RETORT POUCH SEAFOOD

Marine Fisheries Research Department
Southeast Asian Fisheries Development Center
Singapore

Southeast Asian Fisheries Development Center

The Southeast Asian Fisheries Development Center (SEAFDEC) is a technical organization devoted to the accelerated development of fisheries in the region. The member countries of SEAFDEC are Japan, Brunei Darussalam, Malaysia, Philippines, Singapore, Thailand and Vietnam. SEAFDEC has four departments, viz., Marine Fisheries Research Department in Singapore, Training Department in Thailand, Aquaculture Department in the Philippines and Marine Fishery Resources Development and Management Department in Malaysia.

Marine Fisheries Research Department
Southeast Asian Fisheries Development Center
Postal address: Changi Fisheries Complex
300 Nicoll Drive
Singapore 498989

Secretariat: SEAFDEC Secretariat
Suraswadi Building
c/o Department of Fisheries
Kasetsart University Campus
Bangkhen, Bangkok 10900
THAILAND

Retort Pouch Seafood

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Authors

MFRD:

Ng Mui Chng
Lee How Kwang
Evelyn Chia Geok Hoon

Special Fellows, Thailand:

Varatip Somboonyarithi
Chakree Thongraung

Marine Fisheries Research Department
Southeast Asian Fisheries Development Center
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Note: *The mention of trade names in this publication does not imply endorsement of the product.*

FOREWORD

Retort pouch foods have enjoyed rapid growth in demand since its introduction in the late 1960s. Although the main market is in Japan where annual consumption is more than 200,000 tons, there has been increasing interest by food manufacturers outside Japan to produce retort pouch foods, not only for export to Japan but also for local consumption. Recently, consumer preference for genuine and gourmet foods has created a trend towards higher class retort foods. In the beginning, retort food was marketed for its convenience and economy which appealed to consumer preferences for practicality. Recently, manufacturers have targeted their products at a wider range of consumers, from children to adults. The products therefore have expanded in range from curries and stews to "finished cooked foods", cooking sauces and cooking ingredients and are now readily available in most supermarkets in the ASEAN region.

Based on this trend to provide greater diversity of retort pouch foods, the MFRD embarked on a study on retort pouch seafood to provide examples and information on the variety of retort pouch seafood products available in Japan and in the ASEAN region. In addition, the study also gives examples of several seafood products popular in the region and are suitable for processing as retort pouch seafood.

This manual on retort pouch seafood is the result of the study done by MFRD research officers in collaboration with a Japanese short-term expert on retort pouch foods and two Special Fellows from Thailand. I would like to congratulate them for their combined effort in coming up with this manual which I am sure will be extremely useful to the seafood manufacturers not only in the ASEAN but also to the fish processing industry in other developing countries as well.

DR NGIAM TONG TAU
SEAFDEC Council Director for Singapore
and Director, Primary Production Department, Singapore

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INTRODUCTION

The retort pouch is a relatively new type of container for packaging food and it is lighter in weight than metal cans or glass jars. It allows the contents to be warmed up quickly in about 3 minutes by placing the entire pouch in boiling water or heating in a microwave oven before serving. The pouch has been catching up in popularity with the glass jars, metal cans and other plastic materials as a new technique and material for preserving food.

It was the advent of heat-resistant, plastic film, along with non-toxic adhesive compounds, that accelerated the development of what we call today, "retort pouch". The United States Army, noting the great potential of food packaging with plastic bags for battle rations, launched a program to exploit this new method through the Army's Natic Development Center. A number of notable achievements were made by the Center in the 1960s. In 1968, the Center conducted reliability tests for determining the integrity of retort pouch seals, the sterilization characteristics and percent defects in pouch food production, and came out with results which put the retort pouch on par with the metal cans to demonstrate that it is a safe and suitable device for food preservation.

"The pouch has been catching up in popularity with metal cans and glass jars which was commonly used in the early 1950s"

Though its future appeared to be rosy, the retort pouch had to overcome one more hurdle in the United States, that of obtaining an approval from the Food and Drug Administration (FDA). The FDA approval was long overdue because of a lingering doubt about the adhesive compound used for lamination: will it not disperse into the food? In 1977, the pouch was finally cleared by the FDA and this paved the way for commercial production of retort pouch in the United States.

While its commercial production in the United States was held up on account of the question of dietary hygiene, the retort pouch won sanctions in other countries. The Italian and Japanese retort pouch licensees had gone ahead and were already producing the pouch in the late 1960s; the British and West German licensees soon follow suit. Today, retort pouch food is produced not only in these countries but also in many other countries. In Europe and US, retort foods are filled in trays and cups, replacing the pouch. In Asian countries such as Korea and Taiwan, retort pouch food is gaining popularity in the market. In 1968, one Japanese company became the first in the world to produce curry in

aluminum foil pouch for large scale marketing.

Currently, Japan is the biggest producer of retort pouch food where its annual consumption volume in 1995 is about 204,899 tons in which curry accounts for about 43%; sauce for soybean curd (*mapo tofu* ingredients) 6.9%; rice, meat sauces and soups constitute 4.75, 2.79 and 6.07% espectively. Fisheries accounts for 3.39% in 1995. The main product is tuna which constituted 88.1% in fisheries. Initially, curry was marketed with an appeal to the consumers' preferences for practicality, convenience and cost consideration. Recently, manufacturers have been aiming at a wider range of consumers from children to adults. The products have expanded to curries, stews, meat sauces, and other "finished cooked foods" to cooking sauces such as Chinese seasonings and "cooking ingredients" so as to meet consumer preference for home-prepared meals. These have become popular among housewives as time-saving dishes. More consumers especially the working women and young singles are beginning to appreciate the "convenience and appealing" retort food and considerable market growth can be expected.

The characteristics of the retort pouch is its ability to preserve food contents comparable to that of the metal cans. For sterilization, the retort pouch enables its contents to be heated quickly and this property has made it possible to apply heat at a higher temperature in a shorter heating time, thus minimizing its deteriorating effect on the taste, flavour, colour and nutritional value in the preserved food contents.

Sterilization of retort pouch food

As in canning, retort pouch food is sterilized after packing, but the sterilizing procedure differs as the flexible retort pouch is susceptible to rupture owing to changes in the pressure between the pouch and the retort during heating and cooling. When the heating medium is steamed, the hot water or shower which is subsequently cooled under atmospheric pressure is bound to cause the pouch to inflate and burst. To avoid this, compressed air is used to create a pressurized atmosphere in which the pouch is cooled. Thus, the sterilizing and cooling must be carried out under controlled pressure.

Food suitable for retort pouch

A wide range of food is now available in retort pouch and they are represented by the following entrees such as meat balls in tomato sauce, curry sauce and other thick sauces; chicken stew, beef stew; ravioli, spaghetti with meat; barbecued chicken, beef stroganoff; fruits, vegetables, potato salad; cooked cereals (rice), porridge; cooked meats, seafood; sauces, soups, pastries and pet foods.

Although retort pouch seafood constitutes 4% of the total consumption of retort pouch foods in Japan, there is a potential to develop a greater variety of such products due to the increasing consumer perception on seafood as a healthy food. Within the ASEAN region, there has been considerable interest in developing its popular seafood dishes in retort pouch. Dishes like shark fin soup, spicy seafood gravy and tuna flakes are gaining popularity in this region.

Advantages of retort pouch

1. Shelf life of retort pouch products is at least equal to that of foods in metal cans; refrigeration or freezing is not required.

2. There is no hassle in cleaning up utensils when consuming the product.

3. Pouch can be opened up by tearing the notch at the top of the side seam or by using scissors.

4. Storage and disposal space for pouch is lesser than that of metal cans.

5. There is significant reduction in processing time (30-40%) as well as energy due to the rapid heat transfer of the pouch.

6. Lesser heating time will lessen the deterioration of the taste, colour and nutritional value of the food contents.

7. The empty retort pouches will take up less storage spaces and lighter weight. Compared with metal cans, pouches use up 85 spaces lesser: one thousand 4.5 x 7 inches pouches weigh 9.4 lb. as compared to an equal number of cans with an area of 211 x 304 inches weighing 112.5 lb.. A 45-ft trailer holds 200,000 eight-ounce empty metal cans whereas over 2.3 million empty pre-formed pouches can be shipped on the same trailer.

8. Retort pouch labels have more space as compared to metal cans labels.

9. Retort pouch will not be dented as it is a soft package.

10. Retort pouch is safer as consumer would not be cut as in the case of metal cans or broken glass jars.

Disadvantages of retort pouch

1. Major investments expected on the retort and filling equipment, different containers and modifications for different thermal processes.

2. Filling of contents is slow and complex. The filling lines are currently run from 30 to 60 pouches per minute compared to 400 per minute for canned and frozen foods and up to 1,200 per minute for glass jars.

3. For different types of products and container sizes, thermal processing conditions will have to be modified.

4. Detection of leakage on the pouch is more difficult due to its flexible nature. The pouch is also easily punctured.

5. Considerable marketing or advertising expenditures may be required to educate the consumers, although the institutional market may allow easier entry into the retail market.

6. Educating traders and consumers on the handling of retort food is difficult. Tests have shown that some retailers handle retort pouches as if they were frozen foods.


MARUHA
シーフードカレー
Cook Do
干焼蝦仁用
日本の家庭料理 丸美屋 北海の味
さけ釜めしの素
お米といっしょに炊きこむだけ!
さけ増量 おいしさアップ
チャオ! イタリアーノ
エビと野菜のクリームソース用
あ! あれたべよ
MARUHA 新提案
レンジで煮魚
さばのみそ煮
かれいの煮付(筍入り)
House
ククレカレー
リンゴとココナッツのマイルドカレー
辛口 HOT
EASTBAY
Brahim's
SAMBAL TUMIS
Brahim's Instant Chef
KUAH ASAM PEDAS
HOT & TANGY SAUCE
MARUHA
BEAT
チーズかまぼこ
ホタテ貝柱入り
ハンバーグ
CHEESE KAMABOKO
Cook Do
麻婆茄子用
AJINOMOTO
と野菜のたっぷり煮込み

RETORT POUCH SEAFOOD PRODUCTS

Recently high-value seafood products eg. abalone and sharkfin have been marketed in retort vacuum pouch and are gaining popularity with consumers in Southeast Asia.

Japan is the biggest producer for retort pouch products. It is therefore useful for us to take a closer look at the retort pouch market in the country. This section provides examples and market information on retort pouch seafood products available in the supermarkets in Japan and in the ASEAN region. The annual production of retort pouches in Japan increased from 91,292 tons in 1985 to 204,899 tons in 1995. These quantities constitute 13 main product categories namely, curry, stew, *hayashi*, sauce of *mapotofu*, boiled mixture of meat and vegetables, sauce of *kamamesi*, cooked meat, seafood, soups, farm products, rice, meat sauce and other sauces. The curry product makes up the largest portion of the total annual production of retort pouch products in 1995 as shown in Fig.1. For seafood products, although it constituted only 3.39% of the total production in 1995, there is a notable increase between 1985 to 1995 as shown in Fig.2.

For the ASEAN market, most of the retort pouch products are imported from Japan even though there are such factories in these countries which are equipped to undertake retort pouch processing. Recently high-value seafood products eg. abalone and sharkfin have been marketed in retort vacuum pouch and are gaining popularity with consumers in Southeast Asia.

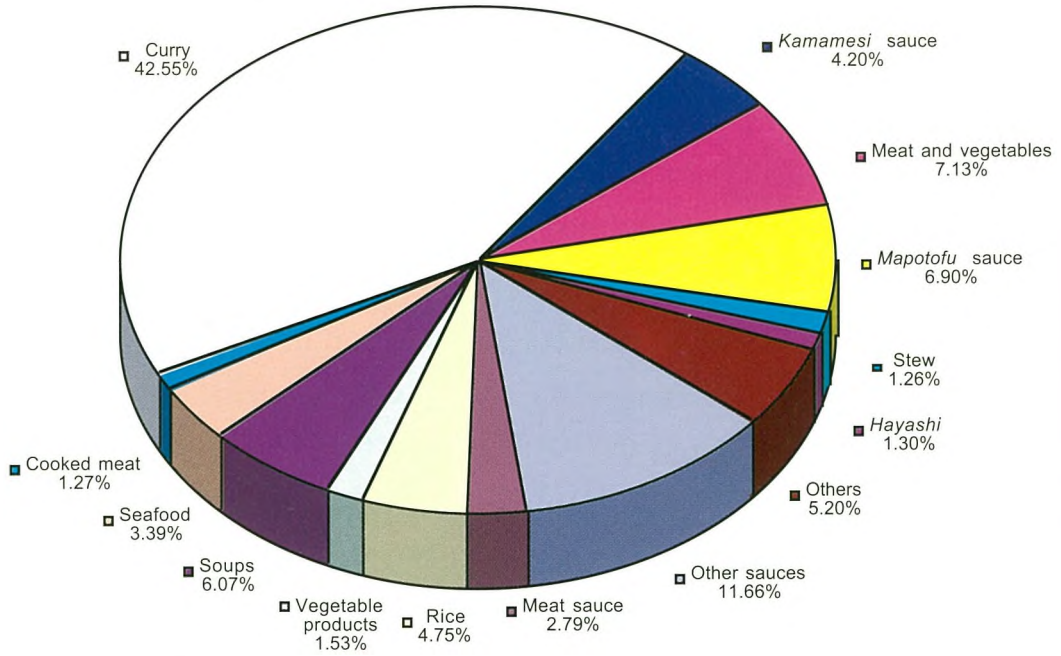


Fig. 1 Percentage of retort pouch foods in Japan, 1995 (Total production volume : 204,899MT)

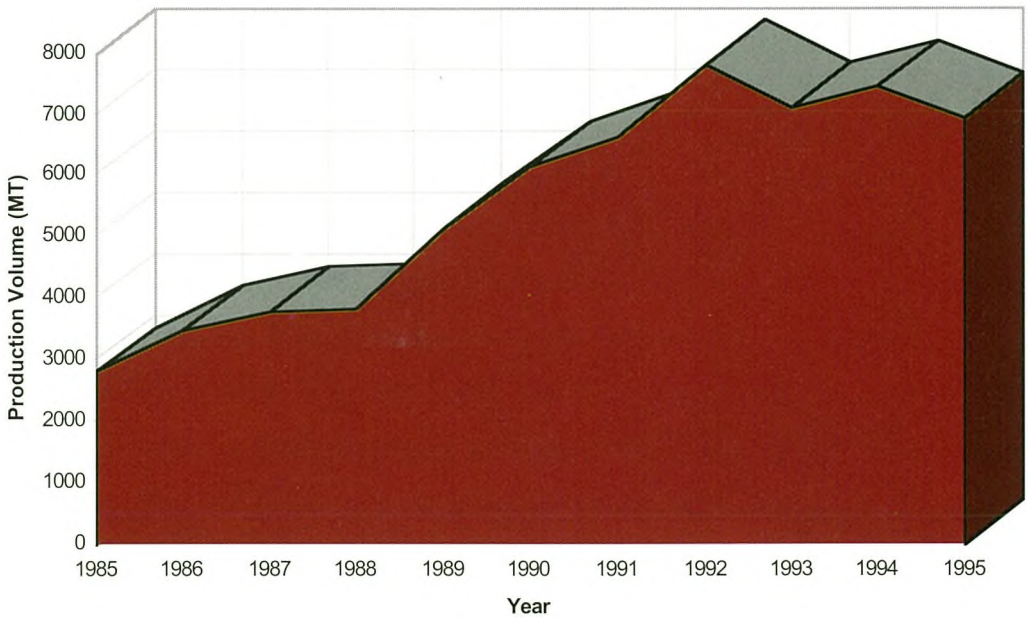


Fig. 2 Annual production volume of retort pouch seafood in Japan

Table 1. Product Information of Retort Pouch Seafood in Japan

Packing Style	Product	Net-weight (g)	Size of container (cm)
Casings	Fish burger	220	-
Trays	Flat fish, cuttlefish, mackerel	220	2.3 x 17.1
Standing Pouch (with Al-foil)	Tomato sauce, fish and vegetable porridge with crab	270	11.8 x 17.7
Bags (with Al-foil)	Tuna mayonnaise	50	9.0 x 14.0
	Tuna chunk	1000	30.0 x 22.8
	Tuna flake	1000	30.0 x 22.8
	Clam	1000	13.3 x 19.5
	Short neck clam	100	12.2 x 19.6
	Crab meat and egg sauce		15.3 x 20.2
	Crab meat with vegetables		15.3 x 20.2
	Spicy tamarind sauce		13.0 x 17.0
Bags (without Al-foil)	*Oden*	2 x 520	-
Vacuum pack (transparent)	Freshwater clam *Hamaguri* clam *Asari* clam	100	13.0 x 19.5
Bags in carton (with Al-foil)	Salmon with seaweed	130	12.5 x 16.8
	Shrimp with chili sauce	110	11.8 x 15.7
	Seafood curry	200	12.8 x 17.2

Spicy seafood sauce from Malaysia

Japanese seafood gravy

Assorted fish products (*Oden*)

Tuna and tuna mayonnaise

Tuna in oil in institutional pack.

Seafood porridge in standing pouch

Squid in retortable trays

Flat fish in retortable trays

Abalone in retortable vacuum pouch

Fish sausages in retortable casings

Retort pouch seafood packed in carton box

Retort vacuum packed clams

PROCESSING OF RETORT POUCH SEAFOOD

Experiments on several retort pouch seafood products were conducted to determine the processing conditions and to provide examples of such products. They are based on popular recipes in the Southeast Asian region.

Prawn products : Sweet and sour prawn
Prawn in garlic and pepper
Prawn in tamarind sauce

Tuna products : Tuna mayonnaise
Tuna vegetables
Tuna vegetables in mayonnaise

Most of the products e.g. sweet and sour prawn, prawn in garlic and pepper are mild in taste except for prawn in tamarind sauce which is spicy and hot. The prawn in tamarind sauce has a strong flavour and is popular with Southeast Asian consumers.

The processing of these products are stated in the following pages and the heat penetration study has been conducted by using the thermocouples and the reading of Fo obtained from a time/ temperature recorder connected to the retort. The low acidity (pH > 4.5) had been maintained before and after retort sterilization. Moreover, the products went through the incubation test at 55°C for 10 days.

Sweet and sour prawn

This product has a combination of sweet, sour and salty taste. The sauce contains vegetables such as tomato, onion and sweet pepper (capsicum). Generally, this sauce can be used for many kinds of meat, not only prawn but also fish meat chunks or fried fish. It has a mild taste suitable for people who do not like hot and spicy food.

Formulation

Sauce

Corn starch	4.86 %
Tomato sauce	3.89 %
Tomato paste	1.62 %
Vinegar	1.50 %
Sugar	4.70 %
Salt	0.26 %
Onion	14.59 %
Sweet pepper	14.59 %
Tomato	19.45 %
Water	33.08 %

Prawn

The ratio of prawn:sauce	2:3

Preparation of sweet and sour sauce

- Dissolve corn flour into half of the water used.
- Boil the rest of the water together with the seasonings (sugar, salt, vinegar, tomato paste and tomato sauce).
- Pour the well stirred corn flour suspensions into the seasonings mixture.
- Reduce heat, add vegetables and stir until cooked.

Sweet peppers, tomatoes and onions are washed and cut.

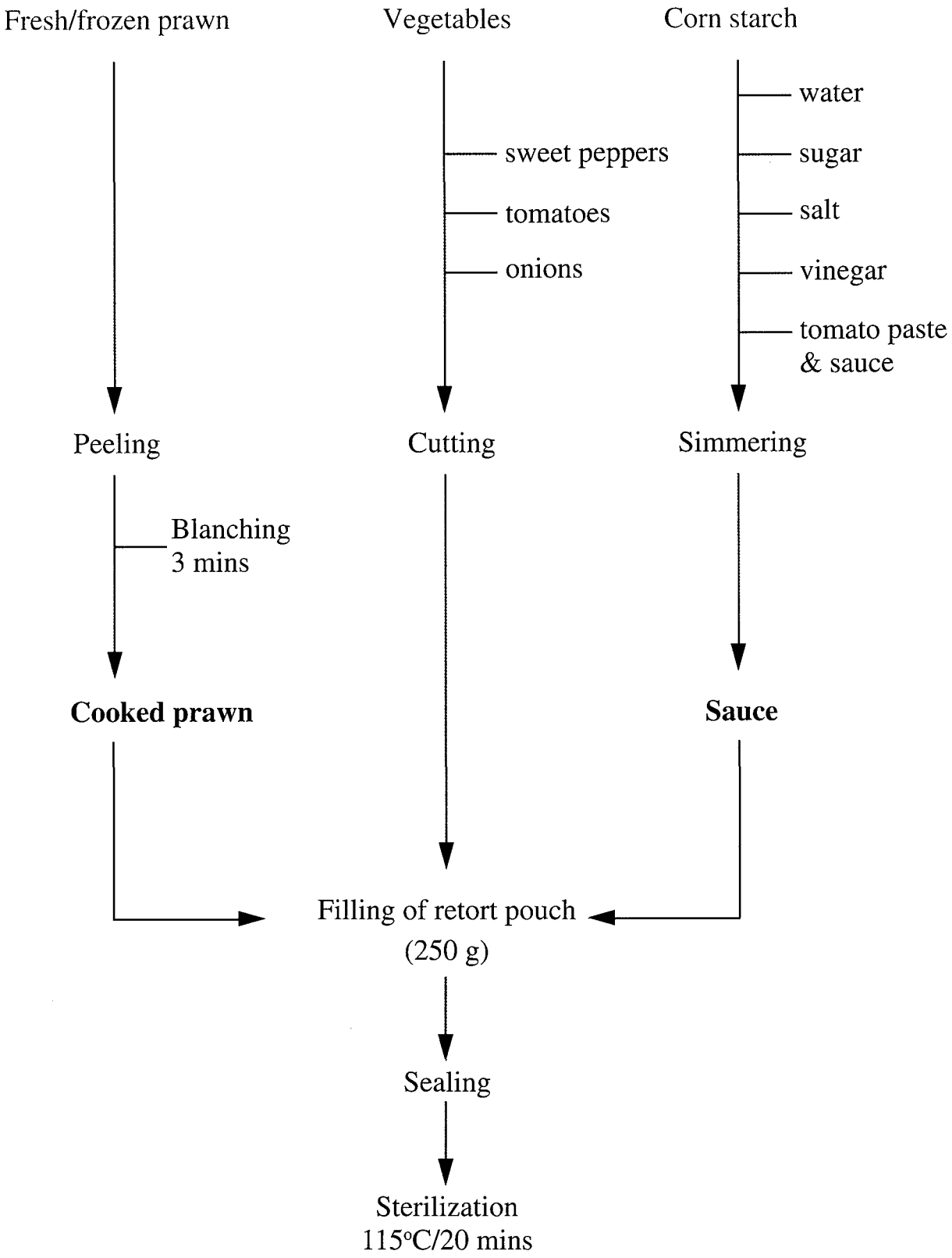
Black tiger prawns (45 pcs/kg) are washed, headed, peeled and blanched for 3 mins.

Ready for packing

Retorting at 115°C for 20 mins.

Finished product

Sweet and sour prawn



Prawn in tamarind sauce

This product is suitable for Southeast Asian consumers as it is hot, spicy and tasty. The sauce can be cooked with many kinds of meat such as fish, crab and shellfish. Vegetables can be also added before serving with rice or bread.

Formulation

Sauce

Onion	12.70 %
Garlic	4.25 %
Laksa leaf	3.40 %
Lemon grass	1.60 %
Yellow ginger	0.45 %
Blue ginger	0.74 %
Chili	17.95 %
Tamarind paste	21.00 %
Shrimp paste	3.10 %
Monosodium glutamate	0.09 %
Sugar	2.78 %
Salt	0.93 %
Water	31.00 %

Prawn

The ratio of prawn:sauce	2:3

Preparation of prawn in tamarind sauce

Ingredients are washed and cut into small pieces.

Black tiger prawns are washed, headed, peeled and blanched for 3 minutes.

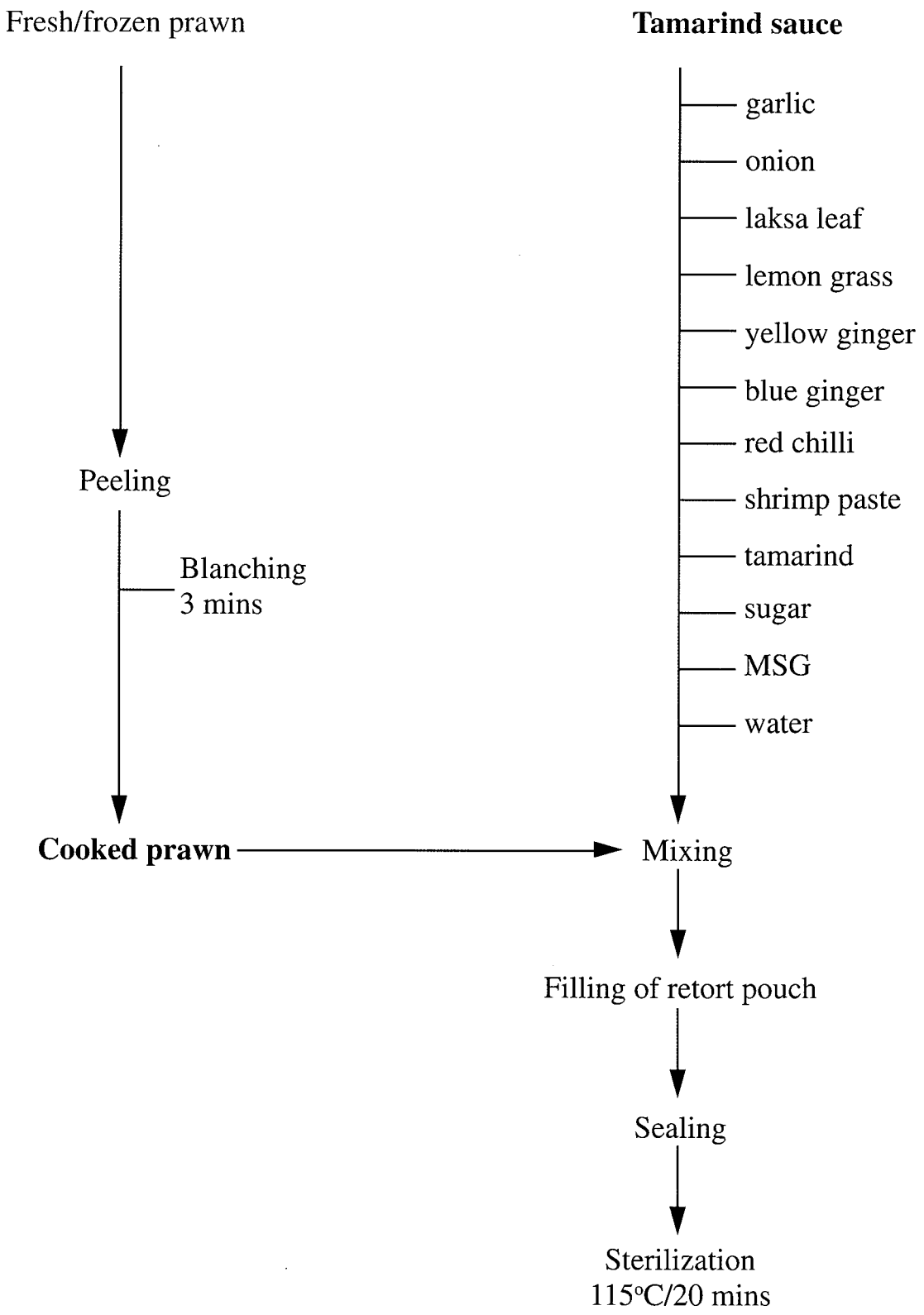
Mince all ingredients in the mincer.*

Retort at 115°C for 20 minutes

Finished product.

* Add water into the ingredients and cook with the seasonings.
Fill the tamarind paste with or without shrimp into the pouch.

Prawn in tamarind sauce



Prawn with garlic and pepper

Fried prawn with garlic and pepper is one of popular home-cooked dish as well as a restaurant delicacy in Thailand. It is usually consumed with rice or noodles.

Formulation

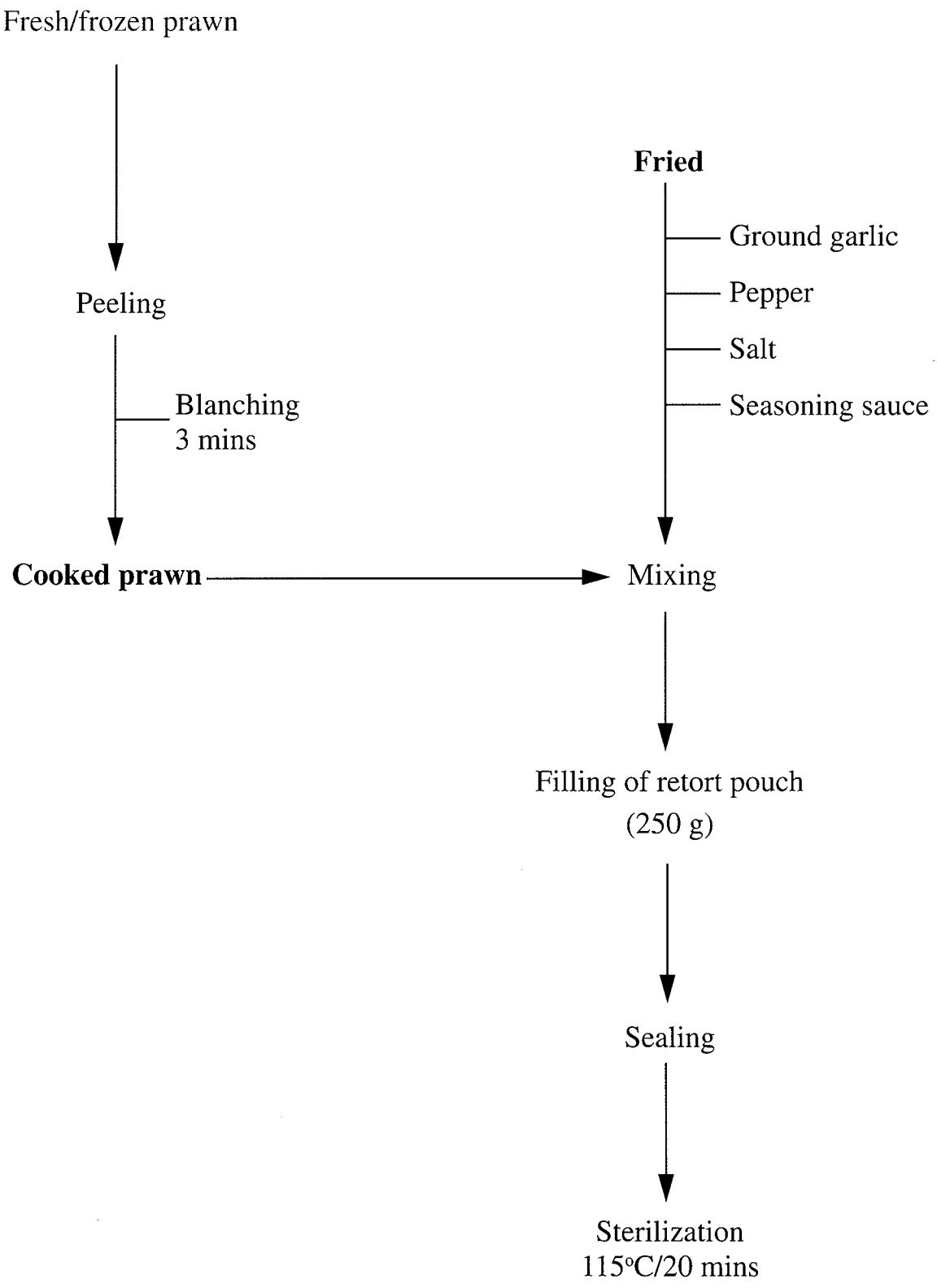
Pepper and garlic paste

Pepper	9.50 %
Garlic	66.18 %
Coriander root	2.36 %
Salt	21.96 %

Prawn

The ratio of prawn:paste	7:3

Prawn in garlic and pepper



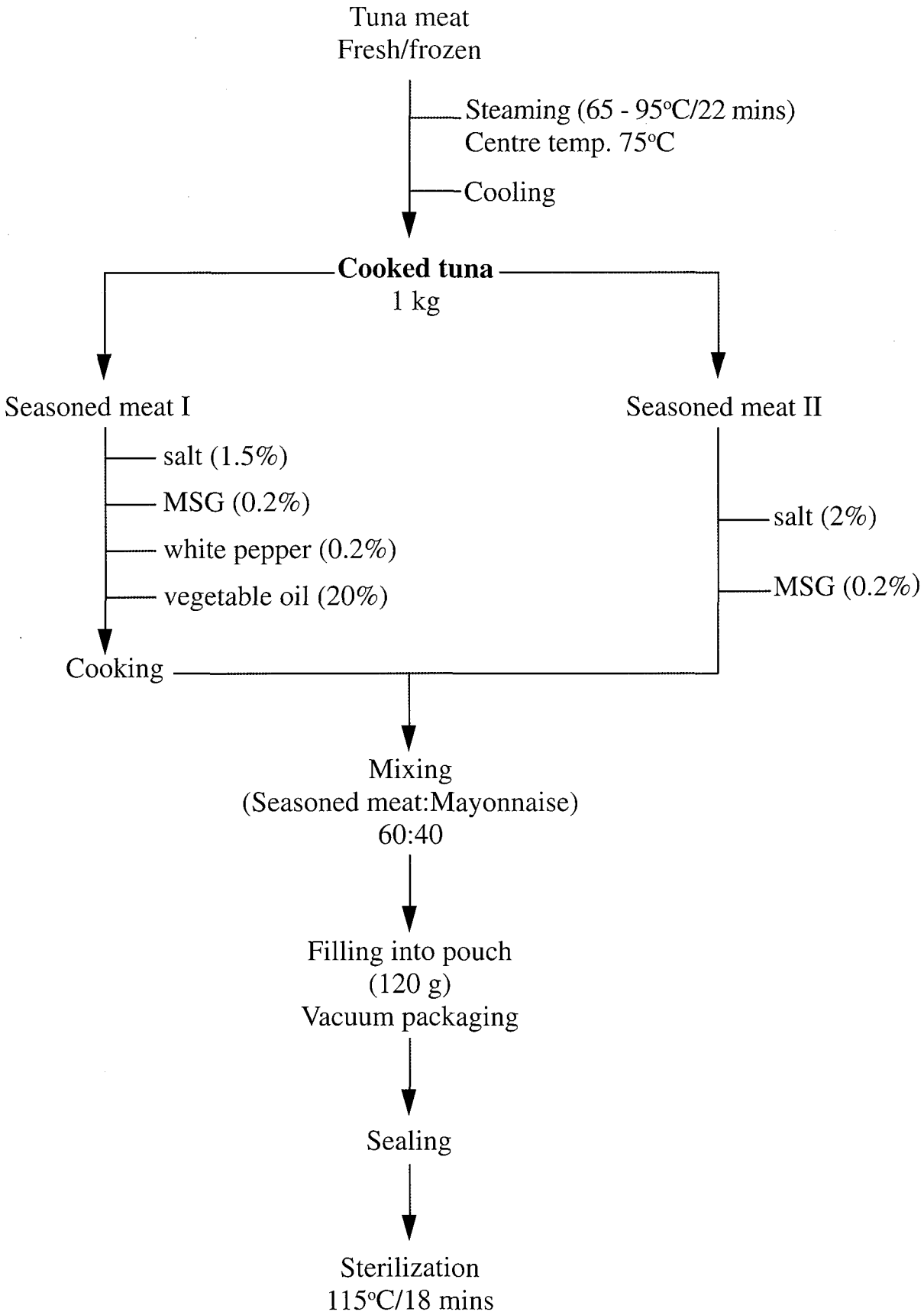
Tuna mayonnaise

This is a popular dish which can be consumed with bread. A special mayonnaise stable under retort conditions was used. This mayonnaise is now commercially available. This product is very tasty and different species of tuna could be used.

Formulation

Tuna meat	82.30 %
Salt	1.00 %
Monosodium glutamate	0.16 %
White pepper	0.16 %
Corn oil	16.34 %
Mayonnaise	81.70 %

Tuna Mayonnaise



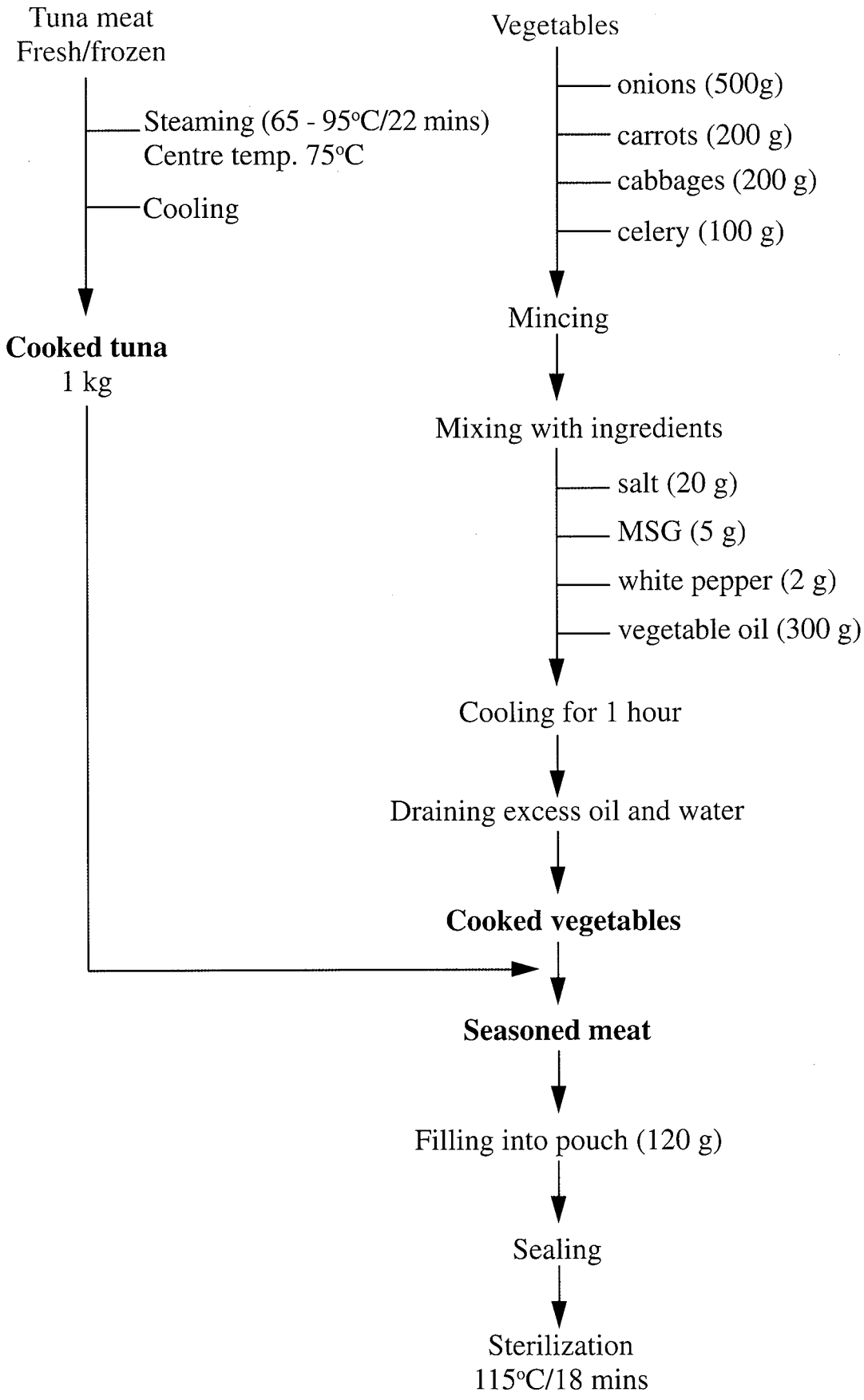
Tuna with vegetables

Carrots, onions and cabbages are vegetables which can enhance flavour of tuna meat. These vegetables are minced and boiled with seasoning until soft and then followed by mixing with tuna meat. The finished product can be served with rice or bread.

Formulation

Tuna meat	42.97 %
Onions	21.48 %
Carrots	8.60 %
Cabbages	4.30 %
Celery	8.60 %
Salt	0.86 %
Monosodium glutamate	0.21 %
White pepper	0.09 %
Corn oil	12.89 %

Tuna with vegetables



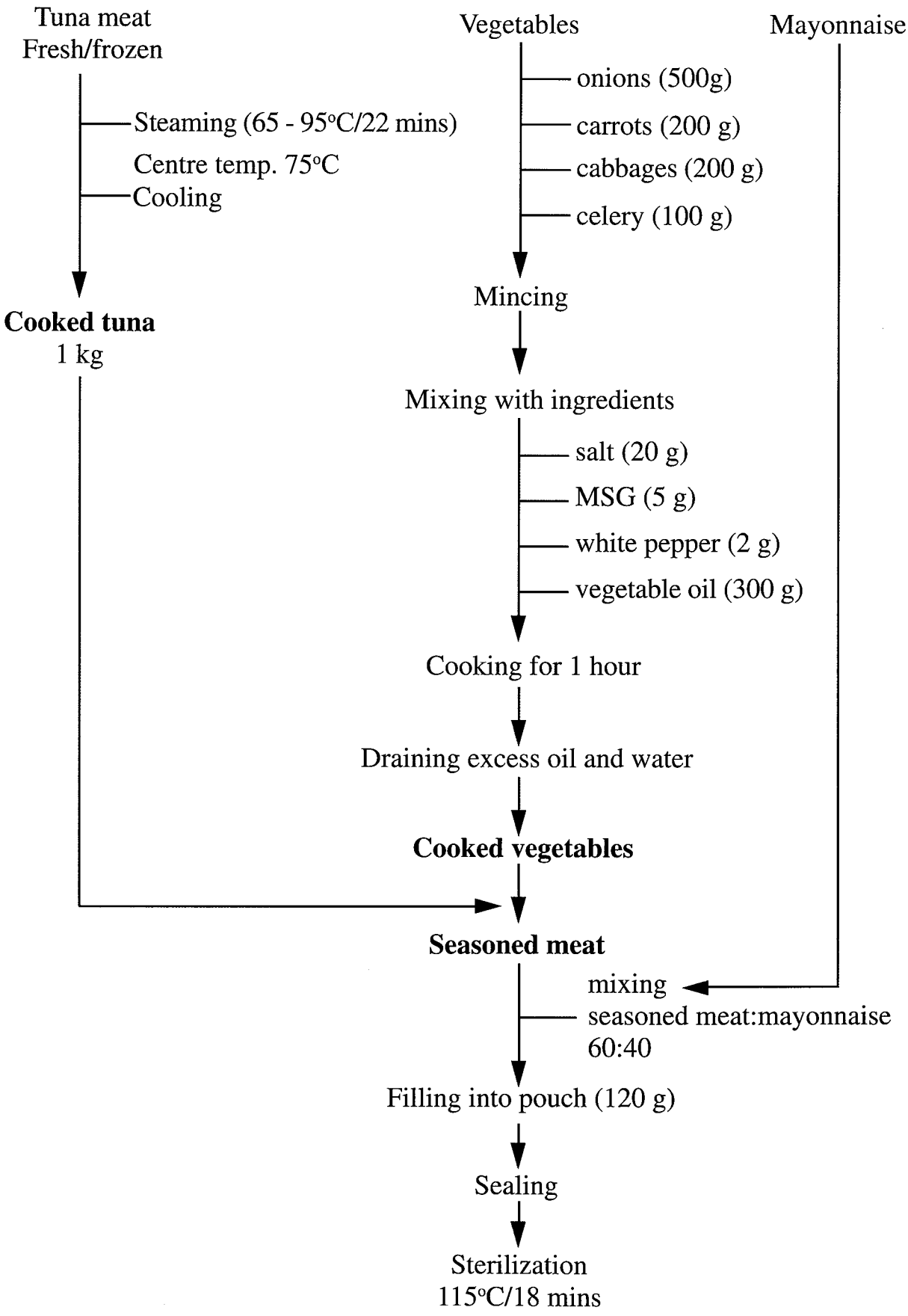
Tuna with vegetables and mayonnaise

This product is the combination of tuna mayonnaise and tuna vegetable. The consumer will like it because it contains not only tuna and mayonnaise but also vegetables which will enhance its appearance and flavour.

Formulation

Tuna meat	33.73 %
Onions	16.70 %
Carrots	6.68 %
Cabbages	3.34 %
Celery	0.67 %
Salt	0.17 %
Monosodium glutamate	0.17 %
White pepper	0.06 %
Corn oil	10.02 %
Mayonnaise	22.27%

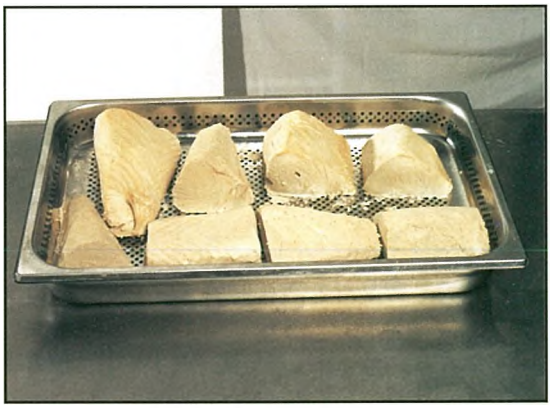
Tuna with vegetables and mayonnaise



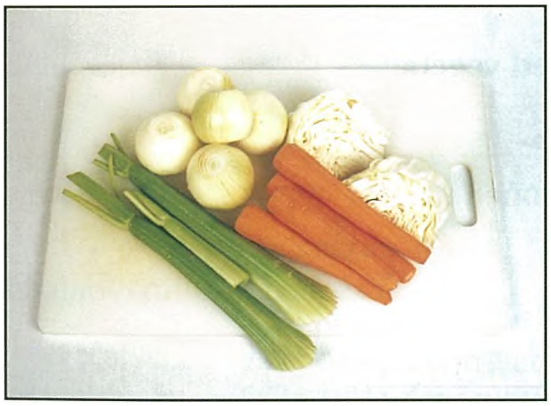
Preparation of tuna products

Raw materials:

Cutting and steaming the semi-thawed frozen tuna meat.



Cooked tuna meat



Celery, carrots, onions and cabbages are washed and cut into small pieces.
(For tuna with vegetables)

Mincing vegetables

Mixing shredded tuna meat with other ingredients

Filling mixture into pouch

Sealing

Retorting at 115°C for 18 mins

Discussion

The processing trials indicated that the prawn and tuna products such as sweet and sour prawn, prawn with garlic and pepper, prawn in tamarind sauce, tuna mayonnaise, tuna vegetable and tuna vegetables with mayonnaise are suitable as retort pouch seafood. The heat penetration study was carried out in all products as shown in Appendix II. The F_o values for all products were greater than 3 minutes.

As these products are low acid food with pH greater than 4.0 (Appendix I), hence sterilization process must be applied. After sterilization all products were incubated at 55°C for about 10 days for sterility test. It was found that all products were still in good condition and there was no swelling in the pouch. This implies that there was no thermophilic bacteria in them as 55°C is the optimum temperature for its growth. Therefore such products are safe for consumption. In addition, sensory evaluation was also conducted to determine the overall acceptability of these products, particularly on their appearance and taste. The prawn products were quite well accepted , except for slight adjustments in its salty and sour tastes. Most of the panelists preferred the hot and spicy taste of the prawn in tamarind sauce. The tuna products were also popular as their appearance, flavour, and taste were readily accepted by the panelists.

RETORT POUCH PACKAGING MATERIALS

The production of retort pouch food begins with the making of pouches from multi-layer sheets or laminations by using plastic films and aluminum foil. Prepared food is packed into the pouch and the top of the pouch is heat-sealed. The filled pouch is then sterilized by heating under pressure. The basic materials of the lamination are 12-micron-thick polyester film, 9-micron-thick Al foil and 70-micron-thick polypropylene film. These films are laminated together by using an adhesive compound.

The outermost layer is polyester which is tough and gives strength to the pouch. The aluminum foil layer serves as a barrier against ultraviolet rays and food-spoiling gases and oxygen. The innermost polypropylene layer has good heat sealing properties and is also non-toxic while retaining the taste and flavour of foods. It also provides flexibility and strength over a wide range of temperatures.

Recently, the lamination of other materials for pouch are widely used, for example:

ON/CPP, PET/ON/Al/CPP, and PET/Al/ON/CPP

Cups and trays are also used as retort containers. In the case of cups, PP is usually used. When oxygen barrier property is required, materials such as PP/Ad resin/EVOH/Ad resin/PP is used. For trays, PP, PP/Al/PP and PP/PET/PP are used.

A number of parameters is routinely measured in determining the barrier ability of packaging materials. Table 2 below shows some of properties requirements.

Table 2 Range of performance requirements for retort pouch materials

Requirement	Criteria
Sterilization temperature	116-145°C
Oxygen permeability	0 cc/m^2/24 hr/atm[a]
Moisture vapour transmission rate	0 g/m^2/24 hr[a]
Seal strength (tensile)[b]	2-3.5 kg/10mm
Bond strength[b]	150-500 g/10mm
Heat seal range	160-260°C
Thickness tolerances	±2 microns (inner ply only) 10% of value ±7.0 g/m^2 (inner ply only)
Burst test	17.2x10^4 Pascal for 30 sec
Residual solvent (taint)	0.5 ppm as toluol

[a] *Assuming shelf-life of 6 months or more is desired; zero based on sensitivity of prevailing procedures.*
[b] *Covers both machine and transverse directions.*
(Source: Lampi, R.A., 1977, Adv. Food Res. 23, 306.)

Materials and laminates for retort pouch

Many kinds of materials for retort pouch are readily available today. Below are examples of materials commonly used for 2 different types of pouches.

a) Flat pouch

PET(12)/Al(9)/CPP(70)	Curry, sauce
PET(12)/ON(15)/CPP(75)	Boiled rice
PET(12)/ON(15)/CPP(85)	Assorted fish jelly product
ON(25)/CPP(80)	Assorted fish jelly product
ON(25)/CPP(60)	Cooked meat
ON(15)/CPP(50)	Seasoning bamboo

b) Standing pouch

PET(12)/Al(7) /ON(15)/CPP(70)	Japanese tea gruel, corned beef, entrails porridge
PET(12)/ON(15) /Al(7)/CPP(80)	Porridge, entrails porridge, fried soy bean cake (seasoning) noodle soup, meat sauce
PET(12)/ON(15)/Al(9)/CPP(60)	Cream stew, sauce for *mapo tofu*
ON(15)/CPP(100)	Sweet bean
ON(15)/CPP(80)	Sweet bean

c) Trays and cups

Trays and cups can also be used for retorting food. Examples of such food in the market are shown in Table 3.

The transparent type is made from polypropylene by thermo-forming method and in some case, by injection molding. This type is not suitable for oily food because it does not have oxygen barrier properties, thus, it is used for cooked white rice, red rice and others.

The transparent, high barrier type is made by co-extruded sheet of polypropylene (PP) and ethylene vinyl alcohol copolymer (EVOH). Modified polypropylene with maleic anhydride (Admer resin) is used to increase adhesion between these two polymers. One example of lamination of the co-extruded sheet is as follows:

PP/Regrind/Ad resin/Regrind/PP

Examples of lamination of light shaded type are as follows:

- Outer protect coat/Al foil (120~130μm)/PP (50μm)
- PP(40μm)/Adhesive material resin/Fe foil (75μm)/Adhesive material resin/PP(75μm)

In the case of trays and cups, easy peelable lid is generally applied. As the lid is perfectly sealed to the container, it becomes very difficult to open. Easy peelable sealant is generally PP polymer blended with LDPE, LLDPE and /or other polymers (PP blend).

Transparent trays shrink when sterilized, and in some case, ON laminated film is used for the lid. Examples are as follows:

Transparent type:

- PP
- PP/PET/PP Blend
- ON/PP Blend
- PP/EVOH/PP Blend
- PET/PVDC/ON/PP Blend

Light shaded type:

- Coat Layer/Al foil/PP Blend
- PET/Al foil/PP Blend
- PET/ON/Al foil/PP Blend

Table 3 Usage of retort trays and cups

Types	Heat resistance	Contents
Transparent	120°C	Rice, *macaroni au gratis*, spaghetti, cooked vegetables (carrots, bamboo shoots, beans, potatoes), cold desserts (puddings and sweet bean cakes)
Light shaded	135°C	Beef curry, beef stew, potato salad, gratin

PET	*Polyethylene terephthalate*
Al	*Aluminum*
ON	*Biaxially oriented nylon*
PP	*Polypropylene*
CPP	*Coated polypropylene*
EVOH	*Ethylene vinyl alcohol copolymer*

RETORT POUCH THERMAL STERILIZATION

Sterilization by means of heat is one of the methods available to preserve food products and give them a longer shelf life. This process is designed to prevent micro-organisms from utilizing the medium present in the food. It will stop the organisms from growing or destroy them completely.

Thermal food processing requires some knowledge of how micro-organisms enter and multiply in food and of the consequences. The micro-organisms involved are those which cause food spoilage and those which are harmful to man. The micro-organisms commonly found in food are mould, yeast and bacteria. Of these, bacteria present the greatest hazard.

Since bacteria are living organisms, they need food for this subsistence and reproduction. Aerobic bacteria can only grow in the presence of oxygen and anaerobic bacteria will only multiply in the absence of oxygen. In addition, temperature and pH are factors for growth. Different species of micro-organisms are characterized by a specific pH value for optimum growth. Particularly Clostridium botulinum, an anaerobic and thermophilic bacteria which is a harmful microorganism. It can multiply and produce its deadly toxin if the pH of the product is higher than 4.6. Therefore canned foods may be classified into three categories based on their acidity (Lopez, 1981):

a) low-acid	pH above 4.6
b) acid	pH 4.0 to 4.6
c) high acid	pH below 4.0

At high acid pH values below 4.0 bacterial growth is hardly possible and although pasteurization will not destroy any bacterial spores, this process can be applied successfully in the preservation of acid foods such as fruit and sauerkraut. Foods in the low acid range must be fully retorted to assume safety. Sterilization has the purpose of eliminating all microbiological activity in a given product, whilst minimizing impairment of the product's quality. The process is carried out at temperatures ranging from 110°C to as high as 140°C. It can be used on most meat products, vegetables, baby foods, pet food and liquid dairy products, and will give them a commercial shelf life up to one year.

The heat treatment applied to a product is determined by the slowest heating point in the container, because by working from this point we can ensure complete exposure to the treatment. For each individual product, it is necessary to establish whether the product has effectively undergone sterilization, based on the requirement that the slowest heating point should reach a given value. The F_o value is a standard unit of lethality which is the value resulting from a constant temperature of 121.1°C applied for a certain number of minutes. It is based on a decimal reduction time (D value) of 1 min at 121.1°C and a Z value of 10°C (Willenborg, 1981).

The retort sterilization equipment in Fig. 1, whether specially designed or modified for the use of retort pouch foods, are available from United States, Europe and Japan. In this experiment, the hot water type of retort sterilizer was used. As the products are wholly immersed in water, there is better heat transfer during sterilization. Hot water with over-riding air pressure was selected as the processing medium because it has a higher heat transfer coefficient and it is also easier to control. Uniform heat distribution within the sterilizer during processing is most important.

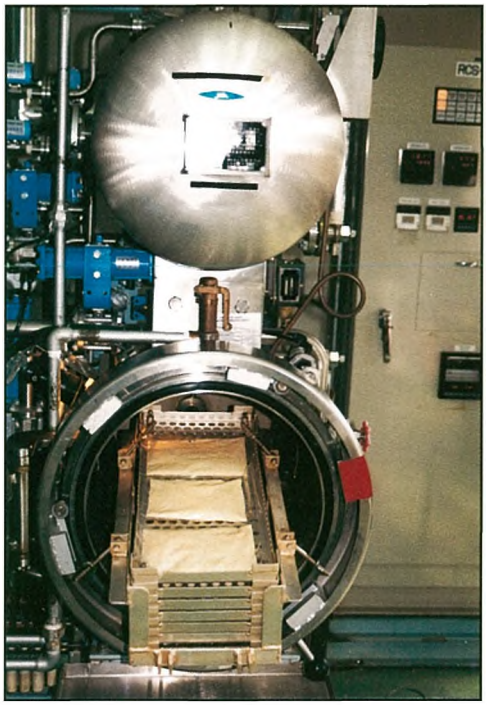


Fig.1 Retort sterilizing equipment

RETORT OPERATIONS

Under proper conditions, pouches can be processed in batch or continuous retorts. Three heating mediums can be applied to process the pouches inside a retort:

a) steam/air
b) water with over-riding air pressure
c) water without over-riding air pressure

Previously, Japanese and European systems tend to favour the steam/air process. While the dominant trend in USA is towards water with over-riding air pressure. At present, Japan use a new type of heating medium namely hot water spray type which is becoming more popular.

Whatever the heating medium, both heat distribution and penetration profiles are critically important for each production line. Pouches should be secured in position to prevent shifting and overlapping due to water flow pressure. However, if the tray duct around each pouch is too tight, the configuration will transmit pressure to the sealed area. It can also lead to under processing of the product. Racks must keep pouches from touching each other during processing. They should provide adequate circulation of the heating medium. Perforated stainless steel or aluminum racks are frequently used.

Measuring thermal conduction

Thermal conduction depends on contents, container's shape and size; thus, each product must be checked for thermal conduction for which depends on the sample. Check the thermal conduction for as many samples as possible. Adopt a proper test method in order to obtain reliable data.

1) Sample preparation

Actual products must be used as samples. In order to accumulate reliable data, the following aspects must be complied with:

a) Depth of the container

The depth of the container affects thermal conduction during the sterilization

process. If the pouch is the same size, the more contents are filled in, the thicker the container becomes. Although packing volume is carefully controlled, actual volumes slightly vary by sample. Thus, use the maximum volume when testing samples. To be safe, add 5% to the specified contents' volume. Because the pouch width during the sterilization period depends on the retort operation (pressure), the retort operation must be done in the same way as the factory produces retort pouch products in daily operation. Use the same type of retainer as daily used.

b) Air volume in retort

After sealing the pouch, a little volume of air may still remain in the container and it affects thermal conduction to a large extent. Head space increases the container's thickness, and air accumulates in the upper part prevents thermal conduction. Thus, maximum head space volume is often used for as a criteria for inspection. Use a syringe to adjust air volume.

In the case of tray containers and injection containers, the lesser the air remains, or the more volume of content is, the more the thermal conduction is reduced. Use the specified maximum contents' volume and reduce air volume.

c) Initial product temperature before sterilization

Initial temperature must be carefully controlled as it affects the sterilization effect. Initial temperature may not be equal, depending on container. Thus, the lowest temperature is used as the initial temperature for thermal conduction testing. Choose a few containers set in the retort at an early time, and then choose a few more at a latter time as the samples. Measure their temperature and determine the lowest one.

2) How to set the sensor

When measuring thermal conduction, decide the location where temperatures should be measured. Generally the lowest temperature is used for setting sterilization conditions. The necessary tools for determination of heat penetration in the pouch are shown in Fig. 1 and Figs 2-7 illustrates how to prepare a pouch for heat penetration study.

Fig.2 Tools for heat penetration study in retort pouch.

a) Liquid type foods

The lowest temperature should be at the geometrical center. However, the pouch is flexible and it is difficult to pinpoint the center by increasing the sensor. Thus, some instruments are required to fix the sensor. For example, the sensor can be fixed by using a needle holder. Such a holder must have similar thickness as that of the pouch. Insert the sensor through the sealed part, and then penetrate into an equal temperature zone to avoid error.

b) Solid-liquid foods

Move the largest solid chunk to the center, and set the sensor in the center of the chunk. The thermal conduction between the solid and liquid in the contents differs widely.

Fig 3 Select a suitable puncher head and fit into the puncher holder.

Fig.4 Mark 2 positions for punching.

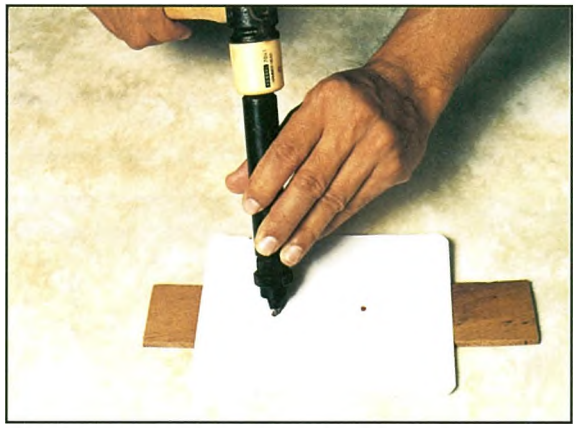


Fig.5 Punch through both sides of the pouch on the first position. At the second position, punch through one side of the pouch.

In order to obtain dependable data, the temperature of the solid contents is measured. Insert the sensor into the center and then tightly close the pouch.

c) Solid foods

It is desirable to use a sensor support for solid foods.

d) Plastic tray

It is difficult to fix a support inside the container. Fix the sensor at the lowest temperature spot. First, make a hole at half height and screw metal clasp in the hole. Then, insert the sensor in the geometric center of the container. (The lowest temperature in dry-pack is also at its geometric center.) In order to firmly fix the sensor in the center, set a block under the sensor and tie the block and the sensor together with a string. The height of such a block is a half of that of the container.

3) Sterilization

For actual production, it is advisable to use the same conditions for the following area:

a) Container arrangements

A thermal conduction test should be conducted by fully loading containers in the retort. Containers should not be put in together, but spread equally in the retort.

b) Come up time

The retort temperature depends on the retort structure, operation method, retort warm-up condition, outside atmosphere, the number of containers, etc.

c) Medium

When air and vapour type is used, vapour/air ratio affects thermal conduction. When hot water type is used, water flow affects thermal conduction, thus, adjust a water flow level at the same level as used in actual production.

4) Testing

a) Samples

After measuring thermal conduction, make sure that the sensor is still fixed in the right of solid, then confirm the total and solid weight of content.

b) Results

When several samples are tested for the same typed product, calculate F-value for each sample. Then, determine sterilization conditions based on the lowest F-value.

c) Records

Test results must be written down on the designated data sheet. The following are the information which should be recorded on the sheet:

(i) Testing date

(ii) Tested sterilization conditions: initial temperature, sterilization temperature, sterilization time, come up time, cooling water temperature, retort pressure.

(iii) Total weight, solid contents weight, size, pH, water activity, viscosity.

(iv) Sketch testing spots in the retort and container. Fill in the test date, products' name, container size, sample number, thermal conduction starting time, sterilization starting and finishing time in chart.

Fig.6 Insert and fix the packaging gland.

Fig.7 Insert and fix the probe holder

Fig.8 Testing for leaks.

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APPENDICES

Appendix I. Product Information

Table 1 Product Information

Name of product	Type of bag	Bag size (cm x cm)	Net Wt. (g)	Meat-liquid ratio	pH
Sweet and sour prawn	ON/CPP (25 /6)	18 x 9.5	200	1:2.33	4.67
Prawn with garlic and pepper	ON/CPP (25 /6)	18 x 9.5	200	-	4.03
Prawn in tamarind paste	ON/CPP (25 /6)	18 x 9.5	200	1:1.5	5.4
Tuna mayonnaise	ON/CPP (15 /70)	11 x 13.5	250	-	5.57
Tuna vegetable	ON/CPP (15 /70)	11 x 13.5	250	-	5.86
Tuna with vegetable & mayonnaise	ON/CPP (15 /70)	11 x 13.5	250	-	5.7

Table 2 Product Costing

Ingredients	Price[1] (S$/kg)	Cost of products					
		Sweet & sour prawn	Prawn with garlic & pepper	Prawn in tamarind sauce	Tuna mayonnaise	Tuna vegetable	Tuna with vegetable & mayonnaise
Garlic	4.20	-	0.94	1.79	-	-	-
Laksa leaves	10.00	-	-	0.50	-	-	-
Lemon grass	7.60	-	-	1.23	-	-	-
Yellow ginger	4.30	-	-	0.20	-	-	-
Chili	5.40	-	-	8.00	-	-	-
Tamarind paste	0.90	-	-	1.00	-	-	-
Shrimp paste	8.00	-	-	2.57	-	-	-
MSG	8.22	-	-	0.07	0.02	0.02	0.04
Sugar	1.29	-	-	0.31	-	-	-
Salt	7.75	-	0.38	0.72	0.15	0.15	0.16
Corn flour	3.50	0.08	-	-	-	-	-
Tomato sauce	3.70	0.18	-	-	-	-	-
Tomato paste	3.90	0.14	-	-	-	-	-
Vinegar	1.41	0.05	-	-	-	-	-
Sweet pepper 1	2.53	0.15	-	-	-	-	-
Sweet pepper 2	1.00	0.06	-	-	-	-	-
Sweet pepper 3	0.71	0.04	-	-	-	-	-
Tomatoes	2.91	0.70	-	-	-	-	-

Table 2 (cont.) Product Costing

Ingredients	Price[1] (S$/kg)	Cost of products					
		Sweet & sour prawn	Prawn with garlic & pepper	Prawn in tamarind sauce	Tuna mayonnaise	Tuna vegetable	Tuna with vegetable & mayonnaise
Onions	5.00	-	-	-	-	2.50	2.50
Carrots	2.00	-	-	-	-	0.40	0.40
Cabbages	1.54	-	-	-	-	0.31	0.31
Celery	1.76	-	-	-	-	0.17	0.18
White pepper	11.66	-	0.37	-	0.02	0.02	0.02
Sunflower oil	6.70	-	-	-	0.67	2.01	2.01
Mayonnaise	5.60	-	-	-	3.73	-	3.73
Tuna meat	24.00	-	-	-	30.65	30.86	30.86
Prawns	12.00	30.00	30.00	108.00	-	-	-
Total cost[2]		17.00	31.69	124.39	35.25	35.60	39.33
Cost/bag (S$)		1.48 (0.524)[3]	4.96	2.16 (0.52)[3]	4.66	4.00	3.39

Remarks:[1]: The unit price of all ingredients is based on the price during 1 Jul-31 Aug, 1996.

[2]: The cost of each product is based on their total weight as follows:

Sweet and sour prawn	1.73 kg
Prawn with garlic and pepper	1.30 kg
Prawn in tamarind sauce	12.00 kg
Tuna mayonnaise	1.89 kg
Tuna vegetable	2.22 kg
Tuna with vegetable and mayonnaise	2.89 kg

[3]: The value in bracket is the cost per bag filled with sauce only.

Appendix II Heat penetration curves

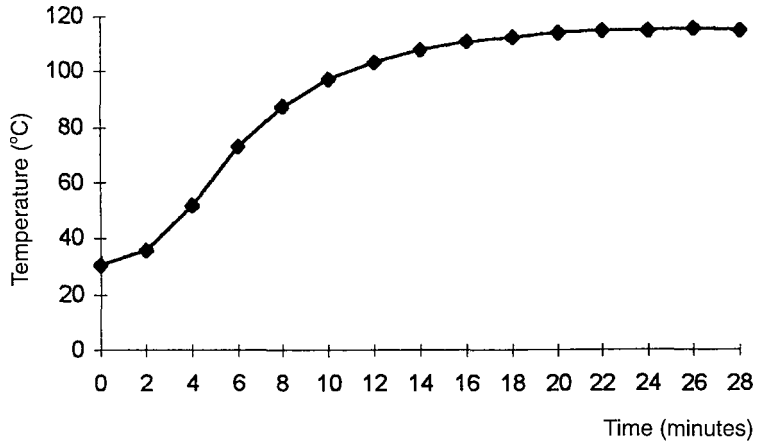

Fig. 1 Heat penetration curve for sweet and sour prawn in pouch

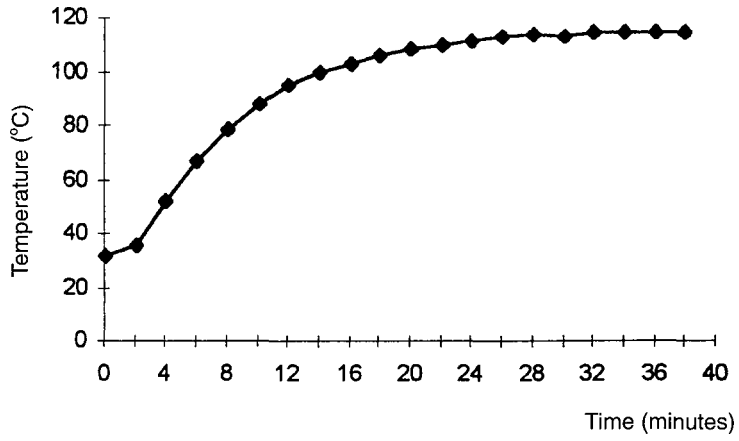

Fig. 2 Heat penetration curve for prawn with pepper and garlic in pouch

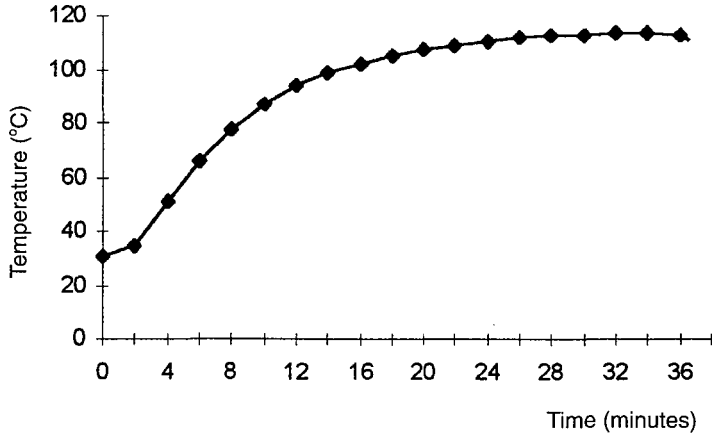

Fig. 3 Heat penetration curve for prawn in tamarind sauce in pouch

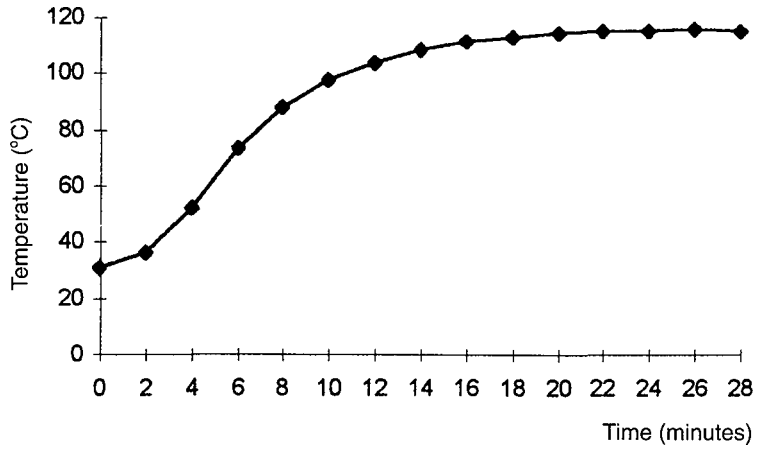

Fig. 4 Heat penetration curve for tuna mayonnaise in pouch

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