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DEVELOPMENT OF CANNED FISH IN TOMATO SAUCE ENRICHED WITH FISH OIL
II. Determination Of Important Factors During Processing

PENGEMBANGAN PRODUK IKAN KALENG BERMEDIUM SAUS TOMAT YANG DIPERKAYA DENGAN MINYAK IKAN :
II. Penentuan Faktor-Faktor Penting Selama Pengolahan

Hari Eko Irianto, Carmen C. Fernandez) dan G.J. Shaw**)*

ABSTRACT : Pre-Cooking in the canning process induced the release of fish oil. The enrichment of fish oil into the canned fish product was aimed at recovering the lost oil.

Determination of important factors in the processing of canned fish enriched with fish oil was carried out. Eight factors screened were brining time, pre-cooking, vacuum headspace, sterilization time, and additions of garlic, shallot and vinegar. Screening of the factors was conducted using Placket and Burman experimental design. The result showed that all those factors were important except brining time of fish. Sterilization time and tomato sauce saltiness were required to be optimized.

ABSTRAK : Proses pre-cooking di didalam pengalengan ikan menyebabkan hilangnya sebagian minyak ikan. Pengolahan ikan kaleng yang diperkaya dengan minyak ikan dimaksudkan untuk memperoleh minyak ikan yang hilang tersebut.

Penentuan faktor-faktor penting di dalam pengolahan ikan kaleng dengan medium saos tomat yang diperkaya dengan minyak ikan telah dilaksanakan. Faktor-faktor yang diidentifikasi pengaruhnya adalah lama perendaman ikan di dalam larutan garam, pre-cooking, kondisi vakum pada headspace, lama sterilisasi, penambahan bawang putih, bawang merah cuka. Hasil penelitian menunjukkan bahwa semua faktor tersebut merupakan faktor penting di dalam pengolahan ikan kaleng dengan medium saus tomat yang ditambah minyak ikan kecuali faktor perendaman ikan di dalam larutan perlu dioptimalkan.

1. INTRODUCTION

Many processing factors affect the canned fish quality as mentioned by Anonimous (1984), Codex Alimentarius Commision (1976) and Warne (1988). Those factors are such as fish brining, pre-cooking, vacuum head space and sterilization. Meanwhile, spices used in the medium preparation also influence the product acceptability.

This experiment was aimed at screening the important factors determining the product quality. Factorial experiments give a large sample, if all those above factors or variables are studied. It is usually possible to eliminate some of those factors by non-statistical screening method, but the problem may still be too large factors to solve using conventional factorial experiment. Statistical design called Placket and Burmann is noted as the most efficient design for screening large number of factors. Placket and Burman design make it possible to screen N-1 variables in N experiment.

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2. MATERIALS AND METHODE

2.1. Materials

Fish oil (manly hoki) was supplied Sealord Product Ltd., Nelson, New Zealand. The oil was refined using macroporous strong acid cation resin. Pilchards (New Zealand sardine) used for raw material were obtained from Star Fish Supply Ltd, Napier, New Zealand. The fish size was 17.5 ± 0. 5 cm in lenght, 1.8 ±0. 1 cm in thick and 44.2 ±0.4.9 g in weight.

2.2. Methods

2.2.1. Canned Fish Processing

The fish, received in frozen condition were thawed in running water. Head, tail and visceral parts were removed and then washed using clean water. In this study, some fish were treated by brining in 15% salt solution after washing. Four washed fish were packed in cans 8,2 cm in height and 5.1 cm in diameter. The fish were pre-cooked using steam at 98° C for 20 minutes, and relased water discarded. Tomato sauce was added to each, leaving headspace at the top around 5-7.5 mm. The cans were then sealed . Before sealing, hot steam was passed over the surface of the can for approximately 2 seconds to provide vacuum headspace in the can. Finally, the canned fish were sterilized in the retort at 121.1° C for specified time.

The tomato sauce prepared by mixing of 18.78% tomato paste, 28.17% fish oil, 46,95% water, 3.00% salt and 3.10% sugar.

2.2.2. Experimental

Plackett and Burman experimental design was used for screening the important factors in the canned fish processing. Eight variables screened and the upper and lower limits for these variables were shown in Table 1. The full design matrix for the variables was shown in Table 2.

Table 1. Variables and limits for Plackett and Burman design of canned fish

Variables	Upper limit	Lower limit
A. Process variables		
Sterilization time (min.)	60	35
Steam treatment during sealing (sec.)	2	0
Brining time in 15% salt solution (min)	10	0
Pre-cooking time (min)	20	0
B. Seasoning variables		
Garlic addition (%)	2	0
Shallot addition (%)	2	0
Vinegar addtion (%)	1.2	0

Table 2. Design matrix for screening important factors in fish canning

Treatments	Variables										
	ST	SVS	BT	PC	GA	SA	VA	D	D	D	D
1	+	+	-	+	+	+	-	-	-	+	-
2	+	-	+	+	+	-	-	-	+	-	+
3	-	+	+	+	-	-	-	+	-	+	+
4	+	+	+	-	-	-	+	-	+	+	-
5	+	+	-	-	-	+	-	+	+	-	+
6	+	-	-	-	+	-	+	+	-	+	+
7	-	-	-	+	-	+	+	-	+	+	+
8	-	-	+	-	+	+	-	+	+	+	-
9	-	+	-	+	+	-	+	+	+	-	-
10	+	-	+	+	-	+	+	+	-	-	-
11	-	+	+	-	+	+	+	-	-	-	+
12	-	-	-	-	-	-	-	-	-	-	-

Note : ST = sterilization time
SVS = steam vacuum sealing
BT = brining time
PC = pre-cooking
GA = garlic addition
SA = Shallot addition
VA = vinegar addition
D = dummy

The t-values indicating significance levels were calculated using the Placket and Burman Program (Van Til, 1991).

2.2.3 Analyses

The products were analysed chemically, physically and organoleptically. The chemical analyses performed were pH, moisture (AOAC, 1984), protein (Kjeldahl method using a Kjeltec 1062 System Distilatting Unit), salt content (AOAC, 1984) and peroxide value (Pearson, 1973).Hunter-L, -a and -b values of fish meat colour were determined using a HunterLab colourquest Spectrophotometer model CQ1200k with version 2.33 software and calibrated with a white tile standard. Organoleptic evaluation was carried out for both the fish and tomato sauce medium by 10 trained panellists. The ideal ratio scoring method, which is basically a line-scale of descriptive testing, was employed during sensory evaluation and the score sheet used is shown in Appendix 1.

3. RESULTS AND DICUSSION

3.1. General Performance of The Products

Table3 shows the chemical analysis results for both fish flesh and tomato sauce. The moisture (MC), protein, fat and salt content of fish were in the range of 66.05-68.13%, 23.33-24.19%, 2.63-4.27% and 1.31-2.33% respectively. The pH of fish flesh and tomato sauce varied from 5,96 and 5.72 to 6.13 and 6.01 respectively. The peroxide value (PV) of fish flesh and tomato sauce were in the range of 23-433 meq/kg and 10-32 meq/kg respectively.

Table 3. Result of chemical analysis of fish and tomato sauce

Treatments	Fish Flesh						Tomato sauce	
	MC (%)	Protein (%)	Fat (%)	Salt (%)	P.V. (meq/kg)	pH	P.V. (meq/kg)	pH
1	66.17	23.52	3.69	1.51	171	5.96	10	5.72
2	66.05	23.54	3.90	1.98	272	6.01	15	5.90
3	66.16	23.08	4.27	2.07	563	6.04	16	5.86
4	66.71	23.51	4.05	2.06	258	6.00	15	5.89
5	67.68	24.19	4.03	1.31	23	6.05	16	6.01
6	67.86	23.33	3.67	1.40	163	5.97	14	5.90
7	66.66	23.75	4.17	1.56	498	6.04	16	5.81
8	68.03	23.42	3.73	1.94	818	6.12	32	6.01
9	67.96	23.73	2.89	1.46	246	6.04	10	5.94
10	66.99	23.33	4.07	2.06	240	5.99	10	5.82
11	68.01	23.36	2.63	2.33	371	6.13	21	6.00
12	68.13	23.27	3.37	1.34	433	6.11	27	5.99

Table 4 shows physical colour changes in fish flesh. The results showed that Hunter-L, -a and -b values of fish were in the range of 44.72 - 51.92, 1.19 - 3.56 and 12.69 - 14.81 respectively.

Table 4. Results of colour analysis of fish flesh

Treatments	L-value	a-value	b-value
1	47.72	3.53	14.81
2	46.72	3.17	14.70
3	49.69	1.73	14.07
4	46.13	3.42	14.82
5	44.72	3.56	13.74
6	44.92	2.88	13.34
7	51.92	1.69	14.58
8	49.52	2.00	14.87
9	49.34	1.19	13.29
10	46.84	3.22	14.59
11	49.39	1.38	13.29
12	50.64	1.76	14.44

The sensory evaluation results for fish and tomato sauce are shown in Tables 5 and 6 respectively. The scores of all sensory parameters varied, depending on the treatment.

Table 5. Results of sensory evaluation for fish

Treatments	Appearance	Texture	Bone softness	Saltiness	Spiciness	Sourness	Fishiness
1	1.35	1.27	0.78	0.81	0.70	1.14	1.31
2	1.43	1.01	0.87	1.35	0.97	1.19	1.42
3	2.62	1.26	0.49	1.48	0.94	1.39	1.64
4	1.96	1.28	0.65	1.49	0.96	1.29	1.57
5	3.08	1.00	0.68	1.34	0.94	1.08	1.42
6	2.08	0.88	0.90	1.33	0.84	1.27	1.28
7	1.78	1.17	0.52	1.05	0.83	1.03	1.66
8	2.87	1.03	0.42	1.30	1.06	0.97	1.63
9	2.58	1.27	0.42	1.11	0.98	1.03	1.23
10	2.28	1.14	0.81	1.14	0.91	0.93	1.22
11	1.86	0.99	0.40	1.20	0.98	1.13	1.40
12	1.45	1.21	0.31	1.08	0.81	0.85	1.77

Table 6. Results of sensory evaluation for tomato sauce and overall acceptability for canned fish

Treatments	Tomato sauce						Overal acceptability of the product
	Colour	Mouthfeel	Saltines	Spiciness	Sourness	Fishiness	
1	0.96	1.35	1.01	0.90	1.14	1.42	0.54
2	0.90	1.43	1.13	1.11	1.10	1.42	0.58
3	0.80	1.43	1.15	1.01	1.14	1.34	0.45
4	1.01	1.41	1.45	0.95	0.99	1.28	0.60
5	0.80	1.17	1.22	0.86	0.94	1.48	0.58
6	0.89	1.40	1.13	0.93	1.21	1.34	0.54
7	0.71	1.64	0.99	1.04	1.11	1.15	0.54
8	0.73	1.20	1.44	1.16	1.17	1.33	0.47
9	0.83	1.42	0.99	1.11	1.03	1.19	0.54
10	0.70	1.05	1.16	1.06	1.02	1.29	0.70
11	0.97	1.33	1.21	1.02	1.24	1.14	0.60
12	0.83	1.11	0.91	0.93	1.10	1.17	0.53

3.2. Study On The Effects Of Process Variables

Table 7 shows statistical analysis of the effects of each variable on the chemical, physical and organoleptic parameters of fish and tomato sauce.

3.2.1. Moisture Content

Brining treatment showed a decreased effect on moisture content and an increased effect on salt content of fish. The increment of salt content and the reduction of moisture content of fish are the common phenomenon in salting as reviewed by Burgess et al., (1965), Voskresensky (1965) and Van Klaveren and Legendre (1965). The salt penetrates into the fish flesh because of the osmotic pressure differences between water phase within the fish flesh and the salt solution surrounding the fish, consequently water is released from the fish. The increase of salt content was also affected by vinegar addition in the tomato sauce. Vinegar, which is basically a dilute acetic acid solution, may have accelerated penetration of salt from the tomato sauce into the fish flesh. Meanwhile, acid can induce denaturation of protein. Thus, acid and sterilization treatments could show a synergetic effect on denaturation of protein which allows the salt to easily to penetrate into the fish flesh.

3.2.2. Peroxide Value

Peroxide value of fish and tomato sauce decreased due to the effect of sterilization and vacuum headspace treatments in the can. Some theories have been developed to explain hydroperoxides behavior in the heating treatment of fats. The formation and destruction of hydroperoxides are extremely rapid at high temperature (Nawar, 1985), since hydroperoxides are readily decomposed thermally (Hiatt and Irwin, 1968). Hydroperoxides also undergo a variety of scission and dismutation reactions to form a wide spectrum of carbonyl compounds, hydroxy compounds, short chain fatty acids, dimers and polymers (Dugan, 1968; Smouse, 1978). These processes may have induced the reduction of hydroperoxide value individually or collectively during sterilization. Vacuum headspace in the can provided a much lower oxygen content compared to non-vacuum headspace. This condition could limit the production rate of hydroperoxides during sterilization.

Peroxide value of the fish increased by brining treatment. Salt normally contains not only sodium, but impurities such as copper, calcium salts, magnesium salts, sulphates and organic matters (Rawson, 1966; Tressler and Lemon, 1960; Burgess *et al,* 1965). Salt and copper have been known as pro-oxidants which act as catalist agents in the oxidation process (Stuckey, 1972; Pokorny, 1987; Buck, 1991). These pro-oxidants may have enhanced the production of hydroperoxides in the fish treated with brine.

Pre-cooking of fish decreased the peroxide value of the tomato sauce. This study showed that the peroxide value of fish was significantly higher than the value of the tomato sauce. The pre-cooking treatment could reduce the oil which might be released by the fish into the tomato sauce during the sterilization. Thus the total peroxide value in tomato sauce was lower than the value in tomato sauce obtained from the canned fish without pre-cooking. The possibility of oil release during sterilization could also be used to explain the increase of peroxide value in the tomato sauce due brining. The peroxide value of tomato sauce also decreased due to vinegar addition. The acetic acid in vinegar might have the capability to act as a chelating agent for removing pro-oxidants from the sauce. This could reduce the oxidation rate in the tomato sauce with vinegar, in comparison with the sauce without vinegar.

Table 7. The main effects and significance levels of process variables on the characteristic of canned fish

Sample	Response Variables	ST	SVS	BT	PCT	GA	SA	VA
FISH	Moisture content	-1.21	-0.01	-1.71a	-2.64b	1.34	0.81	0.47
	Protein content	0.66	0.61	-1.27	-0.11	-0.19	0.91	-0.01
	Fat content	1.49	-0.86	0.51	0.95	-2.19b	0.11	-0.95
	Salt content	-1.06	1.25	10.41c	0.70	0.58	1.07	1.90a
	Peroxide value	-3.81c	-1.67a	2.08a	-0.16	0.05	0.39	1.06
	pH	-4.68c	-0.19	1.12	-2.81b	-0.00	1.12	-1.12
	Hunter value :							
	L	-5.61c	-0.85	-0.23	1.65a	-0.56	0.64	-0.11
	a	14.70a	0.13	0.45	-0.69	-1.80a	1.80a	-2.89b
	b	0.81	-1.20	1.07	0.33	-0.99	0.72	-1.29
	Sensory :							
	appearance	-0.32	0.52	0.23	-0.42	-0.33	0.36	-0.09
	texture	-0.70	1.27	-0.18	1.47	-1.23	-0.62	-0.10
	bone softness	7.23	-1.39	0.10	1.80a	1.12	-0.10	0.51
	saltiness	0.38	0.28	1.96a	-1.26	-0.76	-1.58a	-0.06
	spiciness	-0.75	0.21	1.92a	-0.69	0.37	-0.21	0.21
	sourness	0.80	1.31	0.80	0.19	0,26√	-1.18	0.10
	fishiness	-2.21b	-0.82	0.42	-1.18	-2.01a	-0.54	-1.66a
TOMATO SAUCE	peroxide value	-6.97c	-4.34c	2.39b	-7.66c	0.47	1.43	-4.63c
	pH	-1.24	-0.03	0.37	-2.50b	0.30	-0.37	-0.43
	Sensory :							
	colour	1.19	1.86a	0.27	-1.01	1.31	-1.19	0.27
	mouth feel	-0.42	0.37	-0.32	0.92	0.42	-0.61	0.74
	saltiness	0.87	0.57	2.73b	-1.97a	0.06	0.57	0.15
	spiciness	-2.03a	-1.67a	2.38b	1.67a	1.67a	0.00	0.62
	sourness	-1.12	-0.66	0.37	-0.32	1.70a	0.14	0.03
	fishiness	3.72b	0.61	0.20	0.29	0.53	0.29	-3.15b
CANNED FISH	Overal acceptability	1.96a	-0.24	0.62	0.14	-0.62	0.91	1.77a

Note : ST = Sterilization time
SVS = Steam vacuum sealing
BT = Brining time
PCT = Pre-cooking time
GA = Garlic addition
SA = Shallot addition
VA = Vinegar addition

a = t - test significance level at 90%
b = t - test significance level at 95%
c = t - test significance level at 99%

3.2.3. pH

Both sterilization and pre-cooking showed a decreasing effect on the pH of fish, while the decreased pH value of the tomato sauce was significantly influenced by pre-cooking. In the canning experiment using cat fish, ocean perch and pollack, Paredes and Baker (1987) showed that these fishes exhibited different pH changes as the results of sterilization where pH of both ocean perch and pollack increased, while the pH of cat fish decreased.

3.2.4. Colour

The Hunter-L value was decreased by sterilization which may induce a darker fish colour. The higher Hunter-L value exhibited a lighter colour. Investigations by other researchers noted that when fish is heated from one direction, three distinct changes of opacity can be discerned. An initial increase in translucence is followed by two successive increases in opacity. The second increase in translucence is followed by two successive increases in opacity. The second increase in opacity is due to precipitation of thermally denaturated sarcoplasmic proteins, which appears to begin about 45°C (Aitken and Connell, 1979). Sterilization time and shallot addition revealed an increasing effect on Hunter-a value at a significance level of 90% for each. This indicated that the longer sterilization time tended to give a reddish colour to the fish. The increase in intensity of redness might be due to oxidation of iron pigments from ferrous to ferric derivates (English *et al.*, 1988). However garlic and vinegar additions showed a decreasing effect on the Hunter-a value at significance level of 90% and 95% respectively. Hunter-b value was not affected by any factor.

3.2.5. Sensory Evaluation

Panellists revealed that sterilization and pre-cooking significantly increased the bone softness of fish solubilization of organic matter of bone causes softening of fish bone due to heating process (Soesetiadi, 1977; Ishikawa *et al.*, 1987). Pre-cooking may have resulted in preliminary organic matter solubilization, further solubilization occured during sterilization. Acetic acid proved to accelerate the solubilization rate of organic matter from the fish bone (Ishikawa *et al.*, 1989). However, the panellists did not detect the effect of vinegar addition on fish bone softness in this study.

Brining treatment on fish significantly increased the saltiness of both the fish and tomato sauce. Shallot addition decreased the saltiness in fish. This might be because flavour compounds of shallot showed a stronger performance than flavour compounds of salt. Pre-cooking decreased the saltiness of the tomato sauce. This might be influenced by dilution effect due to moisture and oil released into medium during sterilization process.

Brining improved the spicy properties of both fish and tomato sauce, but sterilization time and vacuum headspace decreased the spiciness properties of tomato sauce. Sterilization may have induced decomposition of the spicy flavour compounds into smaller compounds, which could be volatile by heat sterilization, at the same time thermal degradation of fish components induce flavour formation giving a less spicy taste to the tomato sauce. Pre-cooking treatment of fish could improve the spiciness of the tomato sauce. One of the purposes of pre-cooking is to develop desirable flavour properties (Codex Alimentarius Commission, 1976; Warne, 1988). By removal of undesirable flavour, such as fishy flavour during pre-cooking, the existence of a spicy flavour would be significant. Garlic significantly increased the spiciness of the tomato sauce. The principal chemical compounds of garlic flavouring constituents are diallyl disulphide, allicin, alliin and ajoen (Kritchevsky, 1991). Garlic could also increase the sourness of the tomato sauce.

The fishiness of the fish was decreased as the result of sterilization, but the fishiness of the tomato sauce increased during this treatment. During sterilization, the fishy flavour compounds of the fish might be released into the tomato sauce causing an increase in fishiness. Garlic and vinegar additions decreased the fishiness of the fish, while the fishiness of the tomato sauce significantly decreased due to the effect of vinegar addition. This result indicated that garlic and vinegar have the capability to neutralize the fishy flavour in canned fish with disguised fish oil.

Sterilization time and vinegar addition in tomato sauce significantly increased the overall acceptability of the canned fish product. The above results show that sterilization had a significant effect on the bone softness of the fish. Thus, sterilization was necessary to the optimization experiment. Vinegar addition had a significant effect on the reduction of the fishiness of the fish. The vinegar addition in tomato sauce had to be retained in further experiments. Brining treatment was removed from the fish canning process, since this treatment was removed from the fish canning process, since this treatment increased peroxide value of the fish and saltiness in the tomato sauce. Pre-cooking of fish and vacuum headspace in the can as well as garlic and shallot addition in the tomato sauce are retained in the canning process, because they showed desirable effect on acceptability of the canned fish product.

4. CONCLUSIONS

The Plackett and Burman design proved to be very effective in identifying the important factors in the processing of canned fish with disguised fish oil. Pre-cooking, vacuum headspace, sterilization time, garlic, shallot and vinegar additions were considered as important factors. However, sterilization time and saltiness of the tomato sauce needed optimization.

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