APPLIED SCIENTIFIC RESEARCH CORPORATION OF THAILAND

in collaboration with
DEPARTMENT OF SCIENCE, MINISTRY OF INDUSTRY
DEPARTMENT OF FISHERIES, MINISTRY OF AGRICULTURE AND COOPERATIVES

COOPERATIVE RESEARCH PROGRAMME NO. 31
IMPROVEMENTS IN THE PRODUCTION OF FISH SAUCE (NAMPLA)

RESEARCH PROJECT NO. 31/6
ACCELERATED NAMPLA FERMENTATION ON A SEMI-PILOT SCALE

REPORT NO. 1
ACCELERATED NAMPLA FERMENTATION ON A SEMI-PILOT SCALE

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ASRCT, BANGKOK 1974
not for publication

CONTENTS

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SUMMARY

Accelerated nampla fermentation on a pilot scale has been found to produce an acceptable quality of the product, which is rather high in total nitrogen content and fair in aroma. The fermenting tank has the following internal dimensions, length 68.5 cm, width 67.5 cm, and depth 95 cm. Fishes were processed with an unrefined solar salt in two proportions, i.e. 25 parts of salt to 100 parts of fish and 30 parts of salt to 100 parts of fish by weight. The mixture was maintained at 49°C for 4 to 5 days and subsequently at 37°C for two to three months.

The production cost on a semi-pilot unit with a capacity of 720 litres of primary extract per year was calculated. The plant required an investment of 9,500 baht. The processing costs involved were 3.92 baht per litre of primary extract.

INTRODUCTION

Fish sauce is popular as a flavouring agent in South-east Asia. It provides a salty taste and imparts flavour and aroma to various items of feed. The conventional method of manufacturing takes about 8 to 12 months to produce fish sauce; therefore, new improved methods to shorten the fermenting time are investigated.

Laboratory investigations of accelerated nampla fermentation by biological process showed that the good accelerated nampla from pla sai daeng (Nemipterus hexodon) was produced with high salt concentration by a suitable temperature control. During the initial stage, the mixture was maintained at 49°C until the fishes disintegrated by fermentation and stirring. The fermentation was then continued at 37°C for two months to improve fish sauce quality.

The semi-pilot investigation was carried out based on the laboratory result by controlling the fermentation temperature at 50°C ± 2°C for

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4 to 5 days and its temperature was then dropped to 37.5°C ± 1.5°C for two to three months. Two experimental runs were investigated by using pla sai daeng, employing the salt concentrations of 25 and 30% by weight of fish respectively.

The fermenting tank was made of concrete with the following internal dimensions: 68.5 cm in length, 67.5 cm in width, and 95 cm in depth. The tank was provided with hot water heating coil. The coil was constructed from mild steel pipes and it was embedded in the four walls and bottom of the tank.

This report describes the detail of the pilot scale experiments including the result and production cost with the view of exploiting the process commercially.

MATERIALS AND METHODS

Equipment for pilot plant

Pilot plant for testing accelerated nampla fermentation was designed and constructed by ASRCT staff in the soil-cement storage house at ASRCT.

The plant consisted of (Figure 1):

1) The fermenting tank was of a cubical shape with internal dimensions of 68.5 cm in length, 67.5 cm in width, and 95 cm in depth; and external dimensions of 121 cm in length, 121 cm in width, and 113 cm in depth. The tank was made of 1:2:4 concrete. The wall thickness was 29 cm. The heating coil of an internal diameter of 2.54 cm, external diameter of 3.34 cm and the length of 2,720 cm was embedded in such a way that it was 2 cm from the internal surfaces. Each wall was insulated by 8.8 cm thick polystyrene foam. The foam was placed next to the heating coil and the external wall. The inner side of the tank was plastered by a mixture of cement, sand and water proofing compound at the ratio of 1:3:0.02. The tank had a removable plastic cover of 0.217 cm thick to prevent insect and flies from getting into the tank during fermentation (Figure 2).

2) Hot water tank was made of an old gasoline 200-litre tank. Two electrical heaters of two kilowatts each were inserted through the wall near the bottom (Figure 3).

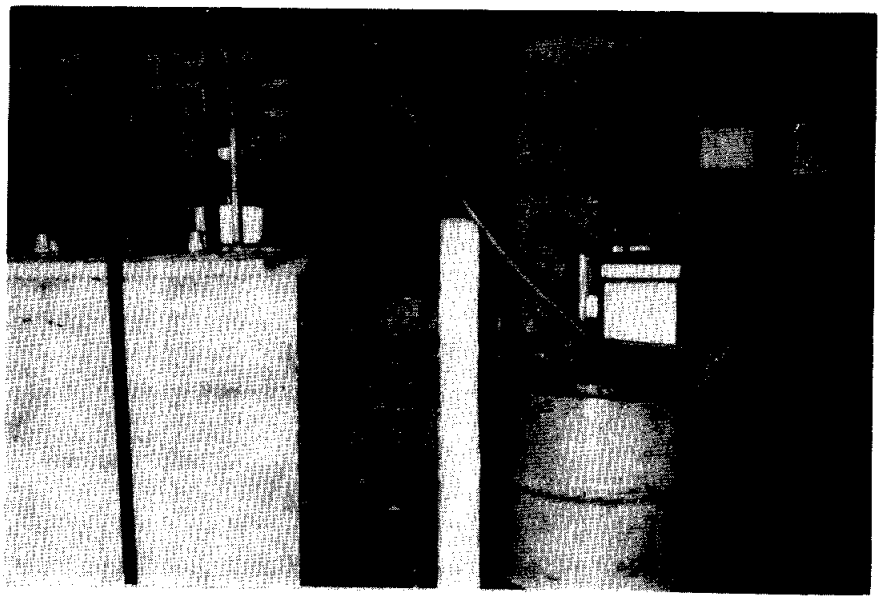

Figure 1. Pilot plant unit: fermenting concrete tank, centrifugal pump, heating tank, and temperature controller.

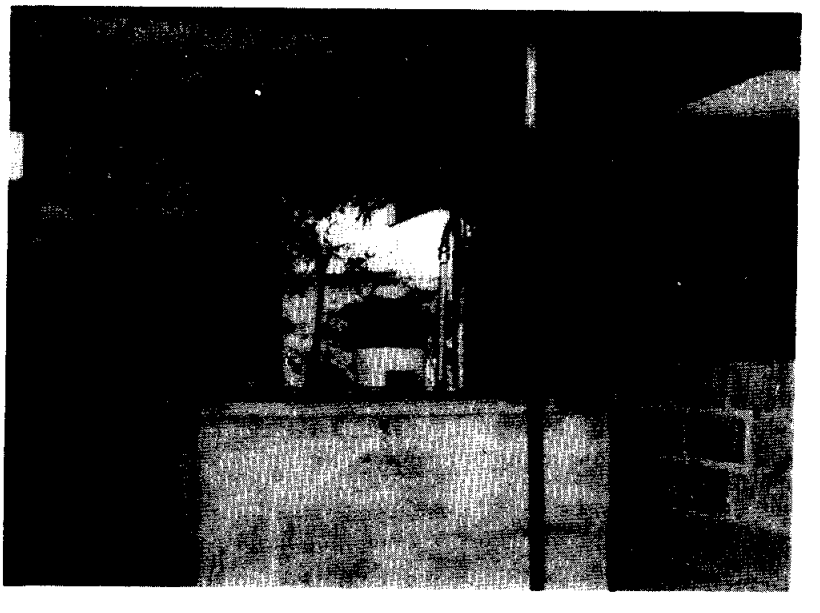

Figure 2. Showing fermenting concrete tank, a plastic cover, and two thermocouples.

3) A pump of $\frac{1}{4}$ horse power was used to circulate heating water from the hot water tank through the heating coil in the fermenting tank.

The temperature of circulating water was regulated by contact thermometer which directly controlled the electrical input into the heaters. Electrical consumption was calculated by multiplying the time consumed by the power used. The time of electrical input to the heaters at a certain period was noted by using a temperature controlling box.

The pilot plant building was also protected from insects and flies by screen.

Fishes

Fishes (pla sai daeng) were bought from the Fish Marketing Organization of the Department of Fisheries, Ministry of Agriculture and Cooperatives. The fishes were partially mixed with ice during the transportation from the sea to the marketing centre in Bangkok.

Filter bag

The filter bag for filtration of size 13 cm width, 27 cm long, and 35 cm depth was made of cheese cloth and it had three layers.

Two batches of fishes were respectively processed with two levels of unrefined salt, namely 25 and 30% by weight of the received fish. Approximately 350 kg of the fish was used in each batch. The fish with salt, after mixing by hand, was left at room temperature overnight on a slightly sloping floor to deslime. The fluid resulting from desliming was collected, boiled for five minutes, and then together with the treated fish mixture was placed in the fermenting tank which preheated to 50°C (Figure 4).

The mixture was fermented at 49°C until the fish was well disintegrated. Stirring at this condition helped to break up the fishes. Four days were required for the first batch and five days for the second batch. Temperature was then dropped to 37°C and maintained until satisfactory aroma of nampla was obtained. During the fermentation period, the tank was covered with plastic cover, the temperature of the fermenting mash was checked daily by using recorder and/or potentiometer connecting with calibrated thermocouple. The mixture was stirred

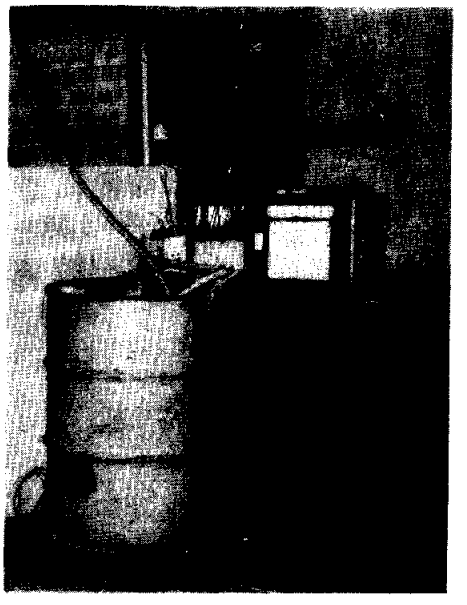

Figure 3. Heating tank, connecting with two heaters and contact thermometer; temperature recorder.

Figure 4. Pouring fish and salt mixture into the tank.

vigorously twice a week for the first batch, and once daily for the second batch (except during week ends and other holidays). Stirring, during 37°C incubation, helped to eliminate the evolving gas and to break up the layer of oil which formed on the surface. Tap water was always added to replace the amount lost through evaporation to the original level.

Small aliquots were taken out from the tank at the end of the first, second month, and the end of the fermentation to be examined for the degree of liquefaction, the pH and the specific gravity of the filtrate, and was also analysed in detail the contents of total solid, sodium chloride, total nitrogen, ammonia nitrogen, organic nitrogen, formaldehyde nitrogen, and amino acid nitrogen (Amano 1962).

The procedure of taking samples and the methods of analysis (Horwitz 1965) were the same as reported in Report No. 1 on Research Project No. 31/4 (Vardhanabhuti et al. 1968).

At the completion of the fermentation crude nampla was filtered through the previously described filter bags.

The residue from each batch was equally divided into seventeen portions and leached in earthen jars. Eight portions of the first batch were leached with the salt solution of 25% weight by volume and the remained portions of the same batch with saturated salt solution in tap water. The amount of salt solution used were based on the original volume of the fermented mash (i.e., the original volume of the fermented mash was 368 litres, the amount of the salt solutions were added into each jar up to 22 litres). For the second batch, eight portions were leached with 30% weight by volume and the remained portions with saturated salt. After mixing thoroughly, most of them were exposed to the sun for one month and filtered through the filter bags.

Primary extract and leaching nampla were stored in 20-litre glass bottles and aged in the sun.

Experimental

The following experimental conditions were selected based on the results from Report Nos. 1 and 2 on Research Project No. 31/4 (Vardhanabhuti et al. 1968; Vardhanabhuti et al. 1970). Chemical contents, colour

and aroma of the filtrate from the aliquot during the fermentation period were strictly followed.

Experimental Batch No. 1

Weight of fish	333 kg
Weight of raw sea salt	83.3 kg

After fermentation at 49°C for 4 days and 37°C for 59 days, 16.65 kg (5% by weight of fish) of salt was added.

Fermentation period	4 days at 49°C
	65 days at 37°C

Experimental Batch No. 2

Weight of fish	360 kg
Weight of raw sea salt	108 kg
Fermentation period	5 days at 49°C
	86 days at 37°C

RESULTS

Time required to heat the mixture of fish and salt from room temperature to approximately 49°C is shown in Figure 5.

The results of pla sai daeng fermentation with two levels of salt concentration maintained at 49°C for 4 to 5 days then controlled at 37°C for different period of time are given in Table 1.

Table 2 has shown the results of leachings for one month of residues from the two experiments.

The results of chemical analysis of fish residues from fermentation are given in Table 3 and total amount of nampla of primary extracts and leachings are given in Table 4.

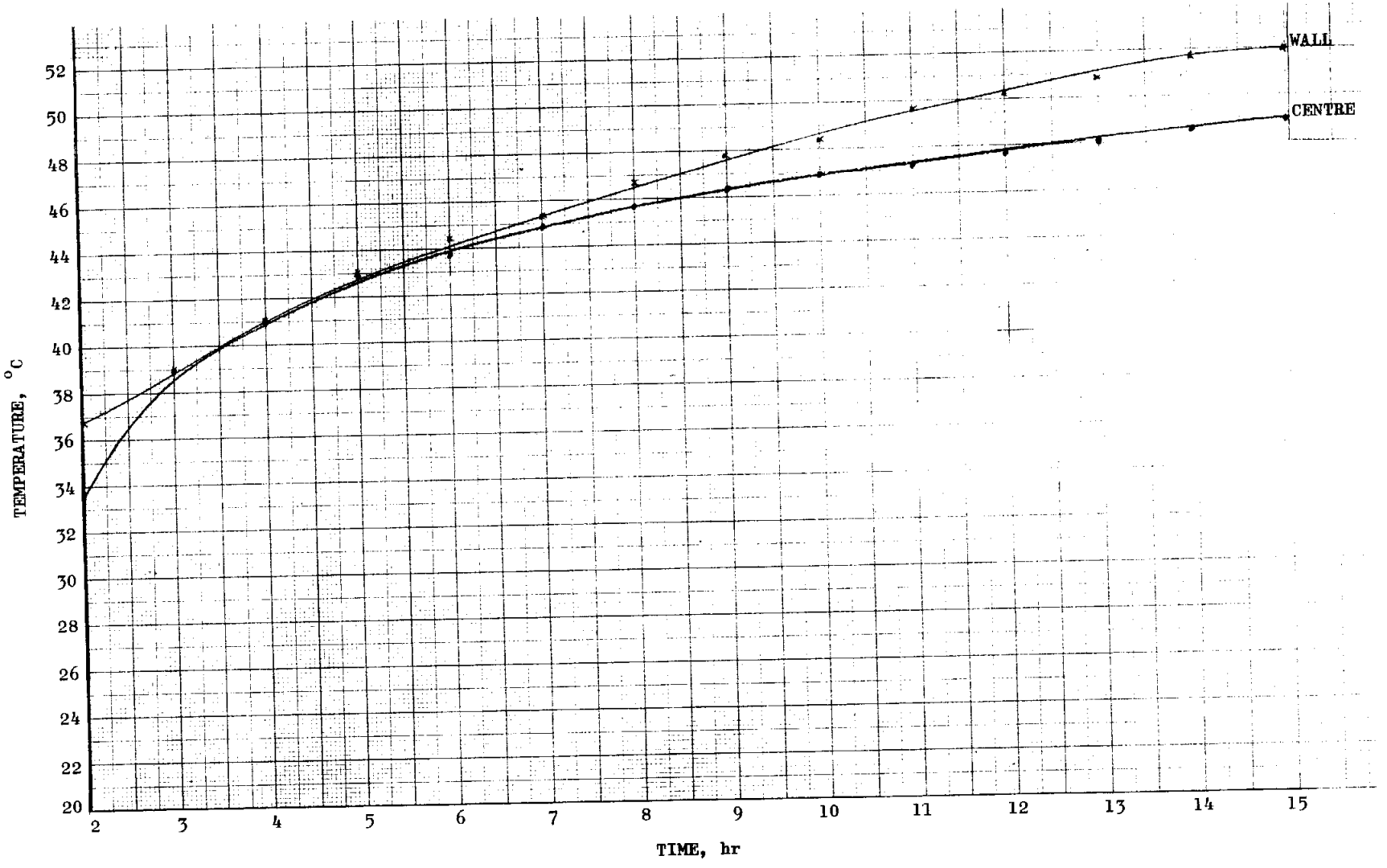

Figure 5. Relationship between heating time and temperature at the initial stage at the wall and the centre of the fermenting tank.

TABLE 1. RESULTS OF PLA SAI DAENG FERMENTATIONS AT 49°C FOR 4-5 DAYS THEN KEPT AT 37°C

Salt concentration	pH	Specific gravity	Total solids (g-%)	Sodium chloride (g-%)	Total N (g-%)	Organic N (g-%)	Formal-dehyde N (g-%)	Amino acid N (g-%)	Ammonia N (g-%)	Liquid portion from 150 ml (ml)	Aroma	Colour
25% salt 4 days at 49°C												
After 1 month	6.5	1.1721	27.41	19.29	1.49	1.08	0.805	0.395	0.41	75	Bad	Yellow
After 2 months	7.3	1.1732	29.41	18.99	1.68	1.22	0.98	0.52	0.46	85	Fair	Yellowish brown
5% salt added 6 days at 37°C	6.85	1.2067	30.72	21.85	1.67	1.18	0.90	0.41	0.49	85	Fair	Yellowish brown
30% salt 5 days at 49°C												
After 1 month	6.15	1.2050	30.54	23.63	1.32	1.14	0.42	0.24	0.18	60	Bad	Brownish yellow
After 2 months	6.35	1.2056	31.01	23.62	1.30	1.10	0.53	0.33	0.20	60	Fair	Brownish yellow
After 3 months	6.75	1.2042	31.40	23.42	1.38	1.14	0.61	0.37	0.24	60	Fair	Brownish yellow

TABLE 2. RESULTS OF LEACHING FOR ONE MONTH OF RESIDUES FROM THE TWO EXPERIMENTS WITH TWO LEVELS OF SALT CONCENTRATIONS IN EACH EXPERIMENT

Original fermentation	Concentration of salt solution for leaching (w/v-%)	Leaching	pH	Specific gravity	Total solids (g-%)	Sodium chloride (g-%)	Total N (g-%)	Organic N (g-%)	Formaldehyde N (g-%)	Amino acid N (g-%)	Ammonia N (g-%)	Aroma	Colour
25% salt													
4 days at 49°C	25	Leaching 1	7.55	1.1526	22.45	19.65	0.58	0.32	0.371	0.11	0.26	Bad	Yellow
59 days at 37°C		Leaching 2	7.42	1.1505	21.21	19.72	0.33	0.13	0.22	0.02	0.20	Bad	Yellow
and then 5% salt		Leaching 3	8.12	1.1503	20.51	19.58	0.16	0.06	0.12	0.02	0.10	Bad	Light yellow
added 6 days at 37°C													
	Saturated salt	Leaching 1	6.62	1.1973	28.27	24.46	0.63	0.44	0.35	0.16	0.19	Fair	Yellow
		Leaching 2	6.25	1.2018	27.06	25.11	0.29	0.18	0.17	0.06	0.11	Bad	Yellow
		Leaching 3	7.55	1.2044	27.09	26.14	0.11	0.05	0.07	0.01	0.06	Bad	Light yellow
30% salt													
5 days at 49°C	30	Leaching 1	7.13	1.1954	28.37	23.54	0.71	0.55	0.36	0.35	0.16	Fairly bad	Yellow
		Leaching 2	7.45	1.1790	24.74	22.50	0.33	0.17	0.23	0.07	0.16	Fairly bad	Yellow
		Leaching 3	7.85	1.1705	23.79	21.89	0.24	0.10	0.12	TRACE	0.12	Bad	Yellow
	Saturated salt	Leaching 1	7.05	1.2080	29.46	24.87	0.65	0.53	0.33	0.32	0.12	Fair	Yellow
		Leaching 2	6.88	1.2031	27.47	25.08	0.38	0.30	0.19	0.11	0.08	Fair	Yellow
		Leaching 3	7.05	1.2022	27.13	25.23	0.14	0.09	0.072	0.022	0.05	Bad	Light yellow

TABLE 3. RESULTS OF CHEMICAL ANALYSIS OF FISH RESIDUES

Original fermentation	Concentration of salt solution for leaching (w/v - %)	Fish residue after the leachings	Per cent sodium chloride (w/w)	Per cent total N (w/w)
25% salt 4 days at 49°C 59 days at 37°C and then 5% salt added 6 days at 37°C	25	Leaching 2	13.92	1.86
		Leaching 3	14.53	1.53
	Saturated salt	Leaching 2	18.60	1.85
		Leaching 3	19.68	1.66
30% salt 5 days at 49°C 86 days at 37°C	30	Leaching 2	18.52	2.03
		Leaching 3	16.42	1.87
	Saturated salt	Leaching 2	20.18	1.95
		Leaching 3	19.67	1.79

TABLE 4. RESULTS OF AMOUNT OF NAMPLA OF PRIMARY EXTRACT AND LEACHING

Experimental No.	Nampla	Total amount of nampla (litre)
1	Primary extract	196.5
	Leaching 1	192
	Leaching 2	223
	Leaching 3	192
2	Primary extract	170
	Leaching 1	156
	Leaching 2	165
	Leaching 3	173

PRODUCTION COST

The production cost of nampla on a semi-pilot scale was estimated. The process condition for calculation was based on the experiment as follow: Fermentation at 49°C for 5 days subsequently at 37°C for 86 days with 30% salt concentration, stirring once daily. 180 litres of primary extract would be achieved from each batch which took about three months. The capacity of this plant was 180 x 4 = 720 litres of primary extract per year, consuming approximately 10 tonnes of raw fish and three tonnes of raw salt.

Semi-pilot plant investment cost*

	Cost (baht)	Depreciation+ (baht)
Cost of the plant: Land	6,800	
heating tank, temperature controller and pump	1,700	340
Fermenting tank and its construction plus the plate to facilitate desliming	1,000	200
Total investment cost	9,500	
Total depreciation per year		540

*Collected data in 1970.

+Straight line, complete depreciation in five years.

Processing costs*

	Unit consumption per litre of primary extract	Unit cost (baht)	Cost per litre of primary extract (720 litres/year) (baht)
Electricity, kW-hr	9.5	0.25/kW-hr	2.37
Operating labour			
One labour for stirring, desliming and two for filtration, hr	0.15	5/hr	0.75
Maintenance and repair @ 4% of investment			0.53
Overhead @ 2% of investment			0.27
Total processing costs per litre of primary extract			3.92

DISCUSSION

Time required, when hot water at 53°C was circulated through the coil embedded in the walls, to heat fish and salt mixture from room temperature to 49°C was 15 hours. A steady state temperature of the coldest point in the middle of the tank at one third of the depth of the tank was 49°C, while the wall temperature was 52°C (Figure 5). During the first two hours, the temperature fluctuated that its record could not be correctly measured.

Two batches were carried out by using whole fish of pla sai daeng with two levels of salt concentration. For the first batch, 25% salt by weight of fish was mixed. After incubation at 49°C for 4 days and subsequently at 37°C for 59 days, salt content was found to be low. It might be due to the fermenting tank which was not cured with salt solution before fermentation; therefore, little amount of salt in the aliquot was possibly absorbed on the surface of the tank during the process. Five per cent more raw salt was added and took further six days at 37°C to completely dissolve. The aliquot had a high degree of

*Collected data in 1970.

liquefaction, high nitrogen retention and slow complete digestion. For the second batch, pla sai daeng with smaller size was processed with 30% salt by weight of fish. It was completely digested when incubated at 49°C for 5 days and 37°C for 7 days. Liquefaction after one, two and three months of fermentation was the same and it was low. The product processed with 30% salt, three months of fermentation were needed, contained low nitrogen retention.

Both primary extracts yielded acceptable products with fair aroma and lighter colour due to insufficient sunlight. Their colour got darker when aging in the sun.

The residue of the first batch was leached with two levels of salt concentration, namely, 25% (w/v) salt solution and saturated salt solution in tap water. Three leachings were made from the residue. The results had been shown in Table 2. The first and second leaching processed with 25% salt solution provided adequate total nitrogen but aroma was not good. Their aroma and colour were improved when the products were exposed to the sun for two months. The first and second leaching, made with saturated salt solution, contained a fair amount of total nitrogen. Its aroma was fair in the first leaching but poor in the second leaching. Three leachings were carried out with the residue of which originally fermented with 30% salt. The residue was processed with 30% (w/v) and saturated salt.

Three leaching products made from 30% salt solution were not as good as from saturated salt. The second leaching could still be made with saturated salt solution. It contained 0.38% total nitrogen and had fair aroma.

The third leaching in all cases had low total nitrogen content and bad aroma.

Table 3 showed that the residues after third leaching contained low total nitrogen and sodium chloride content remained rich when high salt concentration was used.

The capacity of the tank was about 180 litres of primary extract. The volume of primary extract and of each resulting leaching were about the same.

The semi-pilot plant with an annual capacity of 720 litres of primary extract required an initial investment of 9,500 baht. The cost of depreciation was 540 baht or 0.75 baht per litre. The processing costs were 3.92 baht per litre of primary extract. The majority of processing costs was the cost of electricity, spending 2.37 baht per litre. It was quite high because some electricity was consumed for heat loss through hot water system. By efficient heat insulation, approximately 10% of this cost would be saved. From the experiment, leachings could be made to yield acceptable products, hence it would reduce the production cost.

CONCLUSIONS

Both primary extracts yield lighter colour with fair aroma and rather high amount of total nitrogen. Ammonia nitrogen content is low in the product made with 30% salt and stirred every day during fermentation. Important parameters involved the fermentation of fish sauce are time and temperature. A better product of higher nutrition value will be obtained when its fermentation period takes longer time up to three months.

Two acceptable leachings, containing fair total nitrogen, can be easily made with saturated salt solution. Lower salt concentration used in the residue produced poorer aroma.

ACKNOWLEDGEMENTS

We express our sincere appreciation to Mrs. Jiraporn Sukhumavasi and Mr. Chaiyut Klinsukont for their kind assistance during fermentation process, to Mr. Pravate Lauhasiri and staff members of the Analytical Unit for analysis, to Mr. Narong Sukapaddhanadhi and Mr. Vullop Neamprean for construction of the fermenting tank, to the staff members of IRCC Unit and shop unit for situation and repairing equipments. The authors also thank Miss Bung-orn Kasemsarn of the Department of Fisheries for her kind arrangements with the fish dealers at the Fish Marketing Organization in supplying the fresh raw fishes.

One laboratory assistance is required for helping this work and three workers for preparation and transportation fish and salt mixture.

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