Optimising Quality Retention in Processing of Salted-Boiled Fish Based on Kinetic Organoleptic Quality Degradation

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Abstract

Time-temperature dependence of sensory quality factors in relation with thermal processing of salted-boiled product prepared from milk fish (*Chanos-chanos*) was investigated. Organoleptic z-values for the product of 19, 26, 24, 19 and 23°C were found for appearance, odour, taste, flesh texture and bone texture respectively. Based on a level of 50% bone texture change as the most important quality criterion, various processing conditions to optimise other quality factors could be established by computer simulation. The results indicated that in order to obtain optimum quality, retort processing condition set at temperatures between 115 to 120°C were favoured. The results also demonstrated that higher quality retention could be obtained by using smaller fish sizes. Based on microbial sterility evaluation it can be suggested for possible application that hermetically retortable plastic package be used in the processing in order to increase shelf life of the product.

Introduction

Salted-boiled fish (called *pindang* in Indonesia) is a heat processed fish product commonly produced in Southeast Asia. In traditional *pindang* production, fish is simply boiled with salt. The amount of salt used and the duration of heating varies considerably depending on the size of fish used, shelf life required and local preference. A new type of salted-boiled fish called *pindang presto* or simply *presto* has become increasingly popular in Indonesia and has commercial potential in other countries.

Presto is processed at higher temperatures by using pressurized steam. The product is easily distinguished from traditional *pindang* with characteristic soft bones, reminiscent of canned fish. Unlike canned fish, *presto* is not hermetically sealed and is not a microbiologically sterile product so that its shelf life is very short. The main purpose of the heating process is to produce changes in the organoleptic properties of the fish; notably the texture of the flesh and bone, the colour and lustre of the skin and flesh, and flavour.

Historically, microbial safety has been the primary concern of thermal food processors. More recently the loss of nutrients and changes in the organoleptic properties of the food have become increasingly important in determining process conditions. Kinetic microbial destruction by heating is commonly expressed in terms of the rate of isothermal change (i.e. the decimal reduction time, or D value) and the relationship between the rate of isothermal change and temperature (i.e. thermal destruction time, or z-value). Kinetic degradation rates for nutrients and organoleptic factors may employ zero or first order for isothermal chemical reaction and Arrhenius equation to express temperature dependence of the reaction. However, both methods of expression are also often used.

The data on kinetic degradation of food quality factors (microbes, nutrients and organoleptic properties) and heat transfer in food during thermal processing are used to evaluate quality of the thermally processed food. The present experiment was aimed at investigating kinetic degradation rates of various organoleptic factors (colour, appearance, texture and flavour) of fish to be used for optimizing quality retention during thermal processing of *presto*.

Materials and Methods

Milk-fish (*Chanos chanos*) between 300-350g were obtained from Muara Karang, Jakarta. Fish were harvested and transported in ice to the Research Institute for Marine Fisheries (RIMF) laboratory in Jakarta. The fish were cut along the bottom of their abdominal cavities to remove the guts and internal organs and were thoroughly washed and allowed to drain.

A 25% (W/V) brine was prepared (using salt obtained from a local market) and the dressed fish were immersed for two hours. The fish were then stored in a chill store overnight. The fish were filleted and deskinned. Each fillet was further cut into thin slices (2 mm thickness) and made to a rectangular shape (30x20 mm). Each slice was individually placed in retortable pouches, evacuated and sealed. The pouches were placed in a single layer on the shelves of a batch laboratory retort and were processed at various temperatures for different lengths of time. In order to facilitate better panelist judgement to distinguish different levels of heated samples, an interval heating time at one particular temperature should be large enough. For the same reason degrees of heating for other temperatures should be close to each other. Equation (1) could be used to estimate degrees of heating at various processing conditions by taking temperature 120°C as a reference temperature. Table 1 shows times required for various heating temperatures calculated by the equation.

$$t = t_r \times 10^{(T_r - T)/z} \quad \text{.............. (1)}$$

where t is the heating time (minutes) needed to obtain the same degree of heating at reference temperature T_r for heating time t_r by assuming z = 25°C.

Table 1. Heating times (minutes) at various temperatures

T=110°C	T=115°C	T=120°C	T=125°C
50.2	31.7	20.0	12.6
100.5	63.4	40.0	25.2
150.7	95.1	60.0	37.9
200.9	126.8	80.0	50.5

Note : T-120°C was taken as reference temperature.

These samples were assessed by an objective taste panel made up of 13 researchers at the RIMF in Jakarta. Appearance, flavour, odour, flesh texture and bone texture were assessed on an open format, unclassed scale which ranged from "uncooked" to "overcooked".

D-values and z-values of each organoleptic factor were calculated from decimal reduction time curves and thermal destruction curves respectively. The thermal effect for each organoleptic factor was evaluated based on theoretical heat transfer and kinetic degradation of organoleptic factors obtained from the experiment. As fish has an irregular shape, heat transfer in this type of object is difficult to trace accurately by mathematical procedure. Therefore in calculating heat transfer the fish is assumed to be an infinite cylinder where the maximum thickness was taken as the diameter of the cylinder.

The heat transfer calculation is derived from a Gourney-Lowry chart for an infinite cylinder (Jackson and Lamb, 1981). Other assumptions such as thermophysical properties were also made in order to be able to evaluate heat transfer by this mathematical method as described by Suparno (1989) for his study on thiamin losses in this type of product. The quality factors degradation was calculated by following the microbial sterility evaluation (Equations 2 and 3) although other methods of evaluation such as the so-called "cook value" (C-value) may also be used (Ohlsson, 1979; Dagerskog, 1977). A computer program was prepared to facilitate rapid calculation in the sterility evaluation by taking the 3 cm thickness of fish for this study, unless otherwise specifically mentioned.

$$F = \int_{t_o}^{t_a} L \, dt \quad \text{..................... (2)}$$

where

$$L = 10^{(T_i - T_r)/z} \quad \text{................... (3)}$$

and F = the equivalent in minutes at some given reference temperature of all heat considered, with respect to its capacity to destroy quality factors, L = lethal rate, T_i = retort operating temperature, T_r = reference temperature.

Results and Discussion

The z-values and the D-values at 100°C and 121°C for each quality factors are shown in Table 2. These values are consistent with those reported in the range of 13-35°C for other foods (e.g. Lund, 1975; Dagerskog, 1977; Ohlsson, 1980; and Hayakawa *et al.*, 1977). The D-values at 100°C are presented as they are commonly used in evaluation of cook values of thermally processed foods.

Table 2. Kinetic thermal destruction of organoleptic quality factors.

Organoleptic factors	D_{121} (min)	D_{100} (min)	z (°C)
Appearance	129	1644	19
Odour	199	1278	26
Taste	178	1335	24
Meat-texture	142	1809	19
Bone-texture	111	909	23

Cook values are similar to F-value of microbial sterility. For convenience of comparing between organoleptic quality and microbial sterility due to effect of thermal process, the cook value was not used. Instead, quality retention based on microbial sterility evaluation was performed in this study.

In order to evaluate quality retention of processed *presto*, a certain basis of calculation should be chosen. For this purpose initial bone texture degradation rates at various processing temperatures were found. This is in accordance with the fact that acceptability of the product was first judged for bone texture to distinguish it from traditional *pindang*. Thus it is the main target in this processing. Fig. 1 demonstrates an organoleptic quality degradation profile for bone softening during the process as obtained from data generated by running the computer programme. It is obvious that bone softening occurs at faster rates at higher processing temperatures. Similar profiles for other organoleptic factors could be easily drawn.

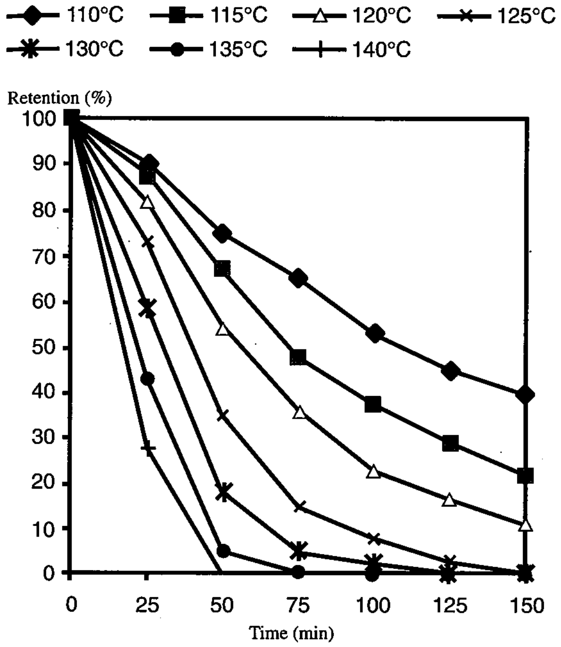
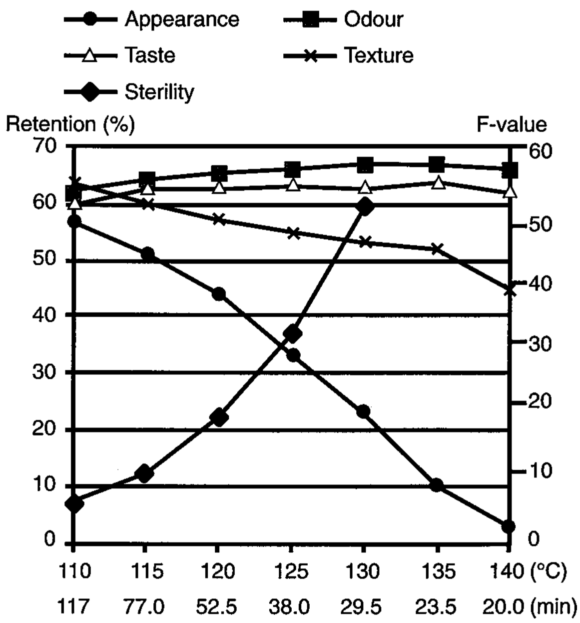


Fig. 1. Thermal degradation of bone at various processing temperatures.

By taking into account bone texture as the first important key factor determining the quality of this product, the minimum level acceptance for bone texture should be found. Suparno (1989) has indicated that at least a 50% bone texture change should be achieved in the process to be acceptable. Then time-temperature relationship in *presto* processing to obtain this bone texture level could be computed for various quality factors including sterility. In the computation, thermal effects on organoleptic factors should be considered based on practical quality assessment as well as the mechanism of heat transfer. For this reason bone texture was taken as the central geometric position and appearance was taken on the surface. Flesh texture, odour, and taste as well as microbial destruction were taken as mass average.

Fig. 2 shows quality factors (appearance, odour, flavour and flesh texture) changes and microbial sterility achieved for various processing conditions on the basis of a 50% bone texture change in the thermal process. It suggests that *presto* processing favours lower processing temperatures when surface appearance is considered as the second (*viz*, after bone) important factor affecting acceptability of the product. A drastic reduction in appearance retention was observed as processing temperatures increased. Only a relatively small reduction was observed for flesh texture. Interestingly, odour and taste increase their retentions at higher processing temperatures. It seems that meat texture, odour and taste contribute only to relatively small changes over various processing conditions. Therefore they do not cause any critical constraints in processing. In contrast to appearance, microbial sterility significantly favours higher processing temperatures.

Microbial sterility is not a primary concern in commercial processing of *presto* as it is not hermetically packed during the process. Consequently its shelf life is very short, *viz* 1-2 days. But in some commercial practices *presto* is often vacuum packed in plastic pouch after processing as an attempt to increase its shelf life. This presents a possible botulism outbreak. In relation to this problem, a quantitative evaluation of product sterility could provide precise information on shelf life extension through packaging in retortable plastic pouches. In recent years retortable plastic pouches received attention due to the fact that higher quality retention could be achieved in thermal sterilisation of food if this type of packaging is used (Teixeira *et al.*, 1975). Based on common commercial sterility practices for thermal processing of low acid foods, a D_{12} concept could be taken as the basis for consumer safety (Stumbo, 1973). Therefore F_o-value of 12 (F_{12}) was used as a basis in the next stage of evaluation.



Note : Based on 50% bone texture changes.

Fig. 2. Organoleptic quality retention and microbial sterility at various processing conditions.

Fig. 3 clearly shows the two important quality factors (bone texture and surface appearance) for various processing conditions on the basis of F_{12} for two sizes (3 and 6 cm thickness) of fish. From this figure there are two interesting phenomena related to behaviour of bone texture and flesh appearance during the thermal process. The first phenomenon is shown by different patterns of destruction between these most important organoleptic factors.

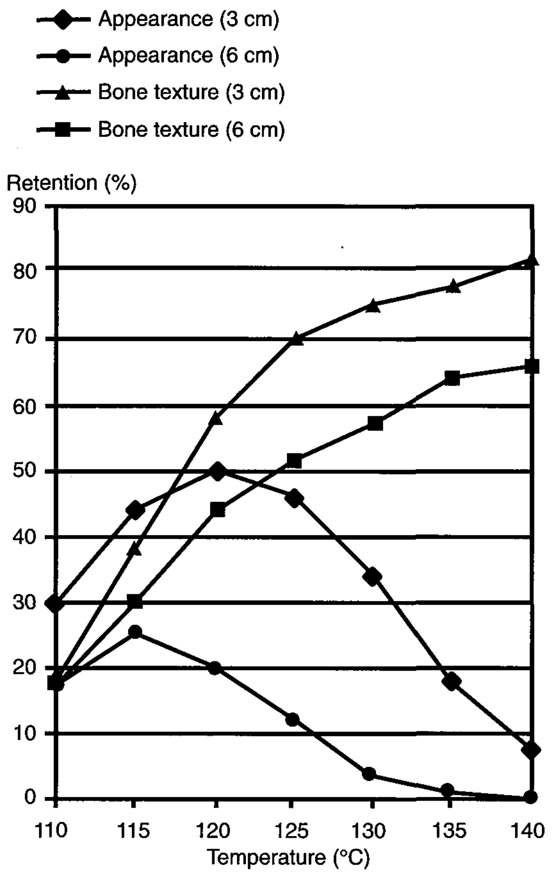


Fig. 3. Bone texture and meat appearance changes during processing at sterilising value F_{12} for different sizes of fish.

Bone texture increases its retention as processing temperature increased and no maximum temperature is observed. It should be mentioned that higher bone texture retention means lower level of bone softening. It also suggests that to achieve a minimum level of 50% bone texture change, the processing temperatures should not exceed 118°C for small fish and 125°C for big ones. On the other hand flesh appearance retention initially increases to a certain maximum temperature and then it gradually decreases. This indicates that flesh appearance could be optimised over a range of processing temperatures. The maximum processing temperatures for appearance are approximately 120°C (50% retention) and 115°C (25% retention) for small and big fish respectively. However, the desirable appearance tolerance limit of this product which is acceptable to consumers should be investigated for this purpose.

The second interesting phenomenon is shown by the effect of fish size on quality retention. It is very obvious that bigger fish have lower appearance and bone texture retentions. There is a shift of maximum appearance retention towards lower processing temperatures as fish size increases. Similarly bone softening increases as fish size increases. This can be explained by the fact that bigger fish requires higher thermal process (by increasing processing time for each temperature) in order to achieve the same sterility. Thus optimising organoleptic quality retention depends significantly on kinetic degradation of each organoleptic factor. In case of *presto* processing, based on microbial sterility as well as on bone texture changes, appearance plays a significant role compared to odour, taste and flesh texture.

In general it may be concluded that optimum processing could be performed at temperatures between 115-120°C. This range of processing temperatures have been widely used in commercial *presto* production. Processing at these conditions are also microbiologically acceptable when hermetic retortable plastic pouches are used in the processing to increase shelf life of the product. The results also indicate that a higher quality product could be obtained by using smaller fish. Similar results were obtained for thiamine retention in this product (Suparno, 1989). This is also in agreement with findings by other researchers for nutrient retention in canned foods of different geometric shapes (Teixeira *et al.*, 1975; Lund, 1977).

Conclusion

Organoleptic z-values for salted-boiled fish of 19, 26, 24, 19 and 23°C have been determined for appearance, odour, taste, flesh and bone texture respectively. Bone texture and appearance are the most important organoleptic qualities of *presto* and they play important roles in optimising the process. On the hand odour, taste and flesh texture do not show any significant role in this type of processing. The optimum processing conditions based on bone texture, appearance and microbial sterility lie in the range of 115-120°C. It has also been shown that higher organoleptic quality could be obtained from smaller fish size.

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Discussion

Regarding the conversion of sensory scores to z-values, Dr Suparno informed the Seminar that a scale was used to compute the values. He also added that there is a potential health hazard when packing and processing is done at room temperature.