American Journal of Food Technology

ISSN 1557-4571

Academic Journals Inc.

www.academicjournals.com

OPEN ACCESS American Journal of Food Technology

ISSN 1557-4571
DOI: 10.3923/ajft.2017.221.226

Research Article
Study on Key Processing Technology for Instant Shrimp of *Litopenaeus vannamei*

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Abstract

Objective: In this study the optimum processing conditions of instant shrimp of *Litopenaeus vannamei* was carried out. **Methodology:** The changes in texture properties, moisture content, salt content, amino acids and sensory evaluation were acted as analytic indexes, the effect of steaming time, formulation of flavoring liquid and the dipping time on product quality were investigated through single-factor test and orthogonal test. **Results:** After raw material cleaning, the materials were steamed 5 min, dipped in flavoring liquid for 1.5 h and then dried in infrared oven for 35 min. The best formulation of flavoring liquid was that the ratio between material and water is 1:3, salt 2%, sugar 3%, cooking wine 2%, white vinegar 0.2% and monosodium glutamate 0.1% for per 100 g water. The amino acid content of obtained instant shrimp is complete relatively and the total amount of amino acid is 349.527 mg g^{-1}. **Conclusion:** The main results provide reference for the industrial production of instant shrimp.

Key words: Instant shrimp, processing technology, amino acid

Received: November 21, 2016 Accepted: February 20, 2017 Published: April 15, 2017

Citation: Jianfeng Sun, Tianshu Yang, Xiongwei Zhao and Xinyue Li, 2017. Study on key processing technology for instant shrimp of *Litopenaeus vannamei*. Am. J. Food Technol., 12: 221-226.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Litopenaeus vannamei is a kind of nutritional and delicious seafood. Protein content is more than 90% (dry basis), fat content is about only 1% (dry basis). *Litopenaeus vannamei* abundant in minerals has the function of preventing from atherosclerosis and coronary heart disease[1]. The characters of *Litopenaeus vannamei* are relatively slim muscle fiber, soft structure of histone, considerable moisture, tender meat and easily digestion and absorption, so it is popular among domestic and overseas customers. *Litopenaeus vannamei* is one of highest aquaculture production among three excellent shrimp species in the world and also is the highest shrimp yield in the world[2]. China has abound resources of *Litopenaeus vannamei*, but the form of products is single and mainly depends on fresh or freezing goods. The traditional dried products are based on dried shrimp products with shell, whose moisture content is less than 20%, it was compared to the fresh products, it has less juice and more dregs, tough texture and poor mastication. This traditional product has little categories and processing yield that it cannot meet markets' need, which restricts shrimp aquaculture to further development. In recent years, with the prevalence of instant seafood in the world, because of its delicious taste and convenience, researches of instant shrimp are progressively increasing. Linjin adopted fresh *Litopenaeus vannamei*, the *Litopenaeus vannamei* of moisture content of approximatly 45-50% was gained and conserved 3 months in the room temperature via the process of flavoring and drying[3]. The influence of salt boiled water on the color, texture and protein of shrimp and high moisture shrimp was got[4,5]. It is not only customers' requirements were reached, but also the practical value of *Litopenaeus vannamei* was enhanced and economic and social benefits were gained by processing *Litopenaeus vannamei* into instant shrimp which is high moisture, soft texture, good taste and easy to eat and take.

For this purpose, the key processing technology for instant shrimp of *Litopenaeus vannamei* was studied and according to the results of the pre experiments that steaming, dipping in flavor liquid have significantly influence on the quality of instant shrimp, the optimum processing conditions were carried out with analyzing the changes in texture properties, moisture content, salt content, amino acids, sensory evaluation, single-factor test and orthogonal test, the effect of different processing conditions on product quality were investigated, aim to provide reference for the industrial production of instant shrimp.

MATERIALS AND METHODS

Shrimp, salt, sugar, cooking wine, vinegar and monosodium glutamate were bought from supermarket. Acetonitrile was used as chromatographic pure, concentrated hydrochloric acid, 2, 4-two nitrochlorobenzene and glacial acetic acid was analytical reagent. The technological process of instant shrimp was as follows: Selected raw material (*Litopenaeus vannamei*) were removed head and catgut, cleaned and removed shell, cooled, drained after steamed, then dipped with liquid seasoning and infrared baking, at last, finished products by vacuum packaging and sterilized.

Optimum formulation of flavoring liquid: In this test, through single-factor test and orthogonal experiment, the optimum formulation of flavoring liquid was investigated. *Litopenaeus vannamei* was pre-treated and steamed, dipped a certain time with the mass ratio of 1:3 that between peeled shrimp and liquid seasoning, then infrared drying 35 min[6]. Liquid seasoning is made up different mass ratio of salt, sugar, cooking wine, vinegar and monosodium glutamate mix with water, respectively and so on. Each 100 g water flavorings initial quantity: Salt 2%, sugar 2%, cooking wine 1%, monosodium glutamate 0.1%, vinegar 0.1%, adding quantity of one kind seasoning were changed successively during experiment, the seasoning addition was used in next experiment that under a better level of the last experimental results. For example, the salt concentration at 1%, that is 1 g salt was added into 100 mL water. The sensory evaluation was used as the main index, the effect of salt, sugar, cooking wine, MSG and vinegar on product quality were studied, respectively.

According to the result of single factor experiments about liquid seasoning, orthogonal experiment was designed to optimize parameters, to determine the best ratio of liquid seasoning. Four main parameters are reported to play dominant role on the sensory evaluation of shrimp, namely; salt, sugar, cooking wine and monosodium glutamate. An orthogonal array L_9 (3^4) was implemented and three levels were set for each of these factors. Table 1 lists the four factors and their levels as well.

Table 1: Factors and levels of orthogonal experiment

Level	Salt	Sugar	Cooking wine	Monosodium glutamate
1	2	2	2	0.1
2	3	3	3	0.2
3	4	4	4	0.3

Table 2: Sensory evaluation standards

	Score			
Index	1~4	5~7	8~10	Weight (%)
Color	Red with black or red have more white, the whole difference is very big	Red is a little darker or lighter, color is not consistent	Present the original red, color is uniform	20
Shape	Quantity of shrimp with incomplete is more, shrimp was significantly reduced	There are a small number of individual obvious shrinkage or incomplete	Shrimp are the basic integrity, uniform	20
Organization	Hardness is too large or too soft have no chewy	Hardness slightly harder or softer, slightly elastic	Moderate hardness, have certain elasticity, chewy	30
Taste and smell	Too salty or too pale, almost have no fresh scent	Salty and slightly heavier or lighter, fresh aroma defects	Salty and delicious, good taste have the unique fresh flavor of products, no peculiar smell	30

Effect of processing technology on the quality of the product: According to the technological process of instant shrimp and the result of formulation of flavoring liquid, the changes in texture properties, moisture content, salt content, amino acids and sensory evaluation were acted as analytic indexes, the effect of steaming time and the dipping time on product quality were investigated, also the optimal processing technology were determined.

Method of sensory evaluation: Sensory evaluation[7], such as color, shape, organization, taste and smell were carried out by 20 member panel who have rich experience in the sensory testing of food products, using a 10 point hedonic scale according Table 2.

RESULTS AND DISCUSSION

Production of instant food was needed to cooking raw material at first. The traditional way is boiling, which can make shrimp boiled and low moisture, the loss of some amino acids and microelements were caused by boiling simultaneously[8,9]. Steaming was adopted in previous study by Cui *et al.*[10], which is good for declining nutritional loss during the process of cook *Litopenaeus vannamei*. After steamed a certain time, the cooking loss and TPA were tested and the experiment results were shown in Table 3. Moisture of shrimp was removed partly by steaming, also drying time was decreased and steaming was played a sterilized role at the same time. According to the Table 3, different streaming time have significant influence on the shrimp loss rate, texture parameter and sensory evaluation, the indexes of 5 min were compared with indexes of 7 min, elasticity and sensory evaluation have no significant difference, but chewiness, resilience, cohesion and sensory evaluation reached maximum in 5 min and shrimp has good taste. Over long steaming time, shrimp was made lose freshness, low elasticity, increased hardness, material was wasted and production cycle and cost were raised. On the contrary, shrimp was made soft, poor mouthfeel by short steaming time. Comprehensive consideration, shrimp with good taste when steaming time is 5 min.

The effect of salt, sugar, cooking wine and monosodium glutamate on the instant shrimp flavor was shown in Table 4, the result of rang analysis show that the primary and secondary sequence of different ingredient effect on the sensory scores for shrimp is A>B>D>C, in order to improve the sensory scores, the suitable combination is $A_1B_2C_1D_2$. To further investigate which factor significantly affects the shrimp sensory evaluation scores, ANOVA is carried out and the results are showed in Table 5. Statistical analyses indicates that salt, sugar and monosodium glutamate are the principal factors who have the most significant effects on the shrimp sensory scores ($p<0.01$), cooking wine is the principal factor who has significant effects on the shrimp sensory scores ($0.01<p<0.05$). Experimental results show that, the optimal formulation of flavoring liquid is ratio of 1:3 between material and water, salt 2%, sugar 3%, cooking wine 2%, white vinegar 0.2% and monosodium glutamate 0.1%. These results are good agreements with the previous analysis of means, sensory test score was verified at 9.3 points according to the condition.

The salt and sugar permeate content in the shrimp were affected by the different dipping time, the osmotic pressure was formed between internal water and external high concentration flavoring liquid, the material exchange were carried out between moisture in shrimps and salt of seasoning liquid, it to balance with the time extending[11]. The effects of dipping time on the salt content and moisture content of shrimp as shown in Fig. 1. Moisture content of dipped shrimp was decreasing with dipping time prolonging, it decreased significantly at the beginning of 0.5 h and tended to balance gradually after 1.5 h. The salt content increased quickly in the 1.5 h and then rose slowly after 1.5 h, got equilibrium from 2.5 h. The over high salt content can not only affects the taste of shrimp, cover the seafood flavor that itself have, but also not conducive to physical health. Comprehensive considered, the best dipping time is 1.5 h.

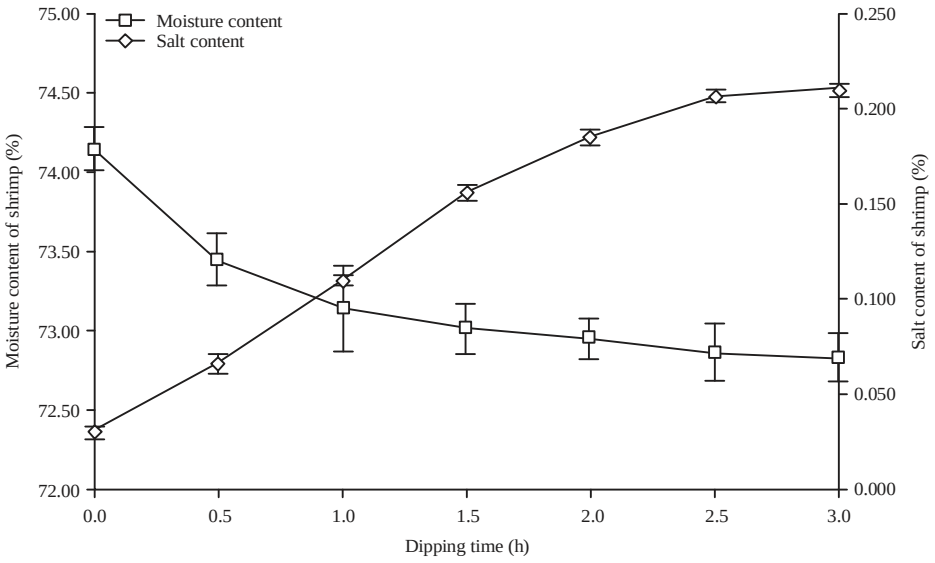

Fig. 1: Influence of dipping time on salt and water content of shrimp

Table 3: Effect of steaming time on texture properties of shrimp

Time (min)	Steaming loss rate (%)	Hardness (N)	Chewiness (mJ)	Resilience (mm)	Cohesion ratio	Sensory score
3	18.63±0.23^{a}	12.19±0.42^{a}	14.27±0.13^{a}	2.49±0.04^{a}	0.44±0.01^{a}	3.80±0.14^{a}
5	21.30±0.42^{b}	14.09±0.23^{b}	23.88±0.06^{b}	3.36±0.06^{b}	0.51±0.01^{b}	5.70±0.20^{b}
7	23.20±0.29^{c}	15.81±0.20^{c}	21.98±0.03^{c}	3.21±0.07^{b}	0.44±0.01^{a}	5.35±0.07^{b}
9	24.37±0.47^{d}	17.06±0.25^{d}	18.54±0.08^{d}	3.01±0.06^{c}	0.43±0.01^{a}	4.60±0.14^{c}

Same column of data with different superscript letters represent significant difference ($p<0.05$)

Table 4: Shrimp sensory evaluation scores of the orthogonal experiment and analysis of means

Treatments	A salt (%)	B sugar (%)	C cooking wine (%)	D white vinegar (%)	Sensory score I	Sensory score II
1	1 (2)	1 (2)	1 (2)	1 (0.1)	7.63	7.84
2	1	2 (3)	2 (3)	2 (0.2)	8.31	8.02
3	1	3 (4)	3 (4)	3 (0.3)	7.81	7.75
4	2 (3)	1	2	3	7.50	7.52
5	2	2	3	1	7.76	7.82
6	2	3	1	2	7.89	7.83
7	3 (4)	1	3	2	7.46	7.38
8	3	2	1	3	7.81	7.69
9	3	3	2	1	7.23	7.09
K_1	7.89	7.56	7.78	7.56		
K_2	7.72	7.90	7.61	7.82		
K_3	7.44	7.60	7.66	7.68		
R	0.45	0.34	0.17	0.26		

Table 5: Analysis of variance showing significance of independent variables on shrimp sensory evaluation scores

Source	SS	df	MS	F	Significance
A	0.618	2	0.309	30.943	**
B	0.426	2	0.213	21.344	**
C	0.091	2	0.046	4.562	*
D	0.193	2	0.096	9.651	**
Error	0.090	9	0.010		

*: Significant at 5% level,**: Significant at 1% level, df: Degree of freedom

Amino acids, the basic units of protein are necessary nutritional elements for human body. Lacking of any kind of essential amino acids, physiological function can be impaired, the normal metabolism of antibody was affected and diseases were caused finally. Also, being short of some non-essential amino acids, metabolic disturbance of antibody can be generated. The composition and content of amino acids are usually regarded as quality indicators of seafood products[12], especially the delicious amino acids, such as Glu, Asp, Ala and Gly are the important source of unique shrimp flavor and closely related to product quality. Amino acids of shrimp can be influenced by different processing conditions, some amino acids can be damaged by maillard reaction in heating treatment, for example, sulfur amino acids (Cys and Met),

Table 6: Amino acid content of shrimp from different methods

	Amino acid content (mg g^{-1})		
Amino acid	Fresh shrimp	Steamed and dipped shrimp	Steamed, dipped and dried shrimp
Aspartic acid**	15.574±0.35[a]	22.896±0.28[b]	44.109±0.29[c]
Glutamate**	20.149±0.13[a]	34.162±0.08[b]	66.163±0.11[c]
Histidine	2.176±0.04[a]	3.227±0.07[b]	6.828±0.03[c]
Serine	4.603±0.15[a]	7.039±0.17[b]	14.136±0.13[c]
Arginine	15.948±0.72[b]	16.800±0.54[a]	30.900±0.67[a]
Glycine**	6.167±0.42[b]	5.453±0.31[b]	11.163±0.57[a]
Threonine*	5.318±0.05[a]	7.720±0.06[b]	15.907±0.05[c]
Taurine	0.902±0.08[b]	0.627±0.10[b]	1.650±0.08[a]
Proline	5.762±0.42[b]	6.673±0.30[b]	11.508±0.37[a]
Alanine**	8.700±0.13[a]	10.712±0.09[b]	21.660±0.07[c]
Valine*	5.958±0.08[a]	9.261±0.07[b]	18.820±0.29[c]
Methionine*	3.857±0.28[a]	5.000±0.22[b]	9.954±0.04[c]
Cystine	0.284±0.03[b]	0.277±0.03[b]	0.631±0.03[a]
Isoleucine*	6.238±0.23[a]	9.337±0.20[b]	17.714±0.24[c]
Leucine*	11.300±0.14[a]	16.885±0.23[b]	32.007±0.27[c]
Tryptophan*	0.000±0.00[b]	0.000±0.00[b]	0.252±0.01[a]
Phenylalanine*	5.431±0.22[a]	8.775±0.22[b]	15.844±0.21[c]
Lysine*	19.928±0.58[b]	24.182±0.72[a]	22.601±0.62[a]
Tyrosine	17.523±0.15[a]	24.155±0.20[b]	7.68±0.15[c]
Total delicious amino acids	50.590[a]	73.223[b]	143.095[c]
Total essential amino acids	58.030[a]	81.160[b]	133.099[c]
19 kinds of amino acids	155.818[a]	213.181[b]	349.527[c]

*Essential amino acid, **Flavor amino acid, some tryptophan were destroyed in acid hydrolysis, fail to test. Same row of data with different superscript letters represent significant difference ($p<0.05$)

Tyr can easily be destroyed, protein hydrolysis can generate some amino acids and change the component of amino acids in products[13].

The amino acid composition and content of instant shrimp which are processed by different methods were tested by HPLC as shown in Table 6. Table 6 shows that, the amino acid content of fresh shrimp was used as contrast (fresh shrimp TAA 155.818 and TEAA 58.30 mg g^{-1}), TAA is 213.181 and TEAA is 81.160 mg g^{-1} of the shrimp that were cooked and dipped, TAA is 349.527 and TEAA is 133.099 mg g^{-1} of the shrimp which were cooked, dipped and infrared dried. Compared with the contrast, TAA of two processing methods were increased about 1.4 and 2.2 times, respectively, TEAA increased by approximately 1.4 and 2.3 times, infrared drying compare to the one who were not dried, TAA and TEAA were increased by 1.6 and 1.8 times. Amino acids between the shrimps which are processed by various methods and the fresh shrimps have significant difference and so do the respective processing method of shrimps, which showed that processing methods have remarkable effects on amino acid content of instant shrimp. In the process, it was considered by analysis that various protease, peptidase and aminopeptidase showed strong activity in proper condition[14], they are beneficial to decompose protein, thus the amino acid content was much higher after the processing. The time of infrared drying is short, which can furthest retain amino acids. However, over longer time of infrared drying can cause higher temperature. Some of amino acid content can be decreased, when temperature deviates from an optimum temperature of the enzyme.

Amino acid composition of instant shrimp in different processing methods is fairly complete and has high level of eight of the essential amino acid (TEAA) and flavor amino acid (DAA). Among them, Lys can promote the development of brain, improve absorption and accumulation of calcium in body, increase the growth of bones and children, Met is part of hemoglobin, tissue and blood serum, Ile is necessary for the formation of hemoglobin, which can steady and adjust blood sugar and energy, participate in metabolism of thymus, spleen and pituitary gland, but Leu can balance Ile, Val can relieve liver failure, protect liver, Phe can control pains and assist in Parkinsonism, Thr can transform some amino acid into balance. Arg and His which are needed for infants fairly have a high level and is very important for children's growth, Taurine can defend heart and brain. In addition, the flavor amino acids (Asp, Glu, Gly and Ala) content of instant shrimp are very high, which makes instant shrimp tasty.

CONCLUSION

In this study, the processing conditions of instant shrimp of *Litopenaeus vannamei* was optimize by single-factor test and orthogonal test, also the changes in texture properties, moisture content, salt content and sensory evaluation were acted as analytic indexes. The main results showed that after raw materials were cleaned, the material were steamed 5 min, dipped in flavoring liquid for 1.5 h and then dried in infrared oven for 35 min. The best formulation of flavoring liquid was that the ratio between material and water is 1:3, salt 2%, sugar 3%, cooking wine 2%, white vinegar 0.2% and monosodium glutamate 0.1% for per 100 g water and then, vacuum packaging by 9.0×104 Pa vacuum degree, 121 sterilization 15 min, natural cooling and finished products. The products have ruddy color, rich seafood flavor, moderate resilience and hardness and tastes good which were produced according to the above formulation and process technology.

The amino acid composition and content of instant shrimp which are processed by different methods were tested by HPLC and fresh shrimp was used as contrast, amino acids content of the shrimps which are processed by various methods have significant increase and so do the respective processing method of shrimps. Those showed that processing methods have remarkable effects on amino acid content of instant shrimp. Amino acid composition of instant shrimp in different processing methods is fairly complete and has high level of eight of the essential amino acid (TEAA) and flavor amino acid (DAA). It illustrated that the instant shrimp protein is a kind of high quality protein, taste delicious, contains a certain amount of valuable nutrient such as, flavor amino acid and functional amino acids, this production can be considered to increasing its comprehensive utilization in the future, it will has good prospects for market development.

ACKNOWLEDGMENTS

This study was supported by Science and Technology Project of Hebei province (No. 14273205D), Education Department of Hebei Province (No.YQ2014037), the 'Double First-rate subject-Food Science and Engineering' program of Heibei Province (2016SPGCA18) and the program of Young and Top Talents of Hebei province.

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