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Research and Development of Functional Tuna and Kelp Soup

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Abstract

With the development of economy and the rise of living standard, people tend to pursue natural and healthy food. Kelp, a source for both food and medicine, is more and more popular for its function of lowering blood pressure and lipid; however, its deep processing and multi-function development are still in preliminary stage. This research aims to produce functional kelp soup based on the whole experiment design, scientific experiment method and sensory evaluation. The result of the research shows that the optimal recipe for the soup is that every 1500 ml of bone soup match 28 g of dry kelp or 112 g of fresh kelp, 110 ml of cooking wine, 2.5 g of flavor & vegetable powder compound, 8 g of tuna, 1.5 g of salt, 0.6 g of tuna flavor, and 5 g of dry clams, and the cooking time is 60 minutes.

Keywords: kelp, orthogonal experiment, tuna

1. Introduction

1.1 The Function of Kelp and the Feature of Tuna and Kelp Soup

Kelp can help lower blood pressure and sugar and protect against radioactive substances, hence an ideal source for functional soup. In traditional Japanese cooking culture, the combination of kelp with tuna can produce strong umami for it contains rich inosinic acid (474 mg/100 g). Such combination is a natural flavor compound in Japanese cuisine. The tuna and kelp soup is natural, healthy, nutritious and multifunctional, and may be developed into a soup of rich nutrition and strong umami because of the synergism of materials. The soup may be used as accompaniment to meal or base for hotpot, or used to cook noodles.

1.2 The Research Significantc of Tuna and Kelp Soup

Firstly, there are not any any additives, preservatives in the Tuna and kelp soup, which is natural nutritional health food. Secondly, it is rich in nutrition and has the high rate of digestion and absorption. It contains iodine, mannitol, calcium, iron, carotene and other compositions the human body needs. Thirdly, it is in soup form, which is most easily absorbed by the body. Last but not least, it contains sodium glutamate, glutamicacid hydrazine were umami substances and tastes delicious.

The research and development of marine food, especially the development of new functional seaweed products with special flavor, not only make it taste delicious, but also has certain curative effect and produce good economic benefit, which has a broad application prospects.

1.3 Primary Materials

Tuna and kelp soup is made of tuna, kelp and other flavors. The following will briefly introduce its cooking and function of dietetic therapy one by one.

1.3.1 Kelp

Kelps belong to laminariaceae. They are large edible perennial seaweeds and frequently used in the preparation of food in the coastal regions of China and Japan. Containing more than 40 kinds of nutrients, such as fucoidan, dietary fiber, minerals, trace elements, vitamins, some of which are not contained in land animals and plants, kelps can perform the function of lowering blood pressure and lipid and preventing cancer and goiter as well as the function of anti-aging, beautification, intelligence enhancing, physical health improvement. Kelp is precious source for both food and medicine Kelps may be tossed in sauce, braised or made into soup.

1.3.2 Tuna

Tuna is usually in the shape of slice, thread or dice in market. With its special fragrance, sweetness and unami, the tuna is often put into dishes, soups, stuffings and hot pot bases to increase flavor and nutrition. In addition, the tuna can contribute to physical health. Frequent intake of the Taurine in tuna can benefit the liver. The Taurine in tuna can enhance the activities of alcohol dehydrogenase and aldehyde dehydrogenase, thus preventing drunk. It can also improve blood pressure, prevent diabetes and improve thin stool. This research will focus on its function of enhancing umami.

1.4 Preparation of Primary Materials

1.4.1 Preparation of Bone Soup

Traditional bone soup integrates flavor compounds; therefore, its umami quickly comes out, which makes it essential for dishes. This research adopts the traditional bone soup as base. The ingredients of the soup are two pig bones, one old hen and a set of chicken bones. The proportion of water to the materials is five to one.

The processing of the soup is as follows. Firstly, clean the materials with water, and remove the guts that may be attached to the chicken bones, if any. Secondly, put the materials into boiling water for a while to get rid of foreign smell such as that contained in blood. The taste of the soup will be affected if this step is omitted. Lastly, put the materials into cold water in the pot, boil the water, then skim the dirty foams and impurities on the surface. 150 minutes later when the soup becomes milky, turn off the fire.

1.4.2 Preparation of Flavor & Vegetable Powder Compound

The spices of the compound are fennel, pepper, cinnamon and shitake mushroom, the proportion of which is five, four, five and 12 respectively.

The preparation of the compound is as follows. Firstly, select quality spices and mix them in proportion. Secondly, put the mixture in a sealed box and keep the box in refrigerator for 12 hours to minimize the volatilization of smell. Lastly, grind the chilled spices into powders and store them in dry and cool places for use.

2. Experiment

2.1 Materials, Instruments and Tools for the Experiment

Materials Are Shown in Table 1.

Table 1. Primary and auxiliary materials and flavors

Name	Brand	Place of origin	quality
Tuna	Youzipai	Zhejiang Province	High grade
Tuna flavor	Xinzi	Japan	High grade
Kelp	Rongcheng Dry Kelp	Rongcheng City	High grade
Cooking wine	Dexinzhai	Jinan City	High grade
salt	Lujing	Shandong Province	High grade
pig bone	----	Jinan City	High grade
A set of chicken bones	----	Jinan City	High grade
Old hen	----	Jinan City	High grade
Fennel	----	Jinan City	High grade
Cinnamon	----	Jinan City	High grade
Dry shitake mushroom	----	Jinan City	High grade
Pepper	----	Jinan City	High grade

Instruments and tools for experiment are shown in Table 2.

Table 2. Instruments and tools

Name	Model or Specification	Function	Number
Electronic balance	Ying Zhan ACS(GVP)-6A	Eeighing solids	1
Measuring cylinder	100 ml	Measuring liquids and flavors	1
Disposable paper cup	—	Containing prepared flavor juice	50
Electromagnetic oven	Jiu Yang JYC-21ES10	Simmering soup	6
Soup container	-—	Simmering soup	1
Stop watch	—	Measuring cooking time	1
Board	30*10 cm	Cutting materials	1
Knife	—	Cutting materials	2

2.2 Gradient Experiment for Concentration of Single Element

2.2.1 First-Round Concentration Gradient Experiment

Purpose: Since different people have different tastes, the experiment aims to find an acceptable concentration among an acceptable range, and prepare for orthogonal experiment

Process: Tuna flavors of different quantities (arithmetic progression) are separately put into each bone soup base (250ml), then the bone soup bases are heated by electromagnetic oven at the same temperature and in equal cooking time until the flavors are completely integrated into the soups. Ten persons are arranged to taste the soups in turn, and an approximate range of concentration for enhancing umami can be found as shown in Table 3.

Table 3. Results of experiment for enhancing umami by tuna flavor

Quantity(g)	0.1	0.3	0.5	0.7	0.9	1.1
Number of persons who favor it	2	3	3	2	0	0

Therefore, 0.1 g-0.7 g is selected as the optimal range. Based on the same method, the experiment results of other flavors are indicated in Table 4:

Table 4. Results of first-round concentration gradient experiment

Tuna(g)	Kelp(g)	Tuna flavor (g)	Cooking wine (ml)	Flavor & vegetable powder compound(g)
4-10	20-35	0.1-0.7	80-140	2-3.5

Second-round concentration gradient experiment and theanalysis of experiment results is shown in Table 5.

Purpose: Five groups, each consisting of four persons, will attend the experiment for evaluation. A more precise range is to be determined in the experiment based on the optimal range in the first-round experiment.

The experiment aims to select the sample of optimal taste among four samples of five elements, hence further determining the range affecting the taste of tuna and kelp soup.

Process: Tuna flavors of different quantities are separately put into each bone base (250 ml), then the bone soup bases are heated by electromagnetic oven at the same temperature and in equal cooking time until the flavors are completely integrated into the soups. The samples are divided into 20 in equal amount and put in 20 paper cups respectively and then marked with random numbers according to the table for experiment preparation. Each person attending the experiment will get four samples of different concentrations and a questionnaire, but the order of samples is different for each person.

Table 5. Analysis of concentration gradient experiment results

Quantity (g)	0.1	0.3	0.5	0.7
Number of persons who choose it	2	6	10	2

The second-round concentration gradient experiment shows that the number of persons who choose 0.5 g is the largest; therefore, 0.5 g of tuna flavor is optimal amount for the taste of the soup.

The experiment is conducted with the same method for the other elements and the optimal amount is shown in Table 6.

Table 6. Results of concentration gradient experiment

Tuna (g)	Dry kelp (g)	Tuna flavor (g)	Cooking wine (ml)	Flavor & vegetable powder compound (g)
8	25	0.5	120	3

2.3 Orthogonal Experiment

2.3.1 The First-Round Orthogonal Experiment

2.3.1.1 Deciding the Level of the Factors in Orthogonal Experiment

Deciding factors: the factors selected in the first orthogonal experiment are: tuna (to enhance umami), kelp (to enhance umami), tuna flavor (to enhance umami), cooking wine (to deodorize/remove fishiness), flavor & vegetable powder compound (to enhance umami and remove fishiness). Mark them respectively: factor A: tuna; factor B: dried kelp; factor C: tuna flavor; factor D: cooking wine; factor E: flavor & vegetable powder compound.

Deciding levels: this experiment selects 5 factors in all and 4 levels accordingly after experiments, as shown in Table 7.

Table 7. Factors and levels

Factors	Level 1	Level 2	Level 3	Level 4
A Tuna(g)	4	6	8	10
B Dried Kelp(g)	20	25	30	35
C Tuna Flavor (g)	0.15	0.3	0.45	0.6
D Cooking Wine (ml)	80	100	120	140
E Flavor & Vegetable Compound Powder (g)	2	2.5	3	3.5

2.3.1.2 Craft Procedure

Wash the kelps, soak them in water for half an hour and then take out to shred them into slips of 1 cm width. Put kelp slips, tuna, cooking wine and flavor & vegetable powder compound in proportion into the pot with 1500 ml bone soup. After the rolling boil, reduce the temperature on the oven to 90 ºC. Let the soup simmer for 60 mins and add salt and tuna flavor 1 min before switching off. Filter the soup and finally put the product in vacuumed package.

2.3.1.3 Experiment Design

This experiment adopts orthogonal experiment with 5 factors and 4 levels in 16 times as shown in Table 8. The 16 experiments are numbered from 1 to 16, and subject to sensory evaluation. 12 evaluators with training experience in sensory test and analysis will comprehensively evaluate the soup with respect to color, taste and smell, and give scores. The average of the 12 scores is adopted for the experiment result.

Table 8. Orthogonal experiment design $L_{16}(4^5)$

Experiment No.	Factors					Result
	A Tuna	B Kelp	C Tuna Flavor	D Cooking Wine	E Flavor & Vegetable Powder Compound	
1	A1	B1	C1	D1	E1	
2	A1	B2	C2	D2	E2	
3	A1	B3	C3	D3	E3	
4	A1	B4	C4	D4	E4	
5	A2	B1	C2	D3	E4	
6	A2	B2	C1	D4	E3	
7	A2	B3	C4	D1	E2	
8	A2	B4	C3	D2	E1	
9	A3	B1	C3	D4	E2	
10	A3	B2	C4	D3	E1	
11	A3	B3	C1	D2	E4	
12	A3	B4	C2	D1	E3	
13	A4	B1	C4	D2	E3	
14	A4	B2	C3	D1	E4	
15	A4	B3	C2	D4	E1	
16	A4	B4	C1	D3	E2	

Collect the data according to the orthogonal experiment design and analyze the result. See the details in Table 9.

Table 9. Orthogonal experiment results $L_{16}(4^5)$

Experiment No.	Factors					Results
	A Tuna	B Kelp	C Tuna Flavor	D Cooking Wine	E Flavor & Vegetable Powder Compound	
1	A1	B1	C1	D1	E1	4.6
2	A1	B2	C2	D2	E2	5.3
3	A1	B3	C3	D3	E3	5.9
4	A1	B4	C4	D4	E4	5.3
5	A2	B1	C2	D3	E4	5.5
6	A2	B2	C1	D4	E3	5.6
7	A2	B3	C4	D1	E2	5.6
8	A2	B4	C3	D2	E1	5.3
9	A3	B1	C3	D4	E2	5.9
10	A3	B2	C4	D3	E1	6.2
11	A3	B3	C1	D2	E4	5.1
12	A3	B4	C2	D1	E3	5.2
13	A4	B1	C4	D2	E3	5.7
14	A4	B2	C3	D1	E4	5.9
15	A4	B3	C2	D4	E1	5.0
16	A4	B4	C1	D3	E2	5.2
K1	21.1	21.7	20.5	21.3	21.1	——
K2	22.0	23.0	21.0	21.4	22	——
K3	22.4	21.6	23.0	22.8	22.4	——
K4	21.8	21.0	22.8	21.8	21.8	——
$\overline{K1}$	5.275	5.425	5.125	5.325	5.275	——
$\overline{K2}$	5.5	5.75	5.25	5.35	5.5	——
$\overline{K3}$	5.6	5.4	5.75	5.7	5.6	——
$\overline{K4}$	5.45	5.25	5.7	5.45	5.45	——
R	0.325	0.5	0.625	0.375	0.325	——

The curve diagram of the orthogonal experiment results is shown below in Figure 1.

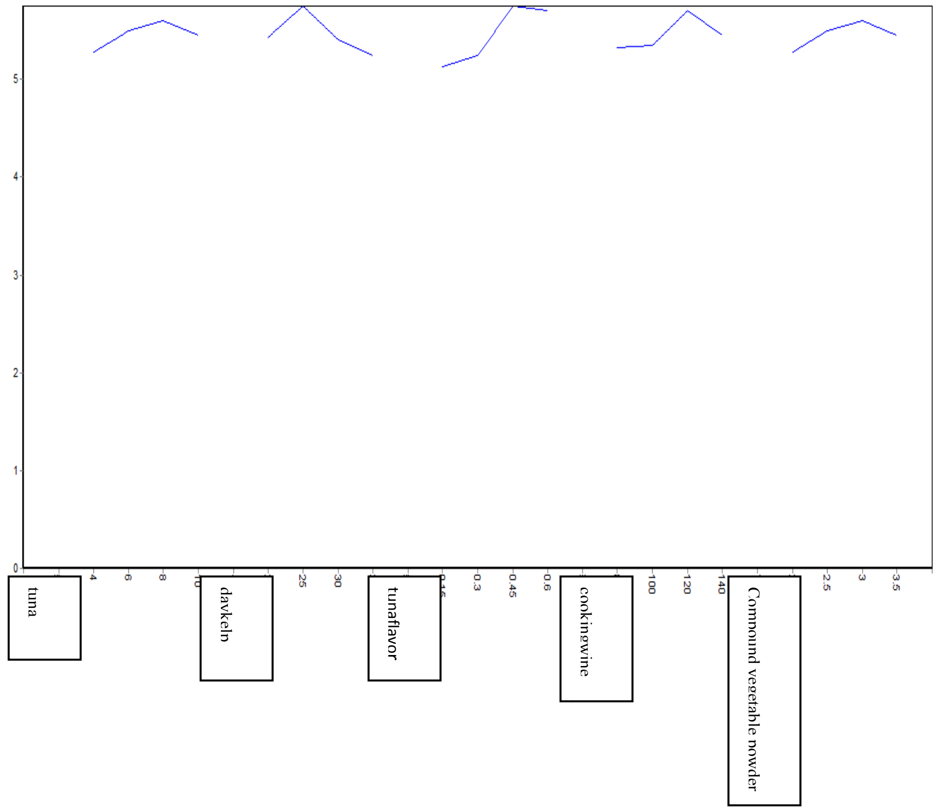

Figure 1. Curve diagram of tuna and kelp soup orthogonal experiment

Data analysis

K1 and $\overline{K1}$ are to be obtained according to Table 9. For example, K1, the corresponding value of Factor A, is the average of the sum of scores of Factor A, namely, the formula for K1 is 4.6+5.3+5.9+5.3=21.1. $\overline{K1}$ is the average of the sum of scores of Factor A1, namely, $\overline{K1}$ =（4.6+5.3+5.9+5.3）÷4=5.275.

The average for each factor is to be obtained by the same method and filled in the table. The value of R is to be calculated too.

It's clear in Table 9 that the highest score of theoretical result is Experiment 10, with the level of 5 factors: tuna 8g, dried kelp 25 g, tuna flavor 0.6 g, cooking wine 120 ml, compound spices 3 g. As the theoretical result deviates from the real one, a second-round orthogonal experiment is needed. Because of R (tuna flavor) > R(kelp)> R(cooking wine)> R(tuna) = R (flavor & vegetable powder compound), the conclusion can be drawn that the tuna flavor affects the taste most, then the kelp and cooking wine, and then the tuna and flavor & vegetable powder compound.

2.3.2 The Second-Round Orthogonal Experiment

Based on the optimization principle, tuna flavor, kelp, cooking wine and compound spices are the chosen factors in the experiment. Take tuna with the constant of 8 g, and then carry out the orthogonal experiment with four factors, each on 3 levels, as shown in the following Table 10.

Table 10. Factors and levels

Factor	Level		
	1	2	3
A Tuna Flavor(g)	0.5	0.6	0.7
B Dried Kelp (g)	22	25	28
C Cooking Wine (ml)	110	120	130
D Flavor & Vegetable Powder Compound (g)	1.8	2.5	3.2

2.3.2.1 Purpose of Optimization Experiment

The second-round orthogonal experiment aims to improve the tuna and kelp soup and decide the optimal recipe.

2.3.2.2 Optimization Experiment Table

Experiment Design: In the optimization experiment $L_9(3^4)$, make random combination of the factors (Factor A: tuna; Factor B: dried kelp; Factor C: cooking wine; Factor D: flavor & vegetable compound powder) and levels that may influence the taste of the tuna and kelp soup:

Table 11. Orthogonal experiment design $L_9(3^4)$

Experiment No.	Factors			
	A Tuna flavor	B Dried kelp	C Cooking wine	D Flavor & vegetable powder compound
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	2	3
9	3	3	1	1

2.3.2.3 Data Analysis of Optimization Experiment

The grading this time takes 1-9 scaling. Get the average of the scores of evaluators on every sample and fill in the averages in the following Table 12 in order.

Table 12. Data Analysis $L_9(3^4)$

Experiment No.	Factor				Scores
	A Tuna flavor	B Dried kelp	C Cooking wine	D Flavor & vegetable powder compound	
1	1	1	1	1	5.3
2	1	2	2	2	5.7
3	1	3	3	3	6
4	2	1	2	3	6.2
5	2	2	3	1	6.2
6	2	3	1	2	7.2
7	3	1	3	2	5.8
8	3	2	2	3	5.5
9	3	3	1	1	5.9
K1	17	17.3	18.4	17.4	——
K2	19.6	17.4	17.4	18.7	——
K3	17.2	19.1	18	17.7	——
$\overline{K1}$	5.667	5.767	6.133	5.8	——
$\overline{K2}$	6.533	5.8	5.8	6.233	——
$\overline{K3}$	5.733	6.367	6	5.9	——
R	0.866	0.6	0.333	0.433	——

Note: Keep one decimal place in the output of the sum of the targets; keep three decimal places in the output of range.

The curve diagram on the optimization experiment is shown in Figure 2.

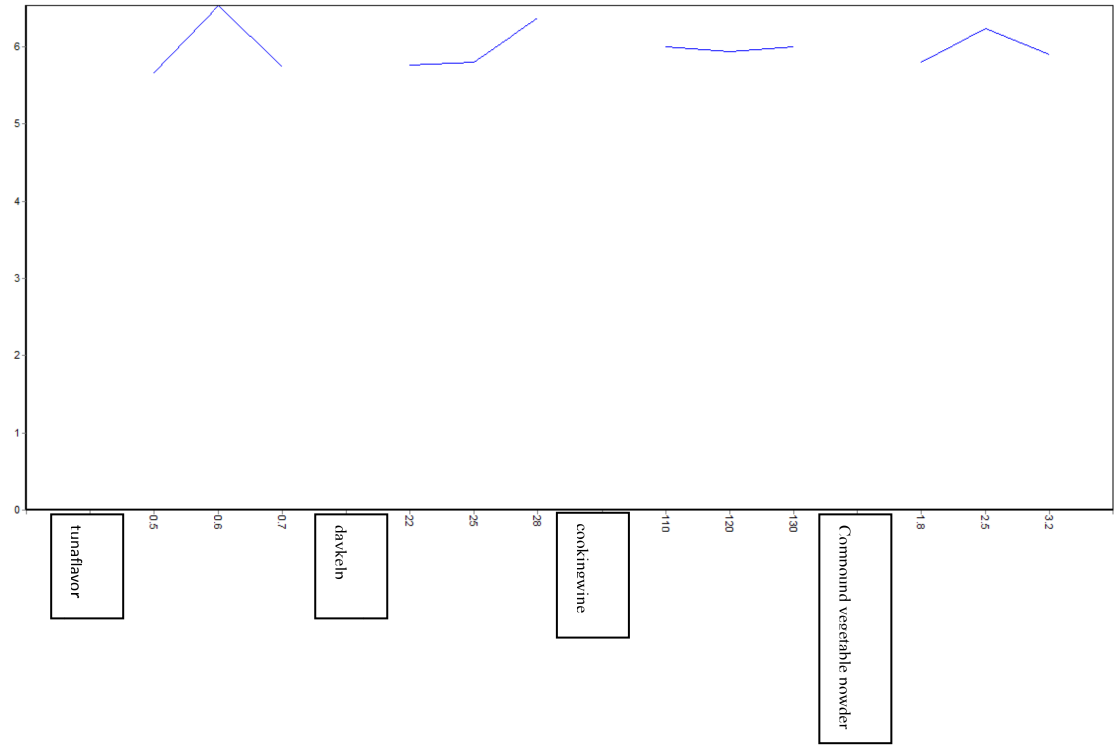

Figure 2. Curve diagram of optimization experiment on tuna and kelp soup

2.3.2.4 Data Analysis

Get the average of every factor by Table 2.11, fill them in Table 2.12 and calculate the range (R).

In Table 2.12, it's clear that the highest theoretical score is Experiment 6, with the level of the four factors: tuna flavor 0.6 g, dried kelp 28 g, cooking wine 110 ml, flavor & vegetable powder compound 2.5 g. According to the target analysis of the factors in the orthogonal experiment, the optimal theoretical values are tuna flavor 0.6 g, dried kelp 28 g, cooking wine 110 ml, flavor & vegetable powder compound 2.5 g and tuna 8 g, coinciding with the real ones.

2.3.3 Triangle Test

2.3.3.1 Purpose

This test aims to check whether there is significant difference between the tastes of the soup made of dried kelps and fresh kelps.

2.3.3.2 Design

Based on dozens of experiments, the expansion rate of dry kelp is 400%. In this experiment, 45 samples of dry kelps (28 g for each sample) and 45 samples of fresh kelps (112 g for each sample) are adopted. The value of α is set to be 0.05. 30 evaluators are equally divided into 10 groups to attend the experiment. Then the experiment is prepared according to the following table.

Table 13. Preparations for triangle test

Sample Preparations Date： No.：		
Sample Type： Tuna and Kelp Soup Test Type： Triangle Test		
Products	Use of the number containing two As	Use of the number containing two Bs
A：Dried kelp sample 28g	286 452	289
B：Fresh kelp sample 112g	176	528 273
Marking of container Group	Order of number	Type of representation
1	286 452 176	AAB
2	289 528 273	ABB
3	528 273 289	BBA
4	176 452 286	BAA
5	286 176 452	ABA
6	528 289 273	BAB
7	286 452 176	AAB
8	289 528 273	ABB
9	528 273 289	BBA
10	176 452 286	BAA
Preparation procedure for samples. Prepare 45 samples for each type respectively and divide them into group A and group B. Based on the numbering in the table, prepare 15 samples for each number and mark each type differently, namely, the group A of dry kelp are marked with 286, 452 and 289, each containing 15 samples; while the group B of fresh kelp are marked with 176, 528 and 273, each containing 15 samples too. Combine the marked samples in accordance with the above table, and send out three questionnaires to each group of evaluators.		

2.3.3.3 Analysis of the Results

After the 30 questionnaires are collected, the answers are checked against the preparation table. According to statistics, 12 persons get the right answers.

According to the table Critical Values for Correct Answers in Triangle Test, when $\alpha=0.05$ and $n=30$, the corresponding vale is 15. When $m<15$, there is no significant difference between these two types of samples; while when $m>15$, differences exist between them. Therefore, the conclusion can be drawn that there is no significant difference between the samples of dry kelps and the samples of fresh kelps.

2.4 Analysis of the Whole Experiments Results

2.4.1 Results of the Whole Experiments Results

After concentration gradient experiment for single element, orthogonal experiment, and triangle test, the optimal recipe is obtained for tuna and kelp soup: every 1500 ml of bone soup match 28 g of dry kelp or 112 g of fresh kelp, 110 ml of cooking wine, 2.5 g of flavor & vegetable powder compound, 8 g of tuna, 1.5 g of salt, 0.6g of tuna flavor, and 5 g of dry clams, and the cooking time is 60 minutes.

2.4.2 Improvents

This experiment has produced tasteful tuna and kelp soup with kelps as primary materials. The soup can not only cater for people's taste, but realizes people's ideal for natural and healthy diet. Flavor & vegetable powder compound is introduced in the experiment, however, the compound may be affected by quite a lot of factors and its recipe still needs to be further researched.

3. Conclusion

This paper mainly conducts research on kelps and aims to develop tuna and kelp soup, also used advanced kelp processing technique from South Korea and Japan for reference. Concentration gradient experiment, orthogonal experiment, etc. are adopted in the research, together with scientific cooking techniques. The resultant optimal recipe for tuna and kelp soup is that every 1500 ml of bone soup match 28 g of dry kelp or 112 g of fresh kelp, 110 ml of cooking wine, 2.5 g of flavor & vegetable power compound, 8 g of tuna, 1.5 g of salt, 0.6 g of tuna flavor, and 5 g of dry clams and the cooking time is 60 minutes.

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