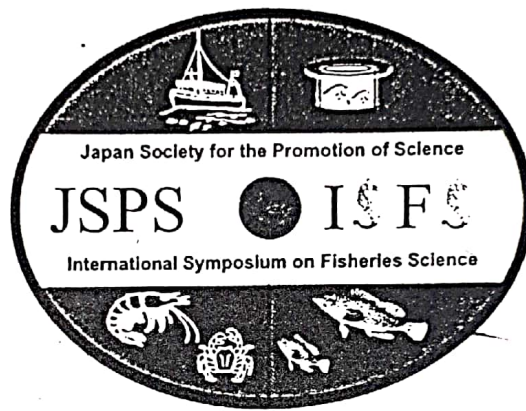


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## DEVELOPMENT OF TOMATO SAUCE ENRICHED WITH FISH OIL FOR CANNED SARDINE MEDIUM

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Canning process of fish, particularly during pre-cooking, does not only affect the quality but also the quantity of fish oil/lipids in fish. Fish oil contains omega-3 fatty acids having health benefits and playing an important role in brain and retina developments. This study developed a tomato sauce enriched with fish oil, which was aimed to replace the fish oil released during pre-cooking. Tomato sauce formula was developed using mixture design. This study showed that mixture design was suitable to be used in the development of tomato sauce enriched with fish oil. The developed formula consisted of 48.84% water, 22.90% tomato paste, 18.32% fish oil 3.56% salt, 3.05% cane sugar, 1.70% garlic, 1.32% ginger extract and 0.31% vinegar 25%. NA-CMC was found to be a more effective emulsion stabilizer compared to Tween 80, carrageenan and Arabic gum. The optimum level of NA-CMC suggested to be used in the developed tomato sauce was 1.75%.

KEYWORDS: tomato sauce medium, fish oil, canned sardine

### Introduction

Fish oil, particularly its omega-3 fatty acids, has been well recognized to have health benefits for human, such as prevention of heart disease. Omega-3 fatty acids have also been proved their role in brain and retina developments. Those facts have indirectly suggested us to consume fish oil for health purposes. However, direct consumption of fish oil has not really attracted due to its undesirable sensory properties, especially smell and taste. One alternative to cope with this problem is by incorporating fish oil into ordinary products. In this study, tomato sauce used as canned fish medium was selected as a product to disguise fish oil, since the properties owned by this product was able to neutralize undesirable characteristics of fish oil.

Canning process of fish shows visible negative effects on fish oil. This process does not only affect the nutritional quality, but also influences the quantity of fish oil remained in the canned fish product. The process, particularly pre-cooking, induces the release of fish oil. The purpose of the pre-cooking step during fish canning is to release body lipids if the fish are excessively oily or if the oil has a very strong flavour.<sup>1,2</sup> It is known that when fish flesh is heated, a significant proportion of water is released from the protein. The amount varies, approximately 17.5% for tuna and 19-34% for sardine, depending on the endogenous fat content<sup>3</sup>. The fat content of Indonesian oil sardine is approximately 2-20.<sup>4</sup>

Disguising fish oil into tomato sauce medium was aimed to replace the fish oil released during pre-cooking without reducing the acceptability of the product. Thus, health benefits of fish oil can be maximally utilized for well-being.

### Materials and Methods

#### Materials

PT. Maya Muncar, a fish-canning factory in Muncar-Banyuwangi, supplied fish oil. Tomato paste "Del Monte" was purchased from a supermarket in Bogor. Cane sugar, salt, ginger and garlic were bought from a retailer in Petamburan, Jakarta. Tween-80, carrageenan, Arabic gum and NA-CMC were obtained from a chemical store in Bogor.

#### Methods

##### (1) Experiment

Tomato sauce formula was developed based on the formula used by a canning factory<sup>5</sup> with composition as follows 74.5% water, 18.6% tomato paste, 3.7% salt and 3.1% sugar. To obtain better acceptability, vinegar (25% acetic acid), ginger extract and garlic were also included in the formula.

The mixture design was used to develop a new formula of tomato sauce disguised with fish oil. In this study, salt, vinegar, ginger extract, garlic and cane sugar were kept constant at 3.56%, 0.3%, 1.7%, 1.62% and 3.05% respectively. Meanwhile, tomato paste, fish oil and water quantities were subjected to change as follows:

Requirements	Low level (%)	High level (%)
Tomato paste (T)	10	30
Fish oil (O)	10	50
Water (W)	40	60

Panellists also performed optimization of the new formula obtained from the above levels to generate the most acceptable tomato sauce. The formula was evaluated organoleptically in terms of smell, taste, colour, consistency, mouth feel, appearance and overall acceptability using hedonic scale 1-5 (1= the most unlikely; 5= the most likely).

Emulsion stability of tomato sauce medium was improved with the use of polyoxyethylene sorbitan monooleic (Tween 80), carboxymethylcellulose (CMC), carrageenan and Arabic gum as emulsifier or stabilizer. Addition levels of emulsifiers were 2% as permitted by the Ministry of Health.<sup>6)</sup> The most effective emulsifier underwent further investigation for optimization by varying its addition levels, i.e. 0.00%, 0.25%, 0.50%, 0.75%, 1.00%, 1.25%, 1.50%, 1.75% and 2.00%. Emulsion stability was determined using modified Lamar method.<sup>7)</sup>

Tomato sauce made of the best formula was used as medium in the processing of canned sardine to evaluate the effect of fish oil enrichment on fatty acid profile of the product. The can size used was 401x211. The pre-cooking was carried out by steaming at 95-97°C. The product was sterilized at 116°C and 1 atm for 90 minutes. Fish lipid for fatty acid profile determination was extracted using Bligh and Dyer method.<sup>8,9)</sup> GC Antek 3000 equipped with OV 275 25°C 80/100 chromororp WAW column was used to analyze the profiles.

## (2) Procedure of Tomato Sauce Processing

To prepare the tomato sauce, water was heated to boiling and then sugar and salt added and boiled until dissolved. Fish oil was added and mixed thoroughly for 5 minutes using hand mixer. Emulsifier was added and subsequently homogenized for 5 minutes. Ginger extract, vinegar, garlic and tomato paste were added and mixed thoroughly using hand mixer for 10 minutes at 85°C. Finally, that hot mixture was homogenized using a waring blender for 2 minutes.

## Results and Discussion

### Tomato Sauce Formulation

### (1). Preliminary Formulation

Fig. 1 shows the complete space available for the mixture design. The limits on the three ingredients given previously restricted the area of experimentation to the shaded, feasible region. From that region, the vertices suitable for the experiments are as follow:

$$\begin{aligned} A &= 500 + 10T + 40W \\ B &= 300 + 30T + 40W \\ C &= 300 + 10T + 60W \\ D &= 100 + 30T + 60W \\ E &= 300 + 20T + 50W \end{aligned}$$

Where, E shows the centre point of region.

Based on these vertices and  $0 + T + W = 150$  g, the tomato sauce formula developed to investigate the behaviours of those ingredients in the product were as follows:

$$\begin{aligned} 68.700 + 13.74T + 54.96W &| \\ 41.220 + 41.22T + 54.96W &| \\ 41.220 + 13.74T + 82.44W &> 5.34\text{g salt} + 4.58\text{g sugar} + 2.55\text{g} \\ 13.740 + 41.22T + 82.44W &| + 2.55\text{g garlic} + 1.98\text{g ginger} \\ 41.220 + 27.48T + 68.70W &| \text{extract} + 0.47\text{g vinegar} \end{aligned}$$

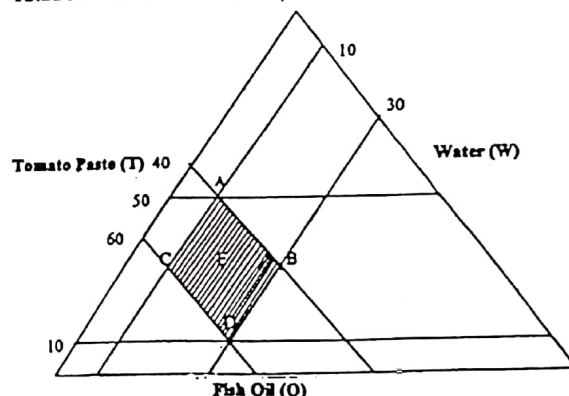


Fig.1 Mixture space showing areas of experiment.

The products made using the above formulas were evaluated organoleptically and the total scores from all panelists for each parameter are shown in Table 1.

Table 1. Total organoleptic score of the tomato sauce products of the preliminary formulation.

Code	Odour	Taste	Colour	Consistency	Mouth feel	Appearance	Overall Acceptability	Coded Note
A	24.00	27.00	20.00	40.00	43.00	33.00	27.00	Hi O;LoT;loW
B	36.00	38.00	50.00	47.00	49.00	50.00	40.00	Hi O;hiT;loW
C	30.00	28.00	27.00	34.00	44.00	23.00	28.00	Hi O;loT;hiVV
D	32.00	39.00	40.00	41.00	48.00	44.00	41.00	Lo O;hiT;hiVV
E	30.00	33.00	42.00	36.00	47.00	35.00	31.00	Median

Note: Lo = low  
Hi = high



### (2) Study of Effects

Table 2 shows the effects of each of the three ingredients used to make tomato sauce on the sensory properties employed to evaluate the acceptability of the product. An example of the calculation to evaluate these effects is shown in Appendix 1. Low level of fish oil gave better odour, taste, consistency, appearance and overall acceptability than high level. High level of tomato paste

resulted in tomato sauce having better acceptability for all parameters than low level. Meanwhile, low level of water gave better acceptability, in terms of colour, consistency and appearance. However, those results indicated that the amount of water used in the processing of tomato sauce showed less effect on odour, taste, mouth feel and overall acceptability.

Table 2. Effects of main ingredients on sensory properties of tomato sauce

Parameter	Fish oil		Tomato paste		Water	
	Low amount	High amount	Low amount	High amount	Low amount	High amount
Odour	32.00	30.00	27.00	34.00	30.00	31.00
Taste	39.00	33.00	27.50	38.50	32.50	33.50
Colour	40.00	42.00	23.50	45.00	35.00	33.50
Consistency	41.00	36.00	37.00	44.00	43.50	37.50
Appearance	48.00	47.00	28.00	47.00	41.50	33.50
Mouth feel	44.00	55.00	43.50	48.50	46.00	46.00
Overall acceptability	41.00	31.00	27.50	40.50	33.50	34.50

### (3) Formula Optimization

The above results suggest that the low level of tomato paste should be increased and the high level of fish oil and water reduced. The tomato paste, fish oil and water levels used for the optimization of the tomato sauce formula are as follow:

Requirements low level (%) high level (%)  
Tomato paste (T) 20 30  
Fish oil (O) 10 30  
Water (W) 50 60

The new area in the mixture space is shown by the increase of tomato paste level, and the reduced levels of fish oil and water. The new area of investigation to obtain the optimum level for each ingredient is shown in Fig. 2.

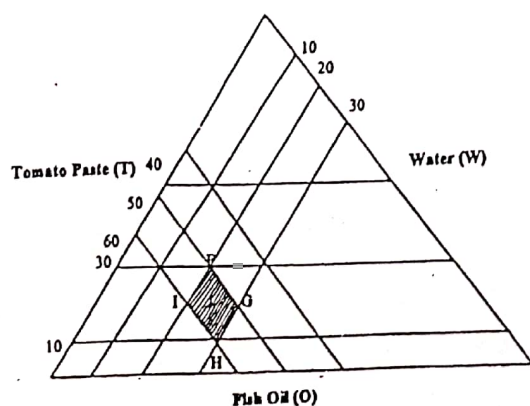


Fig. 2. Mixture space showing new areas of experiment.

The vertices for the new area of optimization are F, G, H, and I, while E represents the center points:

$$\begin{aligned} F &= 300 + 20T + 50W \\ G &= 200 + 30T + 50W \\ H &= 100 + 30T + 60W \\ I &= 200 + 20T + 60W \\ J &= 200 + 25T + 55W \text{ (center point)} \end{aligned}$$

Based on the above vertices, the recipes of tomato sauce to be used for the optimization experiment are as follows:

$$\begin{aligned} &41.220 + 27.48T + 68.70W \\ &27.480 + 41.22T + 68.70W \\ &13.740 + 41.22T + 82.44W > 5.34g \text{ salt} + 4.58g \text{ sugar} + \\ &27.480 + 27.48T + 82.44W \mid 2.55g \text{ garlic} + 1.98g \text{ ginger} \\ &27.480 + 34.35T + 75.57W \mid \text{extract} + 0.47g \text{ vinegar} \end{aligned}$$

Sensory evaluation results for the products made from the above recipes are shown in Table 3.

Table 3. Total organoleptic score of tomato sauce products from the optimization experiment.

Code	Odour	Taste	Colour	Consistency	Mouth feel	Appearance	Overall Acceptability	Total Score
F	36.00	43.00	62.00	60.00	60.00	37.00	49.00	347.00
G	44.00	54.00	65.00	49.00	68.00	67.00	59.00	406.00
H	51.00	54.00	61.00	40.00	69.00	67.00	56.00	398.00
I	44.00	45.00	54.00	56.00	65.00	58.00	57.00	379.00
J	47.00	53.00	58.00	53.00	60.00	71.00	64.00	406.00

Table 3 indicated that tomato sauce G and J showed the highest total organoleptic score. However among three main organoleptic parameters, tomato sauce J had two parameter scores being higher than tomato sauce G. Therefore, tomato sauce J is considered as the most accepted formula. The recipe of that selected formula consisted of 48.84% water, 22.90% tomato paste, 18.32% fish oil, 3.56% salt, 3.05% cane sugar, 1.70% garlic, 1.32% ginger extracts and 0.31% vinegar 25%.

#### Addition of Emulsifier

##### (1) Selection of Emulsifier

Four emulsifiers were investigated their effectiveness to stabilize the emulsion in tomato sauce disguised with fish oil. Results of emulsion stability determination informed that NA-CMC exhibited better emulsifying capability compared to other emulsifiers (Fig. 3). Therefore, NA-CMC was selected as the most suitable emulsifier to be used in tomato sauce disguised with fish oil. NA-CMC is relatively stable in the pH range of 2-10<sup>9)</sup> and more stable to heating treatment,<sup>10)</sup> therefore emulsion in tomato sauce used as medium in canned fish processing is expected still stable due to the presence of NA-CMC. On the other hand, emulsion stability maintained by carrageenan is unstable due to heating treatment and low pH (< 6).<sup>9)</sup> Even though Arabic gum forms viscous and stable emulsion at pH less than 7, but the emulsion is unstable to heating<sup>10)</sup> Tween-80 is the only emulsifier which is not affected by pH emulsion used in this study. However, the emulsion stabilized by that emulsifier is very sensitive to heating.<sup>11)</sup>

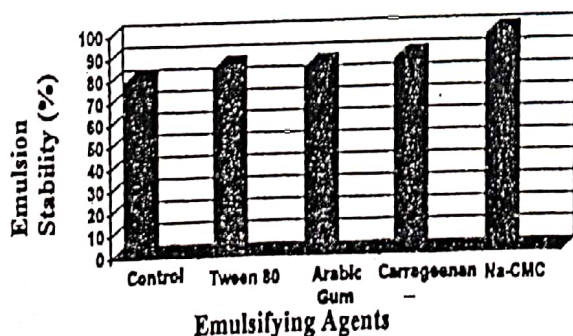


Fig. 3 Emulsion stability of tomato sauce added with several emulsifiers at 2% addition levels each.

##### (2) Optimization of Emulsifier Addition Level

Optimization of emulsifier addition level was carried out by varying the amount of NA-CMC to be used in tomato sauce from 0 to 2%. Results of emulsion stability determination can be seen in Fig. 4. The addition levels of 1.50% and 1.75% were considered as the optimum amount. In order to decide the most optimum addition level, tomato sauce added with NA-CMC at both addition levels were used to process-canned sardine sterilized at 116°C for 90 minutes. This investigation showed that the addition NA-CMC level of 1.75% indicated better emulsifying capability compared to that of 1.50%. The final formula of developed tomato sauce which has been added with NA-CMC consisted of 48.00% water, 22.50% tomato paste, 18.00% fish oil, 3.50% salt, 3.00% cane sugar, 1.72% NA-CMC, 1.68% garlic, 1.30% ginger extract and 1.30% vinegar.

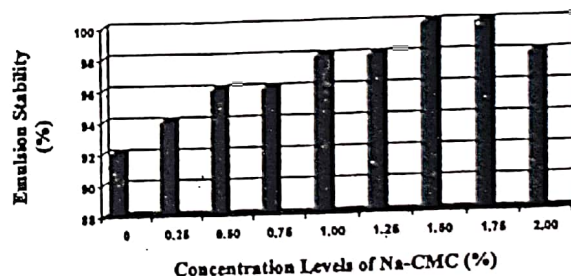


Fig. 4 Emulsion stability of tomato sauce added with NA-CMC at several addition levels.

##### Fatty Acid Profiles

The addition of 18% fish oil into tomato sauce medium significantly increased the omega-3 fatty acid of canned sardine from 916.53 mg/100 to 3,666.50 mg/100g. Meanwhile, EPA and DHA contents were noted to increase from 513.12 mg/100g to 1,427.85 mg/100g and from 313.09 mg/100g to 1,966.61 mg/100g respectively (Table 4).



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Table 4. Fatty acid profiles of canned fish using tomato sauce with and without fish oil enrichment (mg/100g sample).

Fatty Acids	Without Fish Oil Addition	With Fish Oil Addition
C14:0	302.39	492.32
C16:0	482.35	740.47
C16:1	381.99	648.90
C18:0	-	30.52
C18:1	254.22	483.03
C20:1n-9	99.68	217.63
C20:3n-3/C20:4n-4	90.32	272.04
C20:5n-3 (EPA)	513.12	1,427.85
C22:6n-3 (DHA)	313.09	1,966.61
Total omega-3 fatty acids	916.53	3666.50

## Conclusions

The tomato sauce formulation experiment proved that, organoleptically, fish oil addition to tomato sauce was acceptable by panelists and even improved nutritional quality of the product. Fish oil could be added into tomato sauce up to 18%.

NA-CMC was considered as an effective emulsifier to be used in tomato sauce disguised with fish oil. This study suggested adding that emulsifier at the concentration level of 1.72%.

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## Appendix 1. The example of the calculation of ingredient effects.

### 1. Effect of fish oil on overall sauce acceptability

<u>High amount</u>	<u>Low amount</u>
$\frac{27 + 28}{2} = 27.5$	$\frac{40 + 41}{2} = 40.5$

Comments: low amount of fish oil was preferred in terms of overall sauce acceptability

### 2. Effects of tomato paste on overall sauce acceptability

<u>High amount</u>	<u>Low amount</u>
$\frac{40 + 41}{2} = 40.5$	$\frac{27 + 28}{2} = 27.5$

Comments: high amount of tomato paste was preferred in terms of overall sauce acceptability

### 3. Effects of water on overall sauce acceptability

<u>High amount</u>	<u>Low amount</u>
$\frac{40 + 28}{2} = 34$	$\frac{27 + 40}{2} = 33.5$

Comments: high amount of water was preferred in terms of overall sauce acceptability