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Supplementary File

Development and Process Optimization of a Steamed Fish Paste Cake Prototype for Room Temperature Distribution

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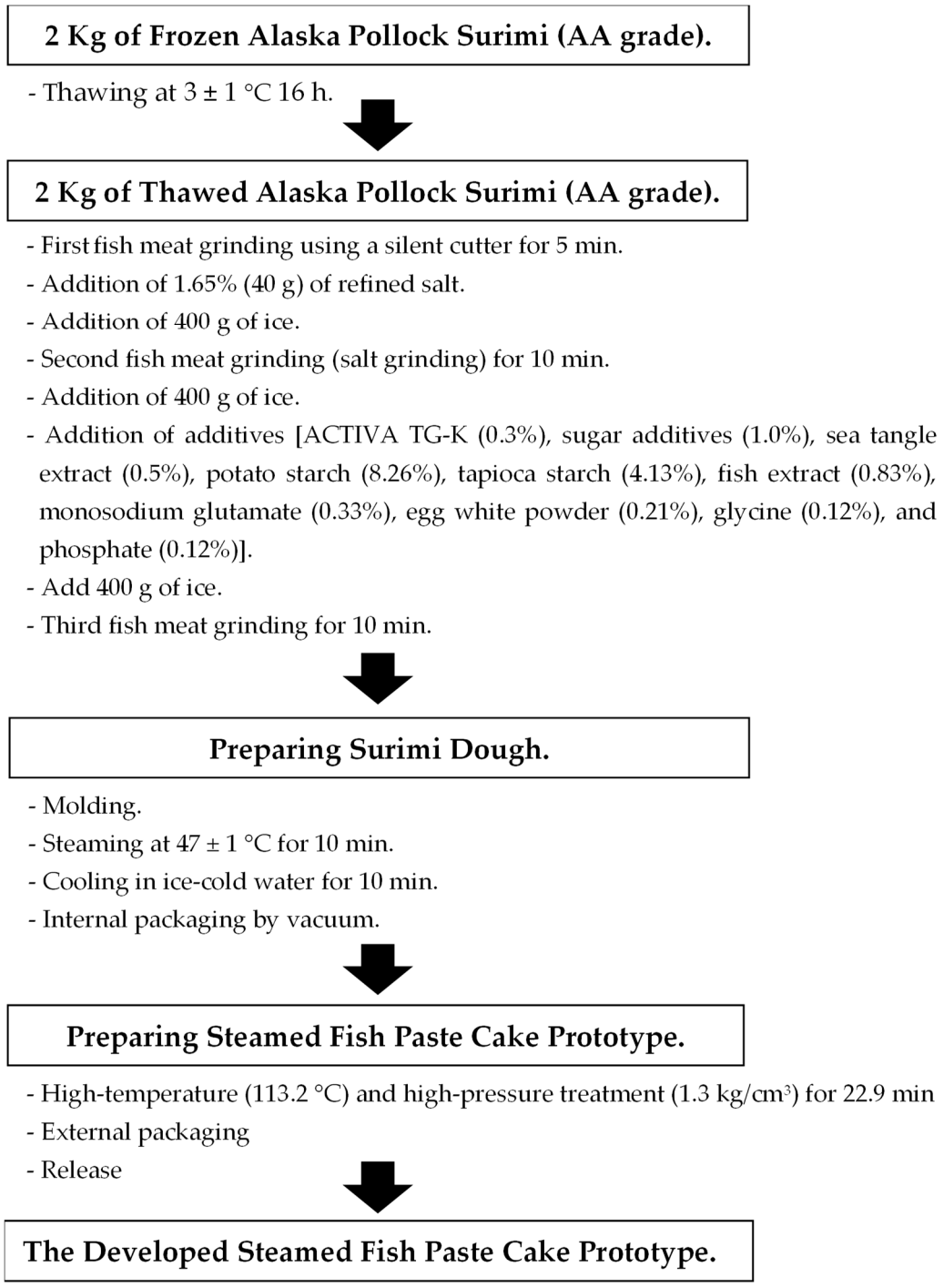


Figure S1. Schematic diagram showing the optimized processing conditions for preparing the steamed fish paste cake prototype.

Table S1. Signs of independent variables presented by central synthesis plan, their codes, and actual values.

Independent variable	Sign	Range				
		-1.414	-1	0	+1	+1.414
Temperature (°C)	X_1	107.9	110.0	115.0	120.0	122.1
Time (min)	X_2	22.9	25.0	30.0	35.0	37.1

X_1: High-temperature processing temperature, °C; X_2: High-temperature and high-pressure treatment time, min.

Table S2. Codes and actual values of samples used for optimizing processing conditions of independent variables based on central synthesis plan.

Coefficients assessed by	**Sample No.**	**Codes**		**Actual values**	
		X_1 (°C)	X_2 (Min)	Y_1 (°C)	Y_2 (Min)
Fractional factorial design	1	-1.000	-1.000	110.0	25.0
	2	1.000	-1.000	120.0	25.0
	3	-1.000	1.000	110.0	35.0
	4	1.000	1.000	120.0	35.0
Star point	5	-1.414	0.000	107.9	30.0
	6	1.414	0.000	122.1	30.0
	7	0.000	-1.414	115.0	22.9
	8	0.000	1.414	115.0	37.1
Central point	9	0.000	0.000	115.0	30.0
	10	0.000	0.000	115.0	30.0
	11	0.000	0.000	115.0	30.0

X_1: High-temperature processing temperature, °C; X_2: High-temperature and high-pressure treatment time, min; Y_1: Gel strength, g × cm; Y_2: Whiteness; Y_3: Sensory score.

Table S3. Attributes, descriptors, definitions, and standard point criteria for descriptive analysis.

Attributes	Descriptors	Definitions	Standard points
Taste	Umami taste	5.0% MSG solution	1.5
		10.0% MSG solution	3.5
		S-brand vegetable fish paste cake	4.0
		G-brand fish paste cake bar	4.5
Smell	Fishy taste	C-brand grilled mackerel	0.5
		C-brand grilled mackerel and grilled flounder	1.5
		S-brand canned sardine	2.0
		S-brand vegetable fish paste cake	4.0
		G-brand fish paste cake bar	4.0
Appearance	Color	Munsell Tablecolor 0.2Y 4.8/4.9 (Brown)	0.5
		Munsell Tablecolor 2.5Y 8.0/1.5 (Ivory)	2.5
		Munsell Table color 9.5N (White)	5.0
Texture	Elasticity	Acorn paste	0.5
		S-brand vegetable fish paste cake	1.5
		Konjac	2.0
		G-brand fish paste cake bar	3.5
		Grape flavored jelly	5.0

Table S4. Dependent variables for optimizing manufacturing conditions of steamed fish paste cake prototype.

Sample No.	Independent variables		Dependent variables		
	X_1	X_2	Y_1	Y_2	Y_3
1	110.0	25.0	127.7	62.9	4.4
2	120.0	25.0	108.9	46.7	5.5
3	110.0	35.0	125.8	54.7	6.5
4	120.0	35.0	94.1	45.5	7.5
5	107.9	30.0	131.5	58.9	5.5
6	122.1	30.0	101.6	37.4	7.2
7	115.0	22.9	123.5	55.7	4.9
8	115.0	37.1	114.1	50.5	6.4
9	115.0	30.0	120.3	52.8	7.5
10	115.0	30.0	119.1	52.1	7.8
11	115.0	30.0	118.0	53.0	7.8

X_1: High-temperature processing temperature, °C; X_2: High-temperature and high-pressure treatment time, min; Y_1: Gel strength, g × cm; Y_2: Whiteness; Y_3: Sensory score.

Table S5. Estimation coefficient and *p* value of quadratic regression equation for optimizing manufacturing conditions of steamed fish paste cake prototype.

Variable	Y_1		Y_2		Y_3	
	Coefficient	*p* value	Coefficient	*p* value	Coefficient	*p* value
Constant	119.113	0.000	52.6333	0.000	7.7000	0.000
X_1	-11.598	0.000	-6.9757	0.000	0.5630	0.005
X_2	-3.749	0.012	-2.0942	0.010	0.7777	0.001
X_1X_1	-2.179	0.118	-1.7854	0.034	-0.6813	0.005
X_2X_2	-1.054	0.404	0.6896	0.315	-1.0313	0.001
X_1X_2	-3.225	0.066	1.7500	0.063	-0.0250	0.887

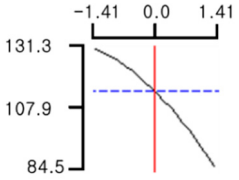
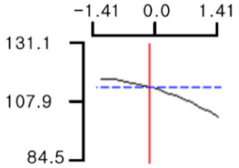
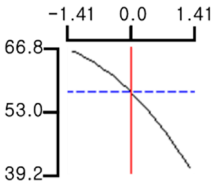
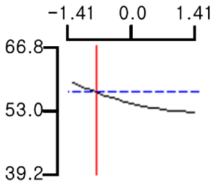
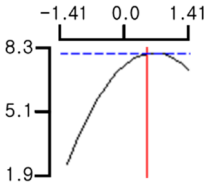
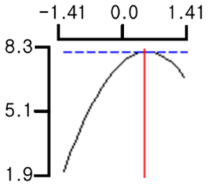
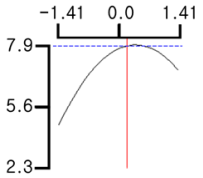
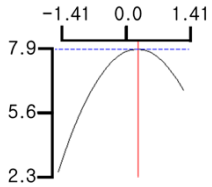
Y_1: Gel strength, g × cm; Y_2: Whiteness; Y_3: Sensory score; X_1: High-temperature processing temperature, °C; X_2: High-temperature and high-pressure treatment time, min; X_1X_1, X_2X_2, and X_1X_2: Coefficients of the quadratic regression equation.

Table S6. Correlation between independent and dependent variables for the reaction model equation of steamed fish paste cake prototype optimal manufacturing conditions.

Dependent variable	Sources	DF	SS	MS	F value	*p* value
Y_1	Model	5	1258.06	251.612	33.34	0.001
	Linear	2	1188.58	594.292	78.74	0.000
	Square	2	27.87	13.936	1.85	0.251
	Cross-product	1	41.60	41.603	5.51	0.066
	Residual	5	37.74	7.548	-	-
	Lack of fit	3	35.09	11.697	8.84	0.103
	Pure error	2	2.65	1.323	-	-
	Total	10	1295.80	-	-	-
Y_2	Model	5	463.742	92.748	43.09	0.000
	Linear	2	424.370	212.185	98.57	0.000
	Square	2	27.123	13.561	6.30	0.043
	Cross-product	1	12.250	12.250	5.69	0.063
	Residual	5	10.763	2.153	-	-
	Lack of fit	3	10.317	3.439	15.40	0.062
	Pure error	2	0.447	0.223	-	-
	Total	10	474.505	-	-	-
Y_3	Model	5	14.2651	2.8530	25.37	0.001
	Linear	2	7.3740	3.6870	32.79	0.001
	Square	2	6.8885	3.4443	30.63	0.002
	Cross-product	1	0.0025	0.0025	0.020	0.887
	Residual	5	0.5622	0.1124	-	-
	Lack of fit	3	0.5022	0.1674	5.58	0.156
	Pure error	2	0.0600	0.0300	-	-
	Total	10	14.8273	-	-	-

DF: Degree of freedom; SS: Sum of squares; MS: Mean square value; Y_1: Gel strength, g × cm; Y_2: Whiteness; Y_3: Sensory score.

Table S7. Predicted optimal conditions for manufacturing steamed fish paste cake prototype using MINITAB statistical program.

Independent variable	Value	X_1		X_2	
Y_1	TV	120.0		120.0	
	CV	0.0		-0.25	
	AC	115.0		28.8	
Y_2	TV	55.0		55.0	
	CV	0.0		-0.88	
	AC	115.0		25.6	
Y_3	TV	9.0		9.0	
	CV	0.21		0.40	
	AC	118.2		33.9	
Optimization conditions for all dependent variables	CV	-0.3637		-0.0240	
	AC	113.2 °C		29.9 min	

TV: Target value; CV: Code value; AC: Actual value; X_1: High-temperature processing temperature, °C; X_2: High-temperature and high-pressure treatment time, min; Y_1: Gel strength, g × cm; Y_2: Whiteness; Y_3: Sensory score.