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NINTH REGIONAL TECHNICAL MEETING ON FISHERIES
(Noumea, New Caledonia, 24 - 28 January 1977)

THE SOLOMON ISLANDS FISH SILAGE PROJECT TERMINAL REPORT

by

T.P. Jones

SUMMARY

The Solomon Islands is now in a fortunate position with regard to sources of the main components of animal feeds. What is equally important is that the components are available at low cost. This means that the Solomons has a good foundation for building up its livestock industry. Pig production immediately falls into this category, but further research into the suitability of fish sillage as a poultry feed supplement could well show favourable results.

Although it can be envisaged that a sudden increase in pig production could flood the home market, there is then opened up the possibility of exporting pork. From a small country such as the Solomons this could in the future prove a valuable source of overseas income.

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BACKGROUND

The acid ensilage technique of preserving fish offal for animal feed was originally developed by A.I. Virtanen in the 1920's. Preservation was accomplished by the addition of mineral acids to the fish waste neutralisation being essential before the product could be satisfactorily fed to livestock. More recently, work methods involving the use of organic acids alone (Petersen)[1], or mixed with mineral acids, have deemed neutralisation unnecessary in many cases. The relative costings of producing a silage from the various acid mixes has been covered by Lovern.[2] Denmark currently leads the world in commercial silage production, presently running at 25,000 tons/annum (1972)[3]. Poland is probably one of the few countries also producing silage on any scale, production currently running at 7,000 tons/annum. Current developments in fish silage manufacture have been reviewed by Tatterson and Windsor[4], Windsor also being involved with recent silage production in Britain.

An alternative technique of producing fish silage involves a microbial fermentation process as a means of acid preservation, but its suitability to under-developed rural situations is, at yet, uncertain.[1, 3, 5, 6].

To date there have been few reports of silage production in the tropical situation however, some work has been done on the subject in India[7] and Ceylon[8]. The Tropical Products Institute, London, is soon to publish Findings on experimental silage production in two tropical areas, this work being backed up with feeding trials. The silage in this case was extended with a carbohydrate and subsequently sundried, thereby producing a stable potential feed supplement.

In 1975 a request by the Solomon Islands Government to the Ministry of Overseas Development, London, for Technical Assistance was made for a Fish Technologist and an Animal Nutritionist to carry out a fish silage project in the Solomon Islands, production being backed up with feeding trials. This resulted in a technologist being posted in the Solomons in December 1975 on a 12 month assignment to work on experimental silage production followed by a nutritionist in April 1976 who was seconded from TTPI for a two month visit to arrange feeding trials.

PROJECT AIMS

To experimentally produce fish silage in a tropical situation, with a view to:-

(a) Assessing its value as an animal feed, and if successful thereby provide a basis for future livestock development.

(b) Assessing the possibility of village level production of fish silage.

(c) Alleviating the need for importing animal feeds.

(d) Solving the problem of disposing of fish waste from the fish processing plant, Tulagi.

THE FISHING INDUSTRY

Fishing in the Solomon Islands is traditionally on a subsistence level, there being abundant resources of fish around all the islands, with the majority of Solomon Islanders being coastal dwellers. The above factors have resulted in the absence of fish preservation techniques, barring some small-scale salting and baking of fish which can be found in a few areas.

Included in the current Solomon Islands Development Plan is the setting up of block ice plants in strategic positions in the Solomons, namely the district centres, with the aim of providing a means of preservation for the local fishermen. With regard to the local market freezing or chilling are at present the only acceptable techniques of preservation as other low technology methods, e.g. smoking, sun drying or salting produce a product foreign to local tastes. Preliminary experiments carried out by the Fisheries Division, Ministry of Natural Resources, have proved the feasibility of transporting iced fish to Honiara from islands up to 100 miles distant. However, even though local supplies of fish will increase in the near future, it is not envisaged that any significant amount of fish waste will result from local market activities, as heads, guts, bones are all consumed. The situation in several years' time will have to be reassessed for many varieties of fish represent a potential export from which significant amounts of waste could arise.

Up to 1971 no large-scale commercial fishing operation was to be found in the Solomons. An attempt had been made by a fishing company to utilise fish resources with the aim of retailing the fish through their own market in Honiara, however the scale was small and the supply irregular, resulting in the cessation of the company's fishing business.

In 1972 a joint venture agreement between the Solomon Islands Government and the Taiyo Fishery Company of Japan was made. This resulted in the construction of a pilot scale canning plant and a smoking plant on Tulagi, Florida Islands, 25 miles north of Guadalcanal. These were completed in October 1973. In December 1975 a further base was completed in the Western Solomons at Noro containing freezer facilities and a fish smoking plant. Currently 14 catcher boats pole and line fish for skipjack tuna (Katsuwonus pelenis) in Solomon Islands waters, the catch varying considerably from month to month. This does not drastically affect the cannery operations, as they are still only of pilot scale. Most of the catch is frozen and exported to canneries in American dependencies in order to avoid the import levies the USA place on canned fish, i.e. canneries in American Samoa and Puerto Rico (Table 1).

Approximately 7.5 tonnes of fish/day is presently processed in Tulagi for either canning or smoking resulting in a waste output of 5 tonnes (Table 1). The majority of this waste has been cooked (80%) and consists of heads, guts, bones and flesh trimmings. (Table 2). The remaining 20% consists of raw heads and guts from fresh fish. However many days see no output of raw material, production relying upon the availability of fresh, not frozen, fish.

The present method of dealing with the waste is by dumping at sea, which Solomon Taiyo Limited manager claims incurs high costs. A proposal by STL for the setting up of a fish meal plant adjacent to the cannery were rejected due to Tulagi being densely populated by Solomon Islands standards, the proposed design of the plant not having the necessary equipment for pollution control. This waste fish was seen as an ideal raw material for an experimental fish silage project.

PROJECT DEVELOPMENT

1. Site Development

In December/January 1975/76 an area of land approximately 35 square yards in area was cleared of bush and drained. The site was in close proximity, ¼ mile from the STL skipjack tuna canning plant on the island of Tulagi, Florida Islands, the land being government owned. A prefabricated hut 40' x 12' was erected on a concrete base and subsequently equipment for experimental silage production was installed (Table 3).

In February 1976 two pig sties 10' x 8' were constructed from bush materials on a concrete base.

2. Experimental Silate Production

Initial work was to investigate technique of converting the waste fish, from the STL canning plant, into fish silage. An analysis of the waste showed that 80-100% on a daily basis was cooked offal, the remainder being raw heads and guts. An analysis of the cooked waste gave the results shown in Table 2. Equipment used for experimental silage production can be seen in Table 6.

Early experiments looked into standard silage production methods involving the use of:-

(a) Sulphuric acid alone at different pH's.

(b) Sulphuric/formic acid mixes at different pH's and concentrations.

(c) Formic acid alone at different concentrations.

(a) Sulphuric acid alone:

Method

Small batches of 200 gms of cooked flesh/bone waste were hydrated in Kilner Jars with 150 mls of water to obtain the required consistency. Each was then acidified down to a specific pH i.e. 2.5, 3.0, 3.5, 4.0 or 4.5, using 35% concentrated sulphuric acid. A control batch containing no acid was also set up. Any changes in the pH of the mixtures were nominated after 1 hour and 25½ hours and 72 hours Structural changes in the nature of the mixture, gas production, and both bacterial and fungal growth were recorded.

Results

After 24 hours the control was smelling "high", giving obvious signs of bacterial decomposition. Of the other batches, only the one at pH 4.5 gave a slightly high smell and showed signs of gas production, the pH 4.0 batch also being noted to show gas production, but with a 'neutral' smell.

After 72 hours all samples were "high" with bacterial and fungal growth being recognised accompanied by gas production.

The pH of the batches was recorded after 1 hour, 25½ hours and 72 hours. The pH was raised by 0.4 on average after 1 hour and thereafter remained constant. Bone was softened at pH 3.5 and below after 25½ hours (belly flap bones).

Conclusions

By comparing the acidified batches to the non-acidified control it has shown that the addition of mineral acid to a fish mix imparted a limited degree of preservation depending upon the final concentration of acid in the mix. The use of mineral acid alone as a fish silage additive was found to be ineffective for lasting preservation in the concentrations which could be used to produce an animal feed.

(b) Sulphuric/formic mixes at different pH's and concentrations

1/ Method

Series of hydrated samples of cooked fish were acidified to pH 3.0 with 35% conc. sulphuric acid. Formic acid was added producing different final concentrations (0.5 - 10% by weight of 100% formic acid).

Results

The experimental samples which contained less than 2% by weight of 100% formic acid were prone to fungal and bacterial attack. A final concentration of 1.5% formic acid gave preservation for up to two weeks whereas concentrations below this remained fresh for between one and seven days, depending on the concentration. Samples with 2% formic acid or over remained preserved for a minimum period of two months.
Bone material: back bones were found to soften after six days.
No liquidation of the samples was observed although there was a slight homogenisation of the flesh, indicating a limited degree of breakdown, this resulted in a fish paste consistency.

Conclusions

A final concentration of 2% by weight of 100% formic acid was found necessary for preserving the cooked fish waste for a period of two months. (This being the length of the storage trials).

2/ Method

As per 1/ but the fish waste was acidified down to pH 2.0 in all cases.

Results

Samples which contained a minimum formic acid concentration of 1% of 100% formic remained fresh for up to two months. Samples with concentrations below 1% were prone to bacterial attack within two days.

Conclusion

Cooked fish waste acidified down to pH 2.0 required a minimum concentration of 1% by weight of formic acid for preservation of two months.

(c) Formic acid alone at different concentrations

Method

Samples which contained less than 2.5% of 100% formic acid were found to be prone to attack within a week of production, depending upon the concentration. Samples containing 2.5% formic or above remained fresh for a storage trial of two months. However slight fungal growth occurred on the surface of the sample if it was left to slowly dry out. The resultant pH of the mix was 3.5 and this was found to be sufficient to soften back bone material within a period of 10-13 days.

Conclusions

Using formic acid alone as the silage additive a minimum concentration of 2.5.% by weight of 100% formic acid was shown necessary for preservation of two months.

Reasons for choosing formic acid alone for Silage Production

i) Lack of enzymic action

Due to the cooked nature of the waste fish little if any liquefaction takes place. This is a result of enzyme destruction. Therefore due to the mineral acid imparting a very limited degree of preservation, method (a) can be dispensed with.

ii) Cost

Acid costs CIF Honiara make the process more viable using formic acid alone.

iii) Simplicity

Production will eventually utilise unskilled labour and using one acid will ease handling.

iv) Palatability

The use of high levels of mineral acid to produce an animal feed is highly likely to result in palatability and physiological problems with the livestock, unless the silage is neutralised prior to feeding.

Silage production techniques for feeding trials

A predetermined weight of water is placed in a 15 gallon plastic bin. A calculated weight of acid is then added to the water and thoroughly mixed in. Cooked fish offal is then added until the required concentration of acid is attained. The fish waste is then thoroughly mixed with the solution by means of plastic paddles.

Using this technique a silage of 25% dry matter containing a concentration of 3% of 100% formic acid by weight is attained. See Table 3 for analysis.

A final concentration of 3% formic acid was used to produce the silage for the feeding trials although 2.5% had shown adequate preservation in experimental trials. However it was thought advisable to leave a safety margin for possible error.

By this technique it was possible to produce ¼ tonne/day in 25 kg batches. These were subsequently shipped over to Honiara and thence to Ilu Farm for the feeding trials. The silage was left to "nature" for 10 days before feeding in order to allow the large vertebrae to soften and hence become palatable.

THE LIVESTOCK INDUSTRY

Livestock production in the Solomons is still in a very early stage of development. At village level pigs and poultry are the traditionally kept animals. However, these tend to be free-range and although widespread throughout the Solomons, production is only found on a subsistence level. Over the last six years the Government livestock policies have been biased towards cattle production. Prior to this, cattle production was limited to the larger copra estates where cattle served the dual purpose of providing additional income and controlling the growth of vegetation on the plantations. Now Government assists the small farmer in providing stock and fencing and improving pasture. Attempts by Government to intensify pig production have been limited to small-scale operations at village level; however due to the lack of any high protein food source success in intiating more intensive production has been limited.

Commercial pig production is limited to Guadalcanal where there are two piggeries, and also one poultry farm. Brower Solomon Associates (BSA) operate one of the piggeries and the poultry farm 15 miles east of Honiara. The other piggery being located at Tambea 27 miles west of Honiara. Both maintain breeding herds of approximately 30 sows, progeny being taken up to pork weight (120-150 lbs). Honiara Technical Institute keeps a small herd based on about eight sows, the meat being used to feed the College students. BSA's poultry production is based on 2,000 layers and 5,000 broilers, which supply the Honiara market.

There is a great deal of scope for pig raising in the Solomons due to the prestige of pork as a meat. At village level pigs tend to be raised for festive occasions and pork does not form a common part of the diet. This is probably due to the lack of any protein source available for village level pig production, hence the pigs take a long time to reach slaughter weight. The high value of pig as a meat source to Solomon Islanders can partially be put down to the high fat content, the average Solomon Islanders diet containing very little animal fat.

It has been estimated by Dr. Frederick (1971)[9] that the pig population in the Solomons was about 16,000 head in 1969 and as there has been no intensive programme to increase production that figure would be a good approximation of today's population.

Local Feed Sources and Livestock Feeding

Cattle production is based entirely on pasture though BSA are considering feed lot finishing of beef, based on rice milling by-products as the main feed components.

Village pigs are most commonly fed on a misture of coconut, greens, such as sweet potato vines, cassava tops, and, occasionally, the root crops themselves or starchy fruit such as breadfruit and bananas. Because the number of pigs owned by a person is a more important criterion than their condition, little attention is usually paid to feeding.

Diets employed at the commercial piggeries are based largely on broken rice, rice bran, sweet potatoes, or cassava with imported protein concentrate (ex Australia) making up the protein component. Greens are also fed at two of the piggeries - banana leaves at Tambea and cut grass (Para grass, Guinea grass) at Ilu Farm

Rice bran and rice chips are available in some quantity locally as by-products of BSA's rice growing enterprise. Since BSA plan a significant expansion of their rice growing activities, there should be a considerable increase in the quantities of these materials available in the next few years (Table 4). Though root crops are grown by BSA specifically for pig feeding (cassava) it is unlikely that very extensive use would be made of cassava for this purpose in the Solomons due to its alternative use as a staple food. Current prices of these feeds are shown in Table 4.

At present there are no major sources of vegetable protein feeds. Though copra is the major agricultural product of the area, copra is not processed locally, furthermore it is not considered that a copra mill would be an economic proposition (Source: Ministry of Agriculture). BSA intend trial plantings of soya bean and mung bean with the view to their use in both poultry and pig feeding. Pig and poultry offal is used in pig feeding by BSA but the quantities involved are not substantial.

All poultry feed used by BSA is imported apart from some scratch grains (maize, broken rice).

A cheap, locally available source of protein would be of immediate benefit to the commercial pig producers, since imported concentrate is both expensive (Table 4) and irregular in supply. If, in the larger term, programmes to improve pig husbandry in the villages are increased, attention to improve feeding, including the provision of cheap sources of protein could be of major importance to such programmes.

Feeding Trials

Dr. Morgan, the animal nutritionist, arrived in mid-April to initiate feeding trials, designed to test the value of the fish silage as an animal feed supplement. During his visit a small initial trial was completed and a more comprehensive trial was set up. The following is an extract from his interim report and as trial 2 is not yet completed, little further can be said at this point in time.

Experimental Facilities

The trials were carried out at BSA's piggery at Ilu Farm. On-site facilities that were made available included six covered pens (10' x 10'), a weighing pen with scales and weighing cage, a feed storage area and a covered concreted area suitable for the hand mixing of feeds. The pens were concreted and equipped with feed troughs and nipple drinkers (the latter during trial 2 only).

Large white X landrace pigs were used in both trials. They were selected according to weight, sex and thriftness. The parent herd has a worm problem, lungworm being the main infection. Animals used in Trial 1 were not wormed but prior to Trial 2 all pigs were dosed with Nilverm (ICI) and again after a three week interval.

Animals were fed twice daily, at 11 a.m. and 4 p.m. The diets were fed wet, water being added in a 2 :1 ratio. The scale of feeding adopted was that proposed by the ARC (1967) for growing pigs.

Trial One

Was undertaken primarily to familiarise the piggery staff with the routine to be used in the trials, and to determine whether a diet incorporating fish silage caused any major problems in terms of diet palatability and carcass quality.

Two groups of six pigs were selected, equalised on the basis of weight and sex. Group 1 were fed a diet containing a proprietary protein concentrate as the major protein source, while group 2 were fed a diet including fish silage. Details of the diets are given in Table 5. The control diet and the silage supplement were mixed by hand in 100kg batches. Prior to each feed the required proportions of supplement and fish silage were weighed out and roughly mixed.

Table 6 indicates that the fish silage diet was difficient in calcium and phosphous. However since this trial was of fairly short duration (1 month feeding period), this was not considered to be a major shortcoming, though higher levels of these nutrients would have been used, had suitable sources been available.

The pigs were weighed fortnightly, and slaughtered when they achieved about 70 kg livestock. Parameters recorded included feed intake, liveweight gain, killing cut %. A visual assessment was made of the carcasses, attention being paid to fat colour and consistency. A simple taste panel study was also made to see if any taint could be discerned in the meat.

Trial Two

This trial, which was initiated in mid-June, was designed to compare the performance of growing pigs fed diets based on fish silage with that of pigs fed diets containing either fishmeal or protein concentrate as the major source of protein (Table 7).

A total of 40 pigs was used, 10 per dietary treatment. Each diet was fed to two groups of five pigs with initial average liveweights of 32 kg and 21 kg respectively. Each group comprised three gilts and two boars.

Parameters to be recorded in this trial are as in Trial 1, plus measure of fat cover in the carcasses. (Black fat thickness on the mid line at points p, and p3 over the last). A fuller taste panel study will be undertaken.

Discussion

At this stage no firm conclusions can be drawn from the trials, but some comments are pertinent. Trial 1 suggested that satisfactory growth could be obtained on a diet based on fish silage though since this diet contained a growth promoter while the control diet did not, a direct comparison of weight gains and feed conversion efficiences would be invalid.

FUTURE DEVELOPMENT

Commercial production of fish silage is due to start within the next two weeks and this production is designed to replace imported protein foods with a local source. Both commercial piggeries have indicated that they are keen to be supplied with fish silage and initial production is designed to cope with this demand.

Little extra equipment is deemed necessary for supplying the two piggeries. Two tonnes of silage per week, which is the estimated consumption, can be produced by hand although a concrete mixer will both speed up and make production easier.

The "fish silage" will be stored and transported in 44 gallon drums which have an acid resistent inside coating and a butyal rubber seal, the top being clamped on.

If demand for the fish silage increases then plans for full-scale production will be brought into operation; these include:-

1. Extending and re-lining the concrete working area.
2. The erection of a leaf building (open plan).
3. The erection of a pre-fabricated storage hut.
4. The laying on of power and water supplies.
5. The construction of a small wharf out of gambian baskets.
6. The construction of an improved drainage system.

The equipment needed for full-scale production will be:-

1. A concrete mixer, bowl capacity approximately 50 kg.
2. A large number of 44 gallon drums with acid resistent linings and clamp tops.
3. A front loading tractor.

Plans to Improve Village Pig Production

One of the major aims of the Solomon Islands fish silage project is to make available a low cost protein food supplement to Solomon Islanders to help improve village pig production. To fulfil this aim village pig production has to be assessed, and economically viable methods of village level pig raising must be identified and brought into operation. This is not a simple task and in order to ensure the success of any village level pig projects one must take into account the many problems which are bound to arise.

It is unfortunate at this point in time that the Ministry of Agriculture and Lands is suffering badly from cutbacks in its budget. This has resulted in an overstretching of their manpower resources along with halting any new projects. This does not however mean that village level projects must be ruled out; this is mainly due to the generosity of the Foundation for the People of the South Pacific, who have donnated US$7,000 to the fish silage project. A village level piggery project plan is now being drawn up and will be presented to the Ministry of Agriculture and Lands for their comments. If acceptable a village level community pig project will be initiated in March 1977 under the close supervision of a qualified pig man.

PRODUCTION COSTS/TONNE OF SILAGE

Estimated production costs/tonne of wet silage, made from formic acid alone.

	$A
Acid costs (maximum)	15.00
Management and Labour - say	3.00
Depreciation of Plant	3.00
Power	1.00
Cost of waste fish/tonne	13.00
	35.00

* * Approximate Total Production Cost = $35.00

The above costs are on expected full production. All costs are on the high side to allow for possible inflation, increases in labour costs etc.

The selling price of the silage will be approximately $60/tonne to the commercial piggeries which works out far cheaper than the imported feeds (Table 4).

TABLE 1

Quantities of Raw Fish used for Processing at the Solomon Taiyo Ltd Factory, Tulagi 1973 - 1975 (Tonnes)

Year	Quantity of Raw Fish used for		Quantity of Waste Produced*	
	Canning	Smoking		(per month)
1973 (3 months)	320	-	144	48
1974	1737	429	953	79.5
1975	2618	1006	1580	132

* Assuming that the wastage factor in canning is 45%, and wastage factor in smoking is 40%.

Data supplied by courtesy of Solomon Taiyo Ltd.

TABLE 2

The Proportions of Offal Produced during Canning Operations

Frozen weight 10 skipjack tuna	:	37.5 kg
Cooked weight	:	27.7 kg
(% weight loss on cooking	:	26%)
As % of cooked fish (cooked entire)	:	

		As % raw fish
Heads and bellies	23%	17.0
Backbones	7.5%	5.4%
Trimmings	23%	17.0
Total Offal	53.5	39.4
Usable fish	46.5%	34.4

TABLE 3

Fish Silage Analysis

	Sample 1	Sample 2
% Moisture	70.44	71.43
% Crude Protein	19.50	20.00
% Ether Extract	4.38	3.48
% Ash	3.92	3.01
% Calcium	1.16	0.66
% Phosphorous	0.78	0.55
Soluble Nitrogen (as % of Total nitrogen)	-	5.05

Sample 1: This silage was made from the total waste from ten fish and therefore is a representative sample.

Sample 2: From a batch of silage used for feeding Trial 2.

TABLE 4

Quantities and Prices of Raw Materials available for Pig Feeding in the Solomon Islands

Material	Present Price/tonne unless otherwise specified	Estimated Annual Production	
		1975 (Tonnes)	1976 onwards
Rice bran	$54	400	2,000
Rice Chips	91	300	1,500
Cassava	66.88		
Imported Pig Concentrate	270 CIF Honiara		
Imported Fishmeal	300 CIF		
Imported mineral/vitamin supplement (per 25 lbs)	$13		

TABLE 5

Composition of Diets (Trial 1)

(a) Formulation of meal mixes (kg/tonne)

Ingredient	Fish Silage Supplement	Control Mix
Broken rice	886.25	705.9
Rice bran	75.8	146.4
Pig concentrate (50%)	33.0	147.7
Mineral vitamin supplement	2.2	
Sodium chloride	2.75	
	1000.00	1000.00

Added to each tonne

Vitamin E supplement (25%)	70g
Thiamin	4.5g

Fed with fish silage in the ratio
1 part fish to 2.39 parts meal

(b) Calculated Composition of Total Diet (air dry basin)

		Control Diet	Fish Silage Diet
Crude protein	%	14.8	15.8
Crude fibre	%	3.8	2.3
Fat	%	6.0	5.3
Calcium	%	1.06	0.52
Phosphorus	%	0.82	0.48

TABLE 6

Equipment used in Experimental Silage Production

1	Tressel-type table of top dimensions 12' x 4' x 1½'
1	Hand mincer
2	Plastic paddles
10	16 gal plastic bins
1	100 kg salter spring balance
1	Portable pt metre plus electrodes and buffers
2	Empty 44 gal drums
2	Cases of Kilner Jars
1	Measuring Cylinder
1	Plastic hand pump
	Cases of Formic Acid
	Cases of Sulphuric Acid
	Cleaning Equipment

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