Project Planning for Small and
Medium Scale Industries No.12

SURIMI and SURIMI-BASED FOOD Manufacturing Plant

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JAPAN CONSULTING INSTITUTE

This technical brochure was compiled to help in the drafting of a suitable plan for the construction of Surimi and Surimi-Based Food Manufacturing Plant.

The production scale and manufacturing process have been described in this brochure on the basis of a typical instance.

The profitability was estimated by fixing certain required conditions, which may differ from country to country.

We hope that the data contained in the brochure will help you to draw up the most suitable plan for the industrialization of your project.

In case a government or public organization requests the Japan Consulting Institute to conduct a feasibility study of the above industry for the purpose of establishing the most suitable plan, it is possible for us to carry this out free of charge.

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INTRODUCTION

By way of wisdom for living, man has exerted his ingenuity in preserving food in various manners, which has resulted in producing such foods as dried, salted, smoked, canned, and frozen. In addition to these basic ways of food preservation, countries, where fish is the main source of nutrition, have begun manufacturing fish-based food, with their own taste in mind. Especially, boiled fish paste such as "kamaboko", "satsumaage" and "tsumire" were manufactured in the southern region of China and in Southeast Asia, with Japan as a major producing nation. Their production scale, however, was mostly smaller than the medium-sized enterprise.

In 1962 or so, frozen surimi, the raw material of boiled fish paste, was developed, and in Japan modernized surimi manufacturing plants and surimi manufacturing ships appeared, starting the mass production of frozen surimi, which spurred on a rapid expansion of boiled fish paste production.

When frozen surimi was first developed, it was chiefly utilized by the manufacturers of fish ham and fish sausage, followed by "kamaboko" makers.

In about 1970 the catch of fish decreased worldwide, and the boiled fish paste, resembling the high-priced crab, was put out under the trade name of "crab legs", and then artificial food having a resemblance to scallop and lobster appeared. Particularly, crab legs gained explosive popularity in Western countries, and crab legs manufacturing plants have begun to be constructed one after another in foreign countries because people prefer fish to animal meat, wishing to avoid taking undesirable food of high calorific value.

This brochure will deal with the manufacture of surimi and surimi-based food such as crab legs and fish sausage.

PART I SURIMI MANUFACTURING PLANT

1. Outline of Product

In making surimi, fish meat is bleached, and the blood and water soluble protein are removed, and then saccharoid and polyphosphate are added to prevent the denaturation of protein. Surimi thus manufactured is frozen so that it can be preserved for a long period of time as the raw material of the boiled fish paste. Surimi is not eaten as it is. A little table salt is added to Surimi, which is then mashed until it becomes pasty. Then, seasonings (and spices when necessary) are added. Passing through these stages, surimi is heated to become what we call the boiled fish paste.

(1) Characteristics of frozen surimi

When surimi, which was preserved in good condition, is mashed with table salt, becoming pasty, and when it is heated, it becomes food having such a rubbery elasticity. The quality of frozen surimi is judged by the degree of its elasticity.

Frozen surimi is very sensitive to the change in temperature. Even if it is preserved in the refrigerator as low as -30°C, if the refrigerator is opened frequently, the inside temperature becomes inconstant, and such a little change in the temperature affects frozen surimi, making it difficult to keep its proper elasticity. Accordingly, in transporting and in preserving frozen surimi, the product, adequate consideration must be given to its temperature control.

(2) Kinds of frozen surimi

Frozen surimi has two kinds, "non-salted surimi" and "salted surimi". The manufacturing method of them is one and the same except a difference in the additives to be used later.

Additives of non-salted surimi	
White sugar	4%
Powdered sorbitol	4%
Polyphosphate	0.25%

Additives of salted surimi

White sugar	5%
Powdered sorbitol	5%
Table salt	2.5%

The difference in the quality of these two kinds of surimi lies in the elasticity which the boiled fish paste made from them respectively has. Which of them is used is decided on by the liking on the side of boiled fish paste makers. The majority of surimi is made as non-salted.

(3) Change in the production

Frozen surimi is also distinguished by the place of manufacture. The surimi manufactured on land is called "land surimi" and the one manufactured on a ship is called " ocean surimi".

Table 1 shows the change in the production of surimi in Japan.

Table 1 Change in the Production of Surimi

Unit: tons

Year	Land Surimi	Ocean Surimi	Total
1980	105,669	183,332	288,901
1981	114,394	192,264	306,658
1982	142,000	198,000	340,000
1983	168,000	208,000	376,000
1984	188,000	210,000	398,000

2. Raw Materials

2.1 Raw Material

In Japan Alaska pollack is mainly used for making surimi. Besides, Atka mackerel, long shanny and croaker are partially used. In addition, the lean meat of sardine and mackerel have recently come to be utilized as raw materials of surimi.

The raw materials to be used for making surimi need to meet the following conditions.

(a) The fish that can be available in large quantities throughout the year.

(b) High in freshness, which determines the quality of surimi first of all.

(c) The fish meat must have strong elasticity, for instance, Alaska pollack, white croaker and yellow croaker.

(d) The fish meat rich in taste, for example, long shanny and croaker.

High-grade boiled fish paste like "kamaboko" requires whiteness in addition to elasticity. Hence, the fish having white meat like Alaska pollack and croaker are needed.

However, fried fish ball, fish sausage and fish ham, do not require whiteness, Atka mackerel, sardine, and mackerel can be used as Alaska pollack.

Shark can be used for making surimi, but is not suitable for high-grade "kamaboko", and is used for making fried fish paste and fried fish ball.

2.2 Auxiliary Raw Materials

The following auxiliary raw materials are all utilized for the purpose of preventing protein denaturation.

(a) Sugar
Cane sugar having the white and fine grain is used.

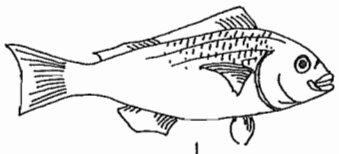
(b) Sorbitol
Sweetening made by processing glucose. There are two kinds, powder and liquid. The former is used.

(c) Polyphosphate
Phosphate made of 50% sodium pyrophosphate and 50% polyphosphate.

(d) Polyethylene bag
Surimi is wrapped to be frozen.

3. Manufacturing process

Fig. 1 shows the standard manufacturing process of frozen surimi, and its gist is explained.



Washing of raw fish in water	Dirt, scales, and slime on the fish body are removed.
Removing of unnecessary parts of raw fish	Head and intestines are removed by machine or by hand.
Washing out the inside	Blood and liquid are removed.
Filleting	Making of butterfly fillet by machine or by hand, and bones are removed.
Taking off of internal organs in water	Adhered internal organs are removed.
Separation of meat and skin	Meat and skin are separated by meat separator.
Bleaching	Blood and the water soluble protein, the substances that denaturate frozen meat, as well as fat are removed by bleaching. Also, fish smell is eliminated.
Refining	Small bones, scales and stringy meat contained in the meat are removed.
Dehydration	Dehydration is made by a screw press.
Additives mixing	Dehydrated meat and additives are mixed by a mixer.
Packing and weighing	A fixed quantity is put into a polyethylene bag by machine.
Freezing	Sharp freezing is done.
Storage after being frozen	

Fig. 1 Manufacturing Process of Frozen Surimi

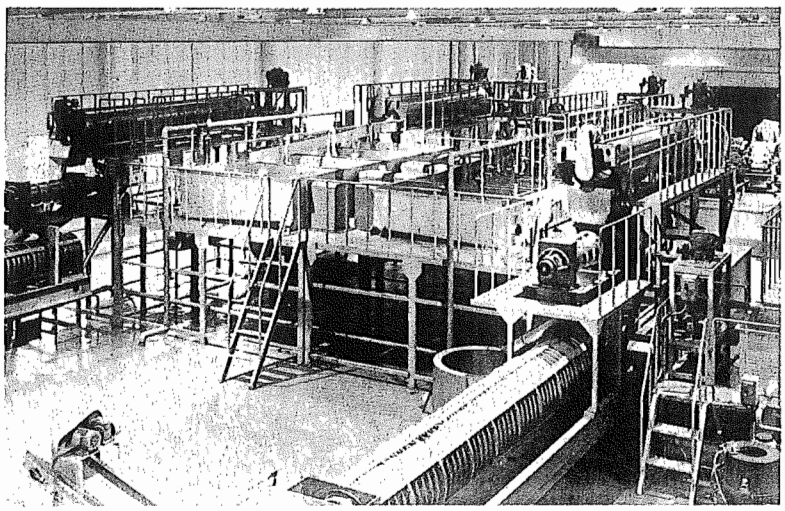


Photo 1 Bleaching Equipment of Surimi

The most important thing in the manufacturing process is as follows.

Care must be taken not to let the meat temperature rise in the state of raw fish until it is frozen. In order to prevent the rise in the meat temperature, it is necessary to apply ice to the raw fish, the water to be used for bleaching is chilled, and the outside of a mixer, which is utilized for mixing the additives, is chilled too. What is ideal is to keep the meat temperature to +8°C when it is packed up.

4. Surimi Model Plant

In selecting the site of a surimi manufacturing plant and in deciding on a production scale, it needs to give consideration to, and fully investigate, the following things.

(a) The site should be selected as near a fishing ground as possible so that very fresh raw material can be obtained.
(b) The site where good water is obtainable. The water containing much iron and high density of salt must be avoided.

4.1 Production Scale

Daily output	2 tons/8 hours
Annual output	460 tons by operating the plant for 230 days a year.

4.2 Required Quantity of Raw Materials

(1) Raw material

Raw fish	2,553 tons/year (Yield: 18% on an average)

(2) Auxiliary raw materials

Sugar (4% weight of dehydrated meat) 18.4 tons

Sorbitol (4% weight of dehydrated meat) 18.4 tons

Polyphosphate (0.25% weight of dehydrated meat) 1.15 tons

Polyethylene bag (10 kg bag) 46,000 bags

4.3 Utilities

The following electricity and water are needed to operate the plant for 230 days a year, working 8 hours a day.

Electricity	148 kWh x 230 days = 340,630 kWh
Water	120 m^3 x 230 days = 27,600 m^3

4.4 Machinery and Equipment

Table 2 Machinery and Equipment

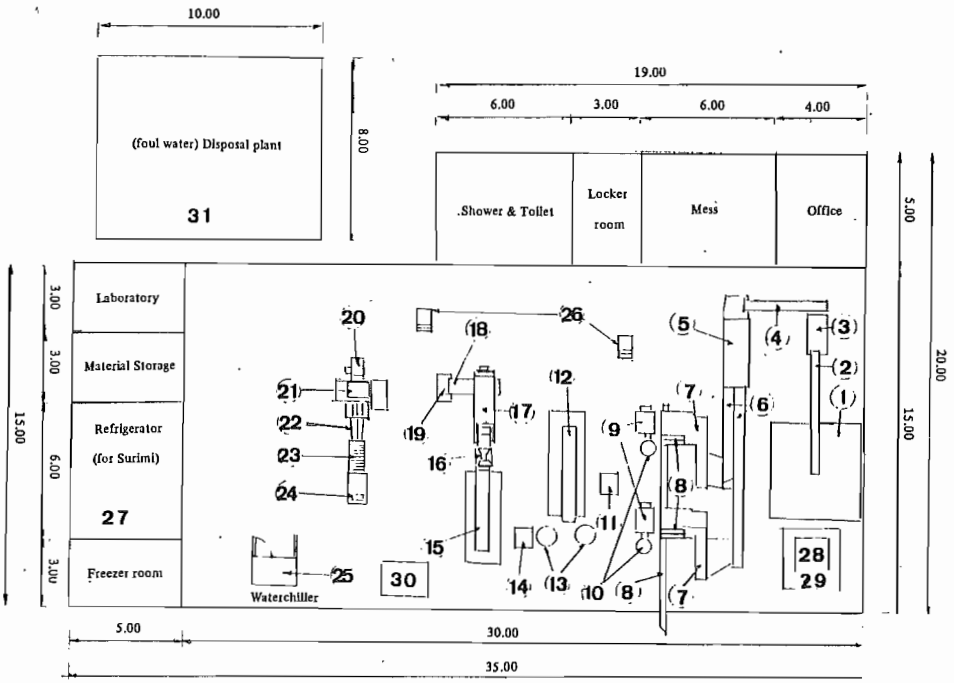
No.	Item	Unit
1	Raw fish receiving tank of 50 m^3 made of concrete	1
2	Belt conveyor for transferring raw fish	1
3	Rotary fish washer	1
4	Belt conveyor	1
5	Grader	1
6	Belt conveyor for supplying raw fish	2
7	Fish processing machine	2
8	Offal conveyor	3
9	Meat separator	2
10	Fish meat receiving tank	2
11	Fish meat transfer pump	1
12	Rotary screen	2
13	Bleaching tank	2
14	Fish meat transfer pump	1
15	Rotary screen	1
16	Refiner	1
17	Screw press	1
18	Conveyor	1
19	Bucket with wheel	3
20	Lift-boy	1
21	Cooling mixer	1
22	Filling machine	1
23	Roller conveyor	1
24	Balance with table	1
25	Contact freezer	1
26	Jet cleaner	2
(Other facilities)		
27	Refrigerator (for surimi) 100 m^3	1
28	Ice machine (4 tons/24 hours)	1
29	Ice storage (4 tons)	1
30	Water chiller (20°C → + 3°C. 1.5 tons/hour)	1
31	Foul water disposal plant (150 tons/24 hour)	1
32	Air conditioning in the factory	1

4.5 Layout of Plant and Building

(1) Area of plant site 1,200 m^2

(2) Building

Surimi factory	450 m^2
Refrigerator	30 m^2
Freezer room	15 m^2



Note: Circled numbers show the numbers of machines in Table 2.

Fig. 2 Layout of Surimi Plant

Materials storage	15 m²
Administration building	110 m²
Total	620 m²

(3) Layout of plant

Fig. 2 shows the layout of surimi plant.

4.6 Required Number of Workers and Placement

Table 3 Required Number of Workers and Placement

Division	Worker		Total
	Male	Female	
Factory manager	1		1
Administrative staff	1		1
Clerical staff		2	2
Raw fish receiving and grading	2	2	4
Fish processing machine		2	2
Meat separator, Fish meat receiving tank		2	2
Bleaching, Screw press		2	2
Balance, Mixer		2	2
Filling machine		1	1
Balance		1	1
Contact freezer	1		1
Refrigerator	1		1
Laboratory		1	1
Sub-total	6	15	21
Engineering staff			
Freezer	1		1
Electricity	1		1
Repairing	2		2
Sub-total	4		4
Total	10	15	25

5. Production Cost

In calculating the production cost, it needs to take into consideration the actual conditions in each country, but it being difficult to do so, calculation in this brochure was made on such basic condiitons as cited below.

5.1 Basic Conditions for the Calculation of Fixed Capital, Working Capital, and Production Cost

(1) Fixed capital

(a) Construction cost of factory and office
Assumed to be US$250/m²

Construction cost of refrigerator
Assumed to be US$700/m²

(b) Cost of machinery and equipment
To be indicated by FOB Japanese port as of 1985

(c) Spare parts — Assumed to be 10% of the FOB price of machinery and equipment

(d) Freight and insurance
Assumed to be 10% of the FOB price of machinery and equipment

(e) Civil engineering cost for foundation (including miscellaneous works)
Assumed to be 10% of the FOB price of machinery and equipment

(f) Erection cost — Assumed to be 10% of the FOB price of machinery and equipment

(g) Guidance and supervision cost
Assumed to be 10% of the FOB price of machinery and equipment

(h) Test run cost — Assumed to be 2% of the FOB price of machinery and equipment

(i) Education and training expenses

		Assumed to be 3% of the FOB price of machinery and equipment
(j)	Contingency	Assumed to be 10% of the FOB price of machinery and equipment

(2) **Working capital**

(a) Raw material cost for two months

(b) Products in stock
Equivalent to one month of the annual production cost

(3) **Production cost**

(a) Raw material cost

Raw fish	US$0.19/kg

(b) Auxiliary raw material cost

Sorbitol	US$1.90/kg
Sugar	US$1.03/kg
Polyphosphate	US$2.50/kg
Polyethylene bag	US$0.05/bag

(c) Utilities

Electricity	US$0.08/kWh
Water	US$0.40/$m^3$

(d) Labor cost
Labor cost is assumed to be as follows in terms of man/year

Factory manager	US$12,000
Clerk	US$ 3,000
Engineer	US$ 5,000
Skilled worker	US$ 4,000
Unskilled worker	US$ 2,000

(e) Maintenance cost
Assumed to be 3% of the FOB price of machinery and equipment

(f) Depreciation
Straight-line method will be adopted.

Machinery and equipment	Machinery and equipment cost x 10%
Buildings	Buildings cost x 3%

(g) Insurance — 0.5% of the fixed capital

(h) Selling and administration cost
As the product is used for manufacturing the secondary products, no calculation will be made on the selling and administration cost.

(i) Interest
One-second of the fixed capital is to be covered by a long-term loan, and its annual rate of interest is 10%.

Note: The exchange rate of the US$ to the Japanese Yen is assumed to be US$ = ¥240.

5.2 Capital Required

(1) **Fixed capital**

	US$
Area of plant site ($1,200\ m^2$)	–
Floor space of factory and office ($US\$250/m^2 \times 590m^2$)	147,500
Refrigerator ($US\$700/m^2 \times 30m^2$)	21,000
Machinery and equipment (FOB Japan)	722,400
Spare parts	72,240
Freight and insurance	72,240
Civil engineering for foundation (including miscellaneous works)	72,240
Erection	72,240
Guidance and supervision fee	72,240
Test run cost	14,450
Education and training expenses	21,672
Contingency	72,240

Sub-total for (1)	US$1,360,462

(2) **Working capital**

	US$
Raw material cost for two months	80,845
Auxiliary raw materials cost for two months	9,848
Products in stock for one month	70,687
Sub-toal for (2)	US$161,380

(3) **Capital required (1)+(2) US$1,521,842**

5.3 Production Cost

(a) Raw material cost

Raw fish (US$190/ton x 2,553 tons)	US$485,070

(b) Auxiliary raw materials cost

	US$
Sugar (US$1,030/ton x 18.4 tons)	18,952
Sorbitol (US$1,900/ton x 18.4 tons)	34,960
Polyphosphate (US$2,500/ton x 1.15 tons)	2,875
Polyethylene bag (US$0.05/bag x 46,000 bags)	2,300
Sub-total for (b)	US$ 59,087

(c) Utilities

	US$
Electricity (US$0.08/kWh x 340,630 kWh)	27,250
Water (US$0.40/$m^3$ x 27,600 m^3)	11,040
Sub-total for (c)	US$ 38,290

(d) Labor cost

	US$
Factory manager (US$12,000 x 1)	12,000
Clerk (US$3,000 x 2)	6,000
Engineer (US$5,000 x 6)	30,000
Skilled worker (US$4,000 x 6)	24,000
Unskilled worker (US$2,000 x 10)	20,000
Sub-total for (d)	US$ 92,000

(e) Maintenance cost (US$722,400 x 0.03) US$ 21,672

(f) Depreciation

	US$
Machinery and equipment (US$722,400 x 0.1)	72,240
Buildings (US$168,500 x 0.03)	5,055
Sub-total for (f)	US$77,295

(g) Insurance (US$1,360,462 x 0.005) US$6,802

(h) Interest (US$1,360,462 x ½ x 0.1) US$68,023

Total (a) to (h)	US$848,239 (US$1.844/kg)

PART II SURIMI-BASED FOOD MANUFACTURING PLANT

As was already mentioned, surimi is the raw material to be used for making boiled fish paste. The gel forming ability, which surimi possesses, is its basic property that helps put out new products. Accordingly, it is not too much to say that surimi can be applied for making any kind of product depending on contrivance to be made.

Surimi is being utilized almost as below.

Kind of "kamaboko":

They are "kamaboko", fried fish ball, etc., which are traditional foods in Japan.

Fish ham and sausage:

Fish ham and sausage were developed in 1954 by using at first tuna and whale. Later in 1962 the frozen Alaska pollack surimi was developed, becoming the main raw material of fish ham and sausage before being utilized by the "kamaboko" makers.

Carrier of animal meat ham and sausage;

Frozen surimi has come to be used as a substitute for tuna because of the rise in tuna price.

Application of surimi for making artificial food analogs:

In 1975 crab legs imitation "kamaboko" was first developed, followed by scallop imitation "kamaboko", and shrimp imitation "kamaboko". Of which, crab legs imitation "kamaboko" is being welcomed even in Western countries.

1. Crab Legs Plant

1.1 Outline of Product

Crab legs is a kind of the boiled fish paste resembling king crab or snow crab in its shape, meat, tissue, taste, and smell.

About ten years ago, a first step crab legs was developed in Japan, which has been improved continuously. The present crab legs product has so much been ameliorated that its external appearance, meat quality, taste, and smell resemble the genuine product.

In Japan crab legs is eaten as it is, using vinegar mixed with sugar, and as part of the soup or of the vegetable salad, and in various other ways.

Table 4 shows the change in the production of crab legs in Japan.

Table 4 Change in the Production of Crab Legs

Unit: tons

Year	Production	Exports
1978	17,000	405
1979	18,000	442
1980	18,000	1,427
1981	25,000	4,044
1982	37,000	9,330
1983	59,000	18,828
1984	Unknown	32,462

Note: Scallop imitation "Kamaboko" is included.

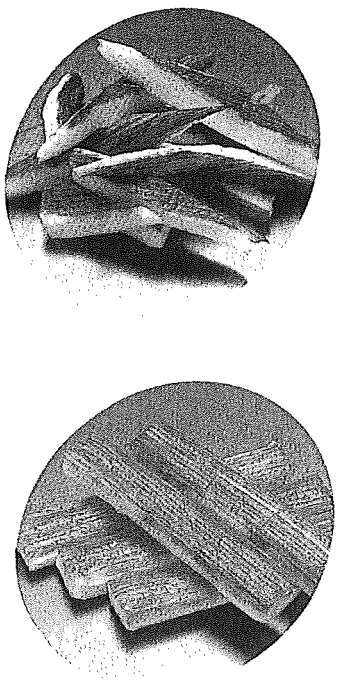


Photo 2 Crab Legs

1.2 Raw Materials

1.2.1 Raw material

The raw material is frozen surimi, which is so far limited to Alaska pollack.

However, any fish can be used as long as it has the white meat and the surimi made from it has much elasticity. For instance, true cod is being partially used.

1.2.2 Auxiliary raw materials

The auxiliary raw materials are food additives such as seasonings, binding aid, flavouring and coloring, as well as packing material.

(a) Refined salt dissolves the salt soluble protein in surimi and makes surimi pasty, and also serves as a seasoning.

(b) Cornstarch is used as carrier.

(c) Processed starch is used for strengthening flexibility.

(d) White egg is used as carrier.

(e) Crab essence is used for adding sweetness of crab.

(f) Crab meat flavour is used for flavouring.

(g) Pigment is used for making the external appearance of crab legs resemble the genuine crab legs.

(h) Seasonings made mainly from various kinds of amino acid are used.

(i) Synthetic resin film is used for applying red pigment to the exterior of crab legs, and at the same time, is used to prevent the condensed waterdrops from adhering directly to the crab legs when steaming is done.

(j) Vacuum packing film is a packing material which prevents the contamination with bacteria to the crab legs, and checks the evaporation of moisture so that the product has a long shelf life as goods.

(k) Carton box is used for packing material of the crab legs product.

1.3 Manufacturing Process

Fig. 3 shows a general manufacturing process of crab legs, and its gist is explained. (See 13 page)

1.4 Crab Legs Model Plant

The production scale of crab legs should be determined by its marketability, but in this brochure the economically minimum scale was adopted.

1.4.1 Production scale

Daily output	2 tons/8 hours
Annual output	400 tons by operating the plant for 200 days a year.

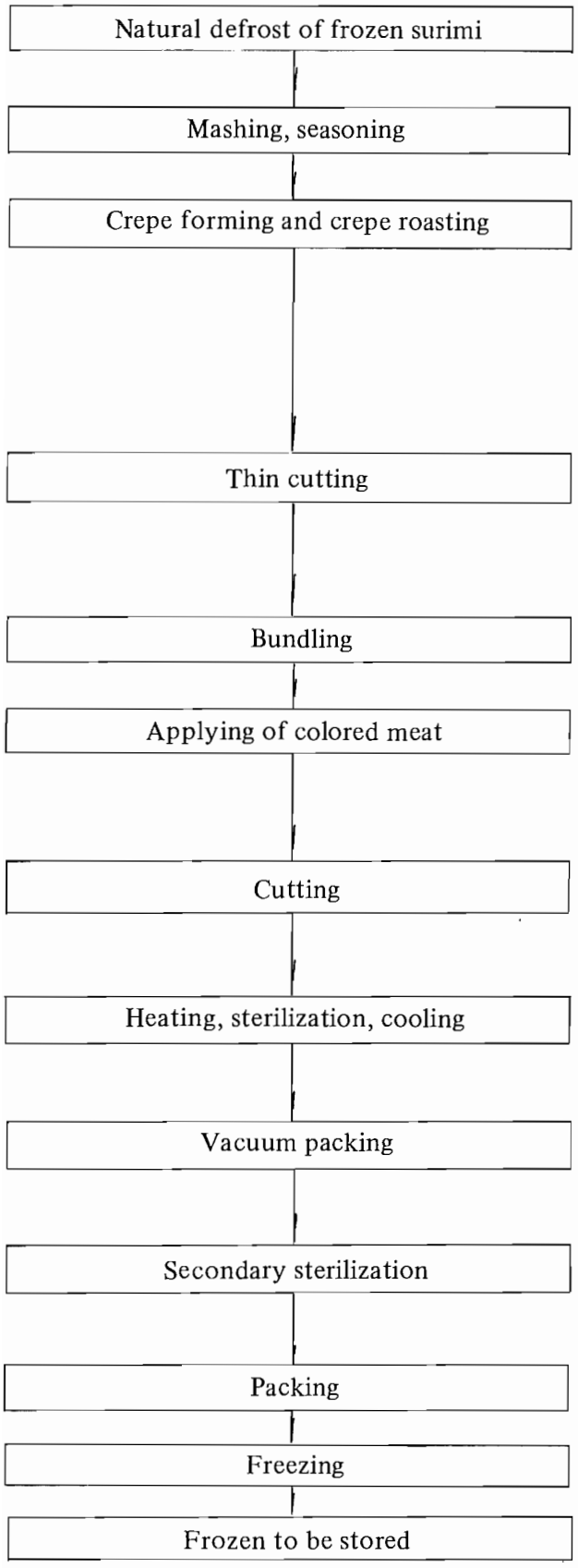
1.4.2 Required quantity of raw materials

(1) Raw material

Frozen surimi	296 tons

(2) Auxiliary raw materials

Refined salt	9.6 tons
Cornstarch	16.0 tons
Processed starch	4.0 tons
White egg	19.2 tons
Crab meat essence	4.0 tons
Crab meat flavour	1.2 tons
Pigment	0.4 tons
Seasonings	19.6 tons
Synthetic resin film	800 reels
Vacuum packing film (200gr.)	2,000,000 bags
Carton box (5 kg)	80,000 boxes



Frozen surimi is left in the room until its central temperature naturally defrosts down to -7°C.

The above surimi and additives including seasonings are put into a silent cutter to be mashed.

After becoming fully pasty, the mashed meat is pumped into a crepe forming machine, and is extended as thin as 1.5 to 2 mm on the steel belt. The thinly extended meat paste is directly heated by fuel gas while being carried along the steel belt. The meat paste thus heated comes to have the nature of rubber-like elasticity.

The wide crepe is cut by a thin cutting machine into the ones having a 1.5 to 2 mm width. (Nevertheless, the crepe is not totally cut off into pieces.)

Then, the crepes are bundled to the thickness of crab legs by a bundling machine.

When the bundled crab legs in shape comes into a wrapping machine, a tape-like film applied with colored meat comes down to go forward, while wrapping the crab legs in shape.

The crab legs in shape goes forward in the form of a long stick and is cut by a cutter into the length of 8 to 10 cm.

Then, it is sent into a heating sterilizing machine to be sterilized by steam, and is cooled by an air cooling machine.

A fixed number of crab legs in shape are bundled together and are put into a vacuum packing film to be packed by a vacuum packer.

In order to prevent the secondary bacteria contamination, the vacuum-packed are sterilized for a short time in the hot water.

Fig. 3 Crab Legs Manufacturing Process

1.4.3 Utilities

The following electricity and water are needed to operate the plant for 200 days a year, working 8 hours per day.

Electricity	733 kWh x 200 days = 146,600 kWh
Water	35 m^3 x 200 days = 7,000 m^3
Fuel oil (heavy oil)	0.747 kℓ x 200 days = 149 kℓ
LPG	144 m^3 x 200 days = 28,800 m^3

1.4.4 Machinery and equipment

Table 5 Machinery and Equipment

No.	Item	Unit
1	Silent cutter	1
2	Silent cutter	1
3	Meat feed pump	1
4	Crepe former	2
5	Crepe roaster	1
6	Thin cutting machine	1
7	Bundling machine	1
8	Colored meat supplying unit	2
9	Inner wrapping machine	2
10	Cutting machine	2
11	Metal detector	2
12	Shuttle conveyor	1
13	Steaming and cooling machine	1
14	Takeout conveyor	1
15	Conveyor with table	1
16	Work table	2
17	Vacuum packer	1
18	Basket	7
19	Cooling tank	1
20	Dehydrating roller	1
21	Belt conveyor	1
22	Work table	2
23	Binding machine	1
24	Silent cutter control panel	1
25.	Crab legs plant control panel	1
26	Vacuum pump	1
(Other facilities)		
27	Boiler 1,000 kg/hour, 6 kg/cm^2	1
28	Air blast freezing room	1
29	Refrigerator	1

1.4.5 .Layout of plant and building

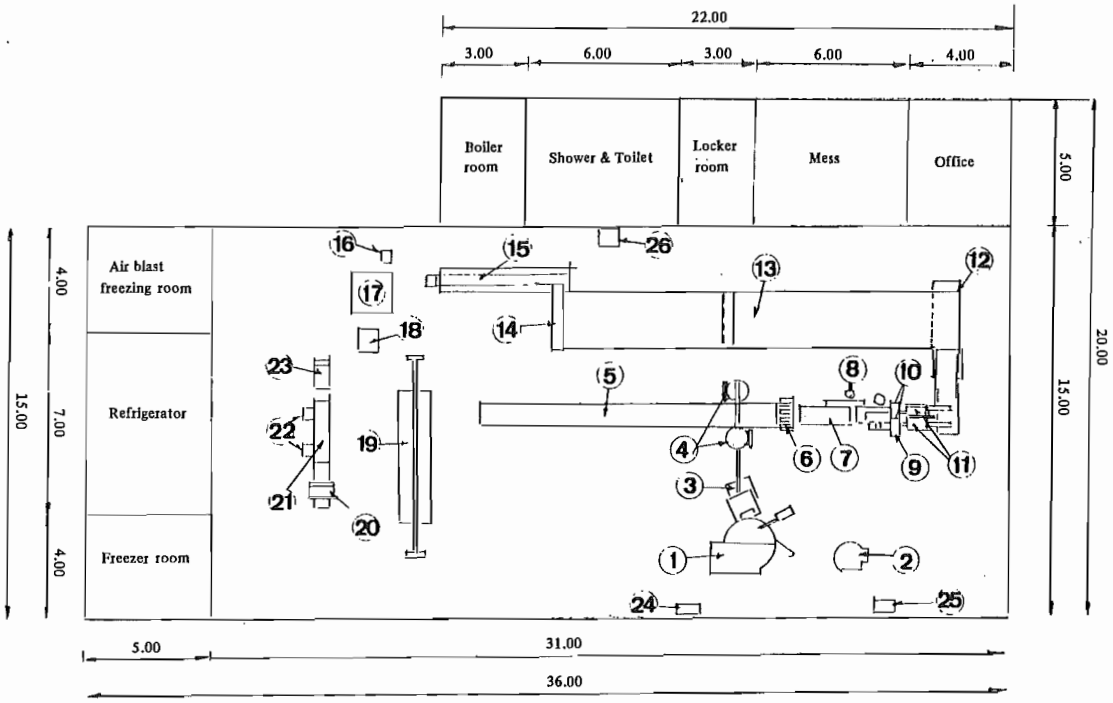
(1) Area of plant site 1,200 m^2

(2) Building

Crab legs factory	465 m^2
Refrigerator	35 m^2
Freezer room	20 m^2
Air blast freezing room	20 m^2
Boiler room	16 m^2
Administration building	110 m^2
Total	666 m^2

(3) Layout of plant

Fig. 4 shows the layout of crab legs plant.



Note: Circled numbers show the numbers of machines in Table 5.

Fig. 4 Layout of Crab Legs Plant

1.4.6 Required number of workers and placement

Table 6 Required Number of Workers and Placement

Division	Worker		Total
	Male	Female	
Factory manager	1		1
Administrative staff	1		1
Clerical staff		1	1
Transport of surimi and additives	1		1
Silent cutter	1	1	2
Crepe former, bundling machine	1		1
Colored meat supply unit, inner wrapping machine		2	2
Cutting machine		2	2
Steaming and cooling machine		1	1
Packing in bag		2	2
Vacuum packer		1	1
Secondary sterilization	1	1	2
Packing in box, freezing		3	3
Total	6	14	20

Note: Laboratory and engineering staff are included in the surimi factory.

1.5 Production Cost and Profitability

1.5.1 Basic conditions for the calculation of fixed capital, working capital, and production cost

(1) Fixed capital — The same as in the case of surimi

(2) Working capital — The same as in the case of surimi

(3) Production cost

(a) Raw material cost

Frozen surimi	US$1.844/kg

(b) Auxiliary raw materials

Refined salt	US$0.21/kg
Cornstarch	US$0.65/kg
Processed starch	US$1.46/kg
White egg	US$1.45/kg

	Crab meat essence	US$7.59/kg
	Crab meat flavour	US$5.61/kg
	Pigment	US$23.59/kg
	Seasonings	US$4.03/kg
	Synthetic resin film	US$7.50/reel
	Vacuum packing film (200 gr.)	US$0.03/bag
	Carton box (5 kg)	US$0.23/box
(c)	Utilities	
	Electricity	US$0.08/kWh
	Water	US$0.40/$m^3$
	Fuel oil (heavy oil)	US$200.00/kℓ
	LPG	US$2.09/$m^3$
(d)	Labor cost	The same as in the case of surimi
(e)	Maintenance cost	The same as in the case of surimi
(f)	Depreciation	The same as in the case of surimi
(g)	Insurance	The same as in the case of surimi
(h)	Selling and administration cost	Assumed to be 3% of the annual sales
(i)	Interest	The same as in the case of surimi

1.5.2 Capital required

(1) Fixed capital

	US$
Area of plant site (1,200 m^2)	—
Floor space of factory (US$250/$m^2$ x610m^2)	152,500
Refrigerator and air blast freezing room (US$700/$m^2$ x55m^2)	38,500
Machinery and equipment (FOB Japan)	728,670
Spare parts	72,867
Freight and insurance	72,867
Civil engineering for foundation (including miscellaneous works)	72,867
Erection-	72,867
Guidance and supervision	72,867
Test run cost	14,574
Education and training expenses	21,860
Contingency	72,867
Sub-total for (1)	US$1,393,306

(2) Working capital

	US$
Raw material cost for two months	90,971
Auxiliary raw materials cost for two months	41,002
Products in stock for one month	98,801
Sub-total for (2)	US$ 230,774

(3) Capital required

(1) + (2) US$1,624,080

1.5.3 Production cost

(a) Raw material cost

	US$
Frozen surimi (US$1,844/ton x 296 tons)	545,824

(b) Auxiliary raw materials cost

	US$
Refined salt (US$210/ton x 9.6 tons)	2,016
Cornstarch (US$650/ton x 16.0 tons)	10,400
Processed starch (US$1,460/ton x 4.0 tons)	5,840
White egg (US$1,450/ton x 19.2 tons)	27,840
Crab meat essence (US$7,590/ton x 4.0 tons)	30,360

Crab meat flavour (US$5,610/ton x 1.2 tons)	6,732
Pigment (US$23,590/ton x 0.4 tons)	9,436
Seasonings (US$4,030/ton x 19.6 tons)	78,988
Synthetic resin film (US$7.50/reel x 800 reels)	6,000
Vacuum packing film (200 gr.) (US$0.025/bag x 2,000,000 bags)	50,000
Carton box (5 kg) (US$0.23/box x 80,000 boxes)	18,400
Sub-total for (b)	US$246,012

(c) Utilities

	US$
Electricity (US$0.08/kWh x 146,600 kWh)	11,728
Water (US$0.40/$m^3$ x 7,000 m^3)	2,800
Fuel oil (heavy oil) (US$200/kℓ) x 149 kℓ)	29,800
LPG (US$2.09/$m^3$ x 28,880 m^3)	60,359
Sub-total for (c)	US$ 104,687

(d) Labor cost

	US$
Factory manager (US$12,000 x 1)	12,000
Clerk (US$3,000 x 1)	3,000
Engineer (US$5,000 x 2)	10,000
Skilled worker (US$4,000 x 5)	20,000
Unskilled worker (US$2,000 x 11)	22,000
Sub-total for (d)	US$67,000

(e) Maintenance cost (US$728,670 x 0.03)	US$ 21,860

(f) Depreciation

	US$
Machinery and equipment (US$728,670 x 0.1)	72,867
Buildings (US$191,000 x 0.03)	5,730
Sub-total for (f)	US$ 78,597
(g) Insurance (US$1,393,306 x 0.005)	US$ 6,967
(h) Selling and administration cost (US$1,500,000 x 0.03)	US$ 45,000
(i) Interest (US$1,393,306 x ½ x 0.1)	US$ 69,665
Total (a) to (i)	US$1,185,612

1.5.4 Annual sales

The selling price of crab legs was fixed at US$3.75 per kg according to the current international market price. Hence, the annual sales will become as below,

Crab legs

US$3.75/kg x 400 tons = US$1,500,000

1.5.5 Profitability

Calculating the profitability of the model plant on the basis of the above conditions, the following result was obtained.

Annual sales revenue	US$1,500,000
Total cost	US$1,185,612
Profit	US$ 314,388

The rate of profit against annual sales revenue

US$314,388/US$1,500,000 = 21.0%

The rate of profit against capital

US$314,338/US$1,624,080 = 19.4%

Therefore, the profitability may be good.

2. Fish Sausage Plant

2.1 Outline of Product

Fish sausage is chiefly made from fish surimi, which is packed in the synthetic resin casing film and is sterilized at a high temperature because it is put on sales at a normal temperature. Fish sausage is one of the boiled fish paste products, to which spices and seasonings are added.

Fish sausage had decreased in demand owing to the animal meat sausage, but it being low in calorie and high in protein, the demand for fish sausage has come to be stabilized.

Table 6 shows the change in the production of fish sausage in Japan.

Table 6 Change in the Production

Year	Production
	tons
1980	90,000
1981	92,000
1982	95,000
1983	98,000

Note: 17% of the figures is of fish ham.

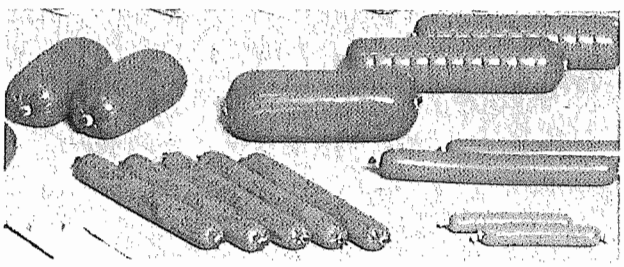


Photo 3 Fish Sausage

2.2 Raw Materials

2.2.1 Raw material

Fish sausage is made from frozen surimi, but being unable to expect a high selling price, it needs to use surimi made from cheap fish. Frozen fish surimi can be made from any fish, for instance, the lean meat of sardine and mackerel.

It may be desirable to fix the price of frozen surimi, which is used as raw material, at US$1.25/kg.

2.2.2 Auxiliary raw materials

Of the auxiliary raw materials of fish sausage, spices are indispensable, serving to give good flavour to fish sausage. In addition to spices, seasonings, binding aid matter and coloring matter are used. Besides these food additives, packing materials are required.

(a) Refined salt dissolves the salt soluble protein in surimi and makes surimi pasty, and also serves as a seasoning.

(b) Cornstarch is used as carrier.

(c) Lard is used as a seasoning.

(d) pH adjusting agent is used to keep a long shelf life of fish sausage.

(e) Synthetic preservative is used to keep a long shelf life of fish sausage.

(f) Anti-oxidant is used to keep good quality.

(g) Seasonings are used for seasoning.

(h) Smoke flavour powder is used to add the nice smoke smell.

(i) Spices are used to add nice smell to sausage.

(j) Coloring agent is used to add a suitable color to sausage.

(k) Casing film: Synthetic resin film, in which sausage is packed.

(l) Aluminium wire is used to clip the both ends of the casing containing sausage.

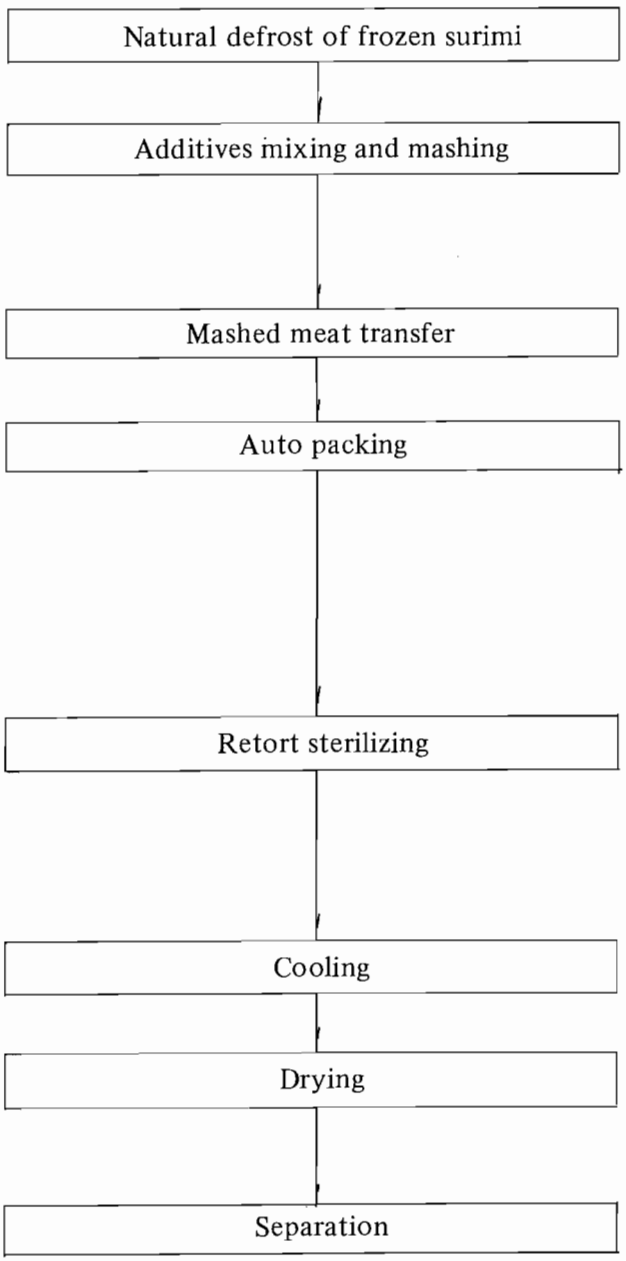
(m) Wrapping bag (2 sausages) is used to wrap a unit of sausages.

(n) Carton box (50 sausages): Packing material in which sausages are put.

2.3 Manufacturing Process

Fig. 5 shows a general manufacturing process of fish sausage, and its gist is explained.

Fig. 5 Fish Sausage Manufacturing Process



Frozen surimi is left in the room until its central temperature naturally defrosts to -7°C.

The above surimi and additives are put into a silent cutter to be mashed. When it becomes pasty, the mashed meat is transferred to a meat feeder.

Mashed meat is sent to the auto pack by a pump of the meat feeder.

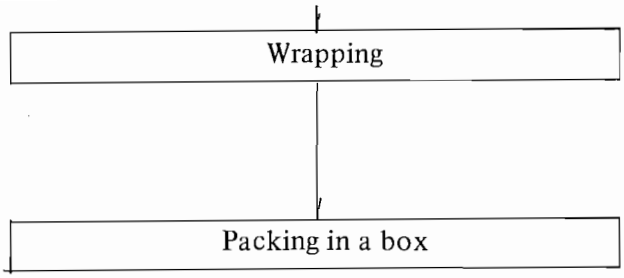
Auto packer automatically weighs the mashed meat, and fills it into the casing film, both of the ends are tied automatically by aluminium wire. One sausage weighs about 50 to 100 grams in general. Raw sausage coming from the auto packer is washed around in the tank with net conveyor to remove dirt.

Raw sausage is put into a basket which is then put into a retort to be sterilized in the heated hot water. Sterilization must be done for four minutes at a temperature of 120°C in the central part of the sausage.

The fish sausage, which was sterilized primarily in the retort, is again cooled in a cooling tank.

Then, the sausage comes into a dryer where the waterdrops around the sausage are blown off with air to be dried entirely.

A broken piece of casing in the dried sausage and an extremely deformed sausage are removed by hand.



The sausage is then sent to an automatic wrapping machine, where each unit of sausages is automatically sealed in a bag according to the selling purpose.

2.4 Fish Sausage Model Plant

2.4.1 Production scale

The scale of a fish sausage plant should be determined according to the demand for it, but in this brochure the economically minimum scale was adopted.

One fish sausage is assumed to weigh 100 grams.

Daily output
12,000 sausages = 1.2 tons

Annual output
12,000 sausages x 200 days
= 2,400,000 sausages = 240 tons

2.4.2 Required quantity of raw materials

(1) Raw material

Frozen surimi	160 tons

(2) Auxiliary raw materials

Refined salt	5.6 tons
Cornstarch	24.0 tons
Lard	12.8 tons
pH adjusting agent	0.08 ton
Synthetic preservative	0.24 ton
Anti-oxidant	0.16 ton
Seasonings	1.28 tons
Smoke flavour powder	0.032 ton
Spices	2.6 tons
Coloring agent	A very small quantity
Casing film	2,400,000 bags
Aluminium wire	4,800,000 pieces
Wrapping bag (two sausages)	1,200,000 bags
Carton box (50 sausages)	48,000 boxes

2.4.3 Utilities

The following utilities are needed to operate the plant for 200 days a year, working 8 hours per day.

Electricity	169 kWh x 200 days = 33,800 kWh
Water	35 m^3 x 200 days = 7,000 m^3
Fuel oil (heavy oil)	0.11 kℓ x 200 days = 22 kℓ

2.4.4 Machinery and equipment

Table 7 Machinery and Equipment

No.	Item	Unit
1	Bucket car	3
2	Lift-boy	1
3	Silent cutter	1
4	Meat feeder	1
5	Auto packer	1
6	Belt conveyor	1
7	Sausage receiving tank	1
8	Retort	1
9	Tray with wheel	4
10	Tray container with wheel	4
11	Cooling tank	1
12	Fan dryer	1
13	Belt conveyor	1
14	Automatic wrapping machine	1
15	Automatic binding machine	1
16	Work table	2
17	Work table	1
(Other facilities)		
1	Boiler 100 kg/hour, 6 kg/cm^2	1

2.4.5 Layout of plant and building

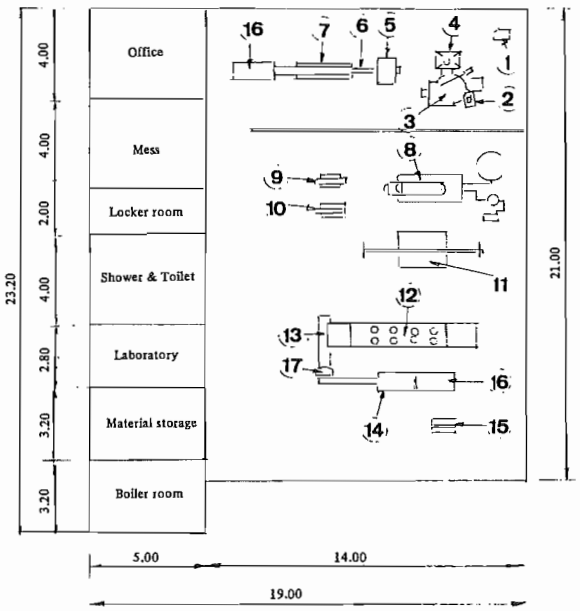
(1) Area of plant site 600 m²

(2) Buildings

Fish sausage factory	294 m²
Boiler room	16 m²
Material storage	16 m²
Administration building	84 m²
Total	410 m²

(3) Layout of plant

Fig 6 shows the layout of fish sausage plant.



Note: Circled numbers show the numbers of machines in Table 7.

Fig. 6 Layout of Fish Sausage Plant

2.4.6 Required number of workers and placement

Table 8 Required Number of Workers and Placement

Division	Worker		Total
	Male	Female	
Factory manager	1		1
Administrative staff	1		1
Clerical staff		1	1
Transport of surimi and additives		1	1
Silent cutter	1		1
Auto packer	1		1
Raw sausage container		1	1
Container Transport	1		1
Retort	1		1
Cooling	1		1
Drying		1	1
Feeding to wrapping machine		1	1
Automatic wrapping machine		1	1
Packing in box		2	2
Automatic binding machine		1	1
Laboratory		1	1
Total	7	10	17

Note: Engineering staff is included in surimi factory.

2.5 Production Cost and Profitability

2.5.1 Basic conditions for the calculation of fixed capital, working capital, and production cost

(1) Fixed capital — The same as in the case of surimi

(2) Working capital — The same as in the case of surimi

(3) Production cost

(a) Raw material cost

Frozen surimi US$1.844/kg

The price of the high-grade frozen surimi, which is used for making crab legs, was adopted.

(b) Auxiliary raw materials

Refined salt	US$0.21/kg
Cornstarch	US$0.65/kg
Lard	US$0.95/kg
pH adjusting agent	US$3.00/kg
Synthetic preservative	US$6.50/kg
Anti-oxidant	US$8.00/kg
Seasonings	US$3.50/kg

Smoke flavour powder	US$4.96/kg
Spices	US$4.95/kg
Coloring agent	–
Casing film	US$0.016/bag
Aluminium wire	US$0.00013/pce.
Wrapping bag (2 sausages)	US$0.025/bag
Carton box (50 sausages)	US$0.23/box

(c) Utilities

Electricity	US$0.08/kWh
Water	US$0.40/$m^3$
Fuel oil (heavy oil)	US$200.00/kℓ

(d) Labor cost — The same as in the case of surimi

(e) Maintenance cost — The same as in the case of surimi

(f) Depreciation — The same as in the case of surimi

(g) Insurance — The same as in the case of surimi

(h) Selling and administration cost — Assumed to be 3% of the annual sales

(i) Interest — The same as in the case of surimi

2.5.2 Capital required

(1) Fixed capital

	US$
Area of plant site (600 m^2)	–
Floor space of factory (US$250 x 410 m^2)	102,500
Machinery and equipment (FOB Japan)	352,960
Spare parts	35,296
Freight and insurance	35,296
Civil engineering for foundation (Including miscellaneous works)	35,296
Erection	35,296
Supervision and guidance	35,296
Test run cost	7,059
Education and training expenses	10,589
Contingency	35,296
Sub-total for (1)	US$684,884

(2) Working capital

	US$
Raw material cost for two months	49,173
Auxiliary raw materials cost for two months	21,598
Products in stock for one month	49,633
Sub-total for (2)	US$120,404

(3) Capital required

(1) + (2) US$805,288

2.5.3 Production cost

(a) Raw material cost

Frozen surimi (US$1,844/ton x 160 tons) US$295,040

(b) Auxiliary raw materials cost

	US$
Refined salt (US$210 x 5.6 tons)	1,176
Cornstarch (US$650 x 24 tons)	15,600
Lard (US$950 x 12.8 tons)	12,160
pH adjusting agent (US$3,000 x 0.08 ton)	240
Synthetic preservative (US$6,500 x 0.24 ton)	1,560
Anti-oxidant (US$8,000 x 0.16 ton)	1,280
Seasonings (US$3,500 x 1.28 ton)	4,480
Smoke flavour powder (US$4,960 x 0.032 ton)	159

	US$
Spices (US$4,950 x 2.6 tons).	12,870
Casing film (US$0.016/ bag x 2,400,000bags)	38,400
Aluminium wire (US$0.00013/pce. x 4,800,000 pcs.)	624
Wrapping bag (2 sausages) (US$0.025/bag x 1,200,000 bags)	30,000
Carton box (50 sausages) (US$0.23/box x 48,000 box)	11,040
Sub-total for (b)	US$129,589

(c) Utilities

	US$
Electricity (US$0.08/ kWh x 33,800 kWh)	2,704
Water (US$0.40/$m^3$ x 7,000 m^3)	2,800
Fuel oil (heavy oil) (US$200/kℓ x 22 kℓ)	4,400
Sub-total for (c)	US$ 9,904

(d) Labor cost

	US$
Factory manager (US$12,000 x 1)	12,000
Officer (US$3,000 x 1)	3,000
Engineer (US$5,000 x 2)	10,000
Skilled worker (US$4,000 x 2)	8,000
Unskilled worker (US$2,000 x 11)	22,000
Sub-total for (d)	US$55,000

(e) Maintenance cost (US$352,960 x 0.03) US$10,589

(f) Depreciation

	US$
Machinery and equipment (US$352,960 x 0.1)	35,296
Buildings (US$102,500 x 0.03)	3,075
Sub-total for (f)	US$ 38,371

(g) Insurance (US$684,884 x 0.005) US$13,424

(h) Selling and administration expenses (US$648,000 x 0.03) US$ 19,440

(i) Interest (US$684,884 x ½ x 0.1) US$ 34,244

Total (a) to (i) US$595,601

2.5.4 Annual sales

The selling price of fish sausage was fixed at US$2.70 per kg according to the current standard market price in Japan.

Fish sausage
US$2.70/kg x 240 tons= US$648,000

2.5.5 Profitability

Calculating the profitability of the model plant on the basis of the above conditions, the following result was obtained.

Annual sales revenue	US$648,000
Total cost	US$595,601
Profit	US$52,399

The rate of profit against annual sales revenue

US$52,399/US$648,000 = 8.1%

The rate of profit against capital

US$52,399/US$805,288 = 6.5%

However, if the frozen surimi is priced at

US$1.25 per kg (which is made from raw fish costing US$0.083/kg), the profitability will become as below,

Annual sales revenue	US$648,000
Total cost	US$500,561
Profit	US$147,439

The rate of profit against annual sales revenue

US$147,439/US$648,000 = 22.8%

The rate of profit against capital

US$147,439/US$805,288 = 18.3%

As is indicated above, the rate of profit against annual sales revenue will sharply rise from 8.1% to 22.8%, and the rate of profit against capital from 6.5% to 18.3%.

CONCLUSION

Marine resources are being effectively utilized across the world, of which the boiled fish paste made from surimi is especially penetrating into various countries because of its real worth has come to be recognized.

Boiled fish paste made from surimi will serve to maintain the health of people and to acquire foreign currency. Thus, boiled fish paste will contribute much to society and economy. Therefore, the construction of a boiled fish paste processing plant will be quite promising for the countries where fish, raw material of surimi, can be obtained at a low price.

Project Planning for Small and Medium Scale Industries

No. 1 Rice Milling Plant and Rice Bran Oil Manufacturing Plant
No. 2 Plastic Woven Bag Manufacturing Plant
No. 3 Container Board Manufacturing Plant
No. 4 Plastic Blow Bottle Manufacturing Plant
No. 5 Concrete Block Manufacturing Plant
No. 6 Glassware Manufacturing Plant
No. 7 Galvanized Iron Sheet Manufacturing Plant
No. 8 Fishing Net Manufacturing Plant
No. 9 Ice Making, Refrigeration and Cold Storage Plant
No.10 Starch and Syrup Manufacturing Plant
No.11 Instant Noodle Manufacturing Plant
No.12 Surimi and Surimi-Based Food Manufacturing Plant

Project Planning for Small and Medium Scale Industries No. 12

Japan Consulting Institute (JCI)

Sumitomo Fudosan Kudanshita Bldg. 3 F
Kanda-Jinbocho 3-5, Chiyoda-ku Tokyo
101-0051 Japan

TEL +81-3-3222-8100
FAX +81-3-3222-8101
URL : http://jci-plant.or.jp

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