste in wet feed systems that could easily be adapted to use wet silage. The major problems facing the ready use of silage in the pig industry are its cost to the farmer, both absolute and relative to protein and energy content, and the possibility of fishy taint in the meat produced. Conflicting evidence arose from overseas trials to assess the occurrence of tainting, though a level of less than 5 percent of fish oil in the animal feed dry matter has been deemed acceptable in the U.K. (Disney, Tatterson and Olley, 1977). To achieve a constant known fat level, the variability of fat content in the raw material indicates it will be necessary to blend silages from different sources. Despite the extra storage space and handling required for blending, it should permit the solution of two further utilization problems.

First, silages occasionally contain hard bones too coarse for the alimentary tract of a feeding animal, e.g., the strong dorsal spines (triggers) of filefish. These disintegrate in time but well after full liquefaction of the remainder; the silage could therefore be used much earlier if the bone was allowed to settle out and the liquid was decanted off. Second, silages of low viscosity, i.e., particularly those prepared from very small fish in the summer, present several problems in use, settle readily into components of different composition and require careful transport to prevent spillage. Blending these with more viscous silages could ameliorate the situation provided that the resulting protein and fat content were suitable. Disney (personal communication) asserts that pigs are quite capable of assimilating silages, particularly those of small soft-bodied fish, well before their full liquefaction. Coarses material, e.g., offal and filefish, would have to be well comminuted; a practice notwithstanding this, essential for thorough acidification.

In the poultry industry most chicken farmers use a dried feed base but duck farming is carried out with a wet feed generally incorporating trash fish. The latter therefore would appear to offer potential for the use of the liquid fish silage. No trials have as yet been conducted.

Commercial production

It has been shown that for all small species, e.g., anchovies, slipmouths, whole fish may be readily hand mixed in small batches to undergo rapid liquefaction, yielding a product with a long storage life. A simple scaling-up of this nonmechanized process, using mixing containers of up to 100 l or more, is possible. Such species constitute only a small proportion of the potential silage material and alone would be insufficient to support a significant year-round demand for feedstuff. The remaining species tested, particularly fish offal, need at least some degree of comminution before acidification and therefore mechanized mixing for quantities greater than 20 kg.

In association with plans to conduct more extensive feeding trials, a pilot-scale plant has been proposed and is illustrated diagrammatically in Fig. 4. Precise control of the proportion of acid to fish material would be difficult in a continuous production plant, hence the proposal involves batch production of 300 kg of raw material per hour; i.e., the methods reported here are scaled up by a factor of 10. A variety of comminuting and or mixing machinery was considered; for large-scale production a type of hasher might serve both comminuting and mixing functions but, for the present, they are achieved by different components. Comminuting is by an electric-powered meat mincer. Mixing will be carried out in a mixer designed for blending meat products, with a mixing bowl of 50 kg capacity that can be tilted to discharge the mixture and mixing achieved by inclined crust of raw material to rise up the container. Supplementary stirring in the maturing containers is, therefore, desirable after initial mixing to ensure the thorough acidification of the raw material. Manual stirring or a simple mechanical stirrer would suffice.

The compact plant, estimated to cost HK.$ 16,000[1], could be installed at an urban wholesale fish market and derive its raw material from processing offal as well as small pelagic and demersal fish landed in excess of normal requirements. Storage and transport will be in 100-l heavy-duty plastic drums which will allow both versatility in mode of transport without expensive handling systems and the ability to separate and, subsequently, blend silages from different material. For blending, a concrete tank of several tonne capacity will also be required.

Economics of production

In Hong Kong there are no fishmeal reduction plants so that the alternative of transporting raw material to such a plant does not exist and the economic viability of silage production may be broadly assessed against the imported cost of fishmeal

Weekly operating costs for the proposed plant illustrated in Fig. 4 have been calculated assuming three hours operation for three days per week at full capacity. Costs are included for the basic alternative raw materials, whole fish and fish offal, and a blend of the two, and it is assumed that these materials may be treated with slightly less acid than during the present trials. Fixed weekly costs including power, labour and delivery of product but excluding capital servicing costs and rental of space, total of HK.$ 315; this ranges from 16-37 percent of delivered cost.

1/ HK. $1 = U.S. $ 0.28 (April, 1978)

Table 6 shows the estimated cost of raw materials for one week's production (2.7 tonnes) and the delivered cost of silage prepared from various raw materials at three possible price levels. The delivered costs may be compared to that of fishmeal of HK.$ 2,280 per tonne. Assuming the fishmeal to have a protein content four times that of silage, its price per unit weight of protein would reduce to HK.$ 570. On this basis, 100 percent offal silages are substantially cheaper than fishmeal; the 1:1 blend of whole fish and offal would also be cheaper. However, only at the lowest raw material price would a 100 percent whole fish silage be cheaper than fishmeal. Such valuations, however, ignore the high-energy value of the fat contained in the silage which would be greater than in the meal.

No statistics are available on the current availability of suitable whole fish at the tabulated prices, although most of the samples reported here were obtained at a higher price than in Table 5. On the other hand, five tonnes of offal are available every day at two urban markets at a price toward the low end of the tabulated range. The fat content of most of the raw material sampled is too low to justify its separation economically, though with some offal reduction of fat content may be desirable from the animal feed view point.

The value of silage production as a method of utilizing fish and their wastes in Hong Kong is seen as the low capital cost of the plant and simplicity of its operation enabling plant to be brought into use easily when the fish supply allows. Should offal prove to yield an attractive animal feed in silage form, then the method would be commercially viable on a regular basis at daily throughputs well below those necessary for a fishmeal plant.

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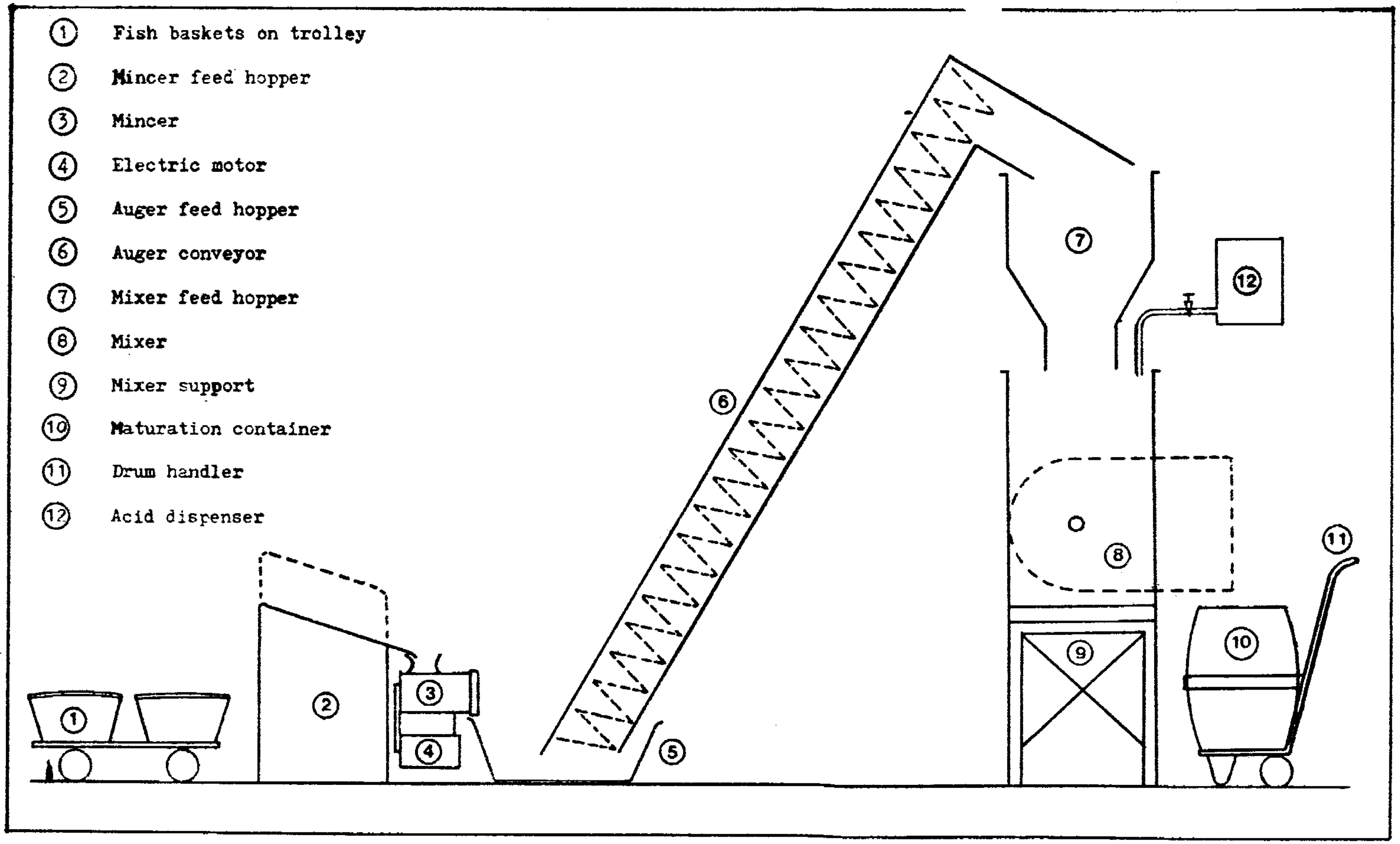

Figure 4 – Diagram of proposed batch-feed pilot scale silage plant of 300 kg/h theoretical capacity

Table 6

Estimated weekly costs of raw materials and delivered products cost in the production of 2.7 tonnes of silage by the proposed silage plant[a/]

Price of raw material (H.K. ¢/kg)	Whole fish	Offal	Whole fish (100%)		Whole fish: offal (1:1)		Offal (100%)	
			Materials cost for one week (HK.$)	Delivered product cost[b/] (HK.$/tonne)	Materials cost for one week (HK.$)	Delivered product cost[b/] (HK.$/tonne)	Materials cost for one week (HK.$)	Delivered product cost[b/] (HK.$/tonne)
Low-price	33	8.3	891	531	558	421	224	311
Medium-price	41	12.4	1 107	611	721	482	335	353
High-price	50	16.5	1 350	700	898	547	445	393
Acid	280		227		265		302	
Quantity of acid used as percentage by weight of raw material			3		3.5		4	

a/ Operating nine hours per week

b/ Inclusive of estimated weekly cost of HK.$ 315 for power, labour and transport