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Effect of Dry-Salted Curcumin and Various Physicochemical and Technical Factors for the Shelf Life of White Shrimp (*Litopenaeus vannamei*)

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ABSTRACT

Loss of quality in seafood has been considered hazardous to consumers due to the proliferation and colonization of pathogenic bacteria. White shrimp (*Litopenaeus vannamei*) is a very important food due to high protein compostion and nutritional component. White shrimp (*Litopenaeus vannamei*) was a product of high value, for local consumption as well as export. However, the quick deterioration of white shrimp was caused owing to high moisture and protein content. Drying was one of the best choices to process this seafood. Besides the preservation purposes, the demand for dried shrimp has also been driven by the flavour of the products. Curcumin has been used in traditional remedy to prevent bacterial and fungal growth. It has been used as an ingredient in food recipes. Objective of this research focused on different technical aspects such as the effect of salt and curcumin concentration during soaking; temperature and time of steaming; temperature of drying to chemical, microbial and sensory characteristics during the processing of curcumin-dry-salted white shrimp. The present study also evaluated shelf life extension of curcumin-dry-salted white shrimp under storage conditions. It has been proved that this white shrimp was highly acceptable level in curcumin-dry-salted condition and also maintained best quality.

Keywords: White shrimp, Curcumin, Salting, Drying, Vacuum, Shelf-life.

INTRODUCTION

Shrimp represents one of the most vital commercial seafood in the world[1]. White shrimp (*Litopenaeus vannamei*) was one of the key species in Vietnamese shrimp farming. Vietnam's shrimp exports in 2017 recorded a remarkable growth with a growth of 22.3% compared with 6.7% in 2016. According to the Vietnamese Directorate of Fisheries (D-Fish), the total output of shrimp in the country in 2017 reached 723.8 thousand metric tons (MT). Of that, brackish water shrimp output reached 683.4

thousand MT including 256.4 thousand MT of black tiger shrimp and 427 thousand MT of white shrimp. The area of brackish water shrimp farming was 721.1 thousand ha, of which that for black tiger shrimp was 622.4 thousand ha and that for white shrimp was 98.7 thousand ha. Vietnamese farmers move away from farming black tiger shrimp (Penaeus monodon) and change to the white shrimp (*Litopenaeus vannamei*). Farmers in Vietnam, particularly in the Mekong Delta of the country are expanding white shrimp farming area. Exports of white shrimp occupied the largest proportion of 65.6%; those of black tiger shrimp accounted for 23%, the rest was marine shrimp with 11.6%.

Regarding to nutritive characteristic of raised white leg shrimp Litopenaeus vannamei, it has good source of protein, carbohydrate, lipid, moisture and ash, calcium, sodium, potassium, manganese, copper, chromium[2]. Shrimps have low fat, less cholesterol and high polyunsaturated fatty acid (PUFA) content[3].

There were several researches mentioned to white shrimp production. Product quality for drying of shrimp by microwave vacuum and air and freeze drying was compared[4]. The effect of drying media to characteristics of shrimp was studied[5]. The effects of different parameters on the drying kinetics and a lot quality characteristics of dried shrimp during drying by bed dryer were investigated[6]. The combine effect of salt and turmeric powder along with smoke-drying process on the production of high quality smoke-dried fish products from *G. chapra*, *X. cancila*, *M. pancalus* and their nutritive value was investigated[7]. The influence of various drying methods on physical and nutritional values of shrimp muscle was investigated[8]. The effect of turmeric on shelf life extension of shrimp Penaeus semisulcatus under chilled storage conditions was evaluated[9]. The effect of spices and herb for maintaining microbiological quality and stability of dried oil sardine fish during preservation under ambient temperature was studied[10]. The dried shrimp was produced by mixing with turmeric and salt under spouted bed technique[11]. Nutrition and stability of dry smoked and gamma irradiated shrimps were studied[12]. The effect of steaming on physical and chemical parameters of white shrimp (*Litopenaeus vannamei*) was determined[13].

The rate of deterioration in shrimp is highly temperature dependent and inhibited by reducing the storage temperature[14]. Several drying techniques such as freeze-drying[15], superheated steam drying[5], jet-spouted bed drying[16], and heat pump drying[17] have been applied to process shrimps. Traditional solar drying and hot air drying are still the most common approaches of shrimp processing. Sun drying is one of the most important low cost methods of shrimp preservation. However, blow flies caused heavy infestation of unsalted dried shrimp. Curcumin has been used in traditional remedy to prevent bacterial and fungal growth. It has been used as an ingredient in food recipes. It's a potential source of new herb to combat a variety of ailments as the species contain molecules credited with antiinflammatory, hypocholestraemic, choleratic, antirheumatic, insect repellent, antimicrobial, antifibrotic, antivenom, antidiabetic, antihepatotoxic as well as it can be used against cancer[18]. Objective of this research focused on different technical aspects such as the effect of salt, curcumin concentration during soaking; time of soaking; temperature of drying to chemical, microbial and sensory characteristics during the processing of curcumin-dry-salted white shrimp. The present study also evaluated shelf life extension of curcumin-dry-salted white shrimp under storage conditions.

MATERIALS AND METHOD

Material

We collected white shrimp (*Litopenaeus vannamei*) from Vinh Chau district, Soc Trang province, Vietnam. They must be reared following VietGAP to ensure food safety. After collecting, they must be temporarily preserved by flake ice and conveyed to laboratory within 4 h for experiments. They were washed and sanitized under washing tank having 25 ppm chlorine with a support of air bubble blowing to remove foreign matters. Besides Litopenaeus vannamei we also used another material during the research such as chlorine, salt, curcumin, poly amid (PA) bag. Lab utensils and equipments included digital weight balance, Rotronic, stomacher, incubator, colony counter, vacuum sealing machine, steaming and dry oven.

(a) (b)

Fig. 1. (a) White shrimp (*Litopenaeus vannamei*), (b) dried shrimp

Researching procedure

Effect of salting concentration to physicochemical, microbiological and sensory characteristics of the dry-salted white shrimp (*Litopenaeus vannamei*)

White shrimps (*Litopenaeus vannamei*) were treated with salt at different ratio (0%, 0.25%, 0.50%, 0.75% and 1.0%) soaking 15 min to create a pleasant taste of dried product. All samples will then be dried by heat pump dryer at 55°C in 4 hours. Five dry-salted white shrimps were chosen randomly to analyse crude protein (%), water activity (aw), total plate count (TPC, cfu/g) and sensory score.

Effect of curcumin addition to physicochemical, microbiological and sensory characteristics of the curcumin-dry-salted white shrimp (*Litopenaeus vannamei*)

White shrimps (*Litopenaeus vannamei*) after being treated with salt were treated with curcumin at different ratios (0%, 0.25%, 0.5%, 0.75%, 1.0%) soaking 15 min to create a pleasant taste of dried product. All samples will then be dried by heat pump dryer at 55°C in 4 hours. Five dry-salted white shrimps were chosen randomly to analyse crude protein (%), water activity (aw), TPC (cfu/g) and sensory score.

Effect of steaming temperature and time to physicochemical, microbiological and sensory characteristics of the curcumin-dry-salted white shrimp (*Litopenaeus vannamei*)

White shrimps (*Litopenaeus vannamei*) after being treated with salt and curcumin were steamed at different conditions (100°C, 60 sec.; 105°C, 45 sec.; 110°C, 30 sec. and 115°C, 15 sec. All samples will then be dried by heat pump dryer at 55°C in 4 hours. Five dry-salted white shrimps were chosen randomly to analyse crude protein (%), water activity (aw), TPC (cfu/g) and sensory score.

Effect of drying temperature and time to physicochemical, microbiological and sensory characteristics of the curcumin-dry-salted white shrimp (*Litopenaeus vannamei*)

White shrimps (*Litopenaeus vannamei*) after being treated with salt, curcumin and steamed were dried by heat pump dryer in different conditions (35°C, 6 h; 40°C, 5.5 h; 45°C, 5.0 h; 50°C, 4.5 h; and 55°C, 4 hours). Five curcumin-dry-salted white shrimps were chosen randomly to analyse crude protein (%), water activity (aw), TPC (cfu/g) and sensory score.

Shelf-life of the curcumin-dry-salted white shrimp (*Litopenaeus vannamei*) during storage

Curcumin-dry-salted white shrimp (*Litopenaeus vannamei*) products were kept in two different packing (zipper top, vaccum) ways in PA bag and two different temperature storage conditions (4±2°C, 28±2°C). Sensory score was evaluated in 3 months interval for 12 months.

Physico-chemical, microbial and sensory analysis

Crude protein amount in the white shrimp samples was determined[19]. Water activity (aw) was measured by Rotronic instrument. TPC (cfu/g) was analysed by 3M-Petrifilm. Sensory score of Litopenaeus vannamei was assessed by a group of panelist using the 9-point hedonic scale.

Statistical analysis

The experiments were performed in triplicate. Statistical analysis was conducted by the Statgraphics Centurion XVI.

RESULT & DISCUSSION

Effect of salting concentration to physicochemical, microbiological and sensory characteristics of the dry-salted white shrimp (*Litopenaeus vannamei*)

The raw shrimp was composed of nearly 80% of water. This figure was reported with black tiger shrimp and white shrimp[20]. White shrimps (*Litopenaeus vannamei*) were treated with salt at different ratio (0%, 0.25%, 0.50%, 0.75% and 1.0%) soaking 15 min to create a pleasant taste of dried product. All samples will then be dried by heat pump dryer at 55°C in 4 hours. Five dry-salted white shrimps were chosen randomly to analyse crude protein (%), water activity (aw), TPC (cfu/g) and sensory score. Results from Table 1. Showed that white shrimps (*Litopenaeus vannamei*) should be soaked with 0.75% salt in 15 min to get a pleasant taste.

In another study, the best quality dried shrimp was noted by two different groups: group one (salting 5% with whole shrimp and then cooking for 20 min, drying at 7°C for 2 h), group two (peeling and treating under the same conditions as group one only for 10 minutes)[21].

Table 1: Effect of salting concentration to physicochemical, microbiological and sensory characteristics of the dry-salted white shrimp (*Litopenaeus vannamei*)

Salting concentration	Crude protein (%)	Water activity (a_w)	TPC (cfu/g)	Sensory score
0%	35.38±0.01^{c}	0.74±0.03^{a}	4.9x102±0.02^{a}	5.11±0.03^{c}
0.25%	36.01±0.02^{bc}	0.72±0.00^{ab}	4.1x102±0.01^{ab}	6.09±0.03^{bc}
0.50%	36.12±0.02^{ab}	0.78±0.03^{b}	3.1x102±0.03^{b}	6.76±0.02^{b}
0.75%	36.75±0.04^{ab}	0.66±0.00^{bc}	2.5x102±0.00^{bc}	6.94±0.04^{ab}
1.0%	37.21±0.01^{a}	0.65±0.02^{c}	2.4x102±0.01^{c}	7.09±0.01^{a}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Effect of curcumin addition to physicochemical, microbiological and sensory characteristics of the curcumin-dry-salted white shrimp (*Litopenaeus vannamei*)

In tropical climate and under humid condition, heavy infestation of salted dried white shrimp was caused by blow fly and beetle larvae. To avoid such infestation and microbial contamination, salt and salt-curcumin were used combined in order to achieve the desire product. White shrimps (*Litopenaeus vannamei*) after being treated with salt were treated with curcumin at different ratios (0%, 0.25%, 0.5%, 0.75%, 1.0%) soaking 15 min to create a pleasant taste of dried product. All samples will then be dried by heat pump dryer at 55°C in 4 hours. Five dry-salted white shrimps were chosen randomly to analyse crude protein (%), water activity (aw), TPC (cfu/g) and sensory score. From table 2, the appropriate curcumin concentration should be used at 0.5% to get the highest crude protein content (%), lowest water activity (aw), lowest microorganism (TPC, cfu/g) while having the highest sensory score.

Table 2: Effect of curcumin addition to physicochemical, microbiological and sensory characteristics of the curcumin-dry-salted white shrimp (*Litopenaeus vannamei*)

Curcumin	Crude protein (%)	Water activity (a_w)	TPC (cfu/g)	Sensory score
0%	36.75±0.04^{ab}	0.66±0.00^{a}	2.5x102±0.00^{a}	6.94±0.04^{b}
0.25%	36.82±0.02^{ab}	0.66±0.03^{a}	2.0x102±0.01^{ab}	7.11±0.01^{b}
0.50%	36.90±0.02^{ab}	0.65±0.02^{ab}	1.2x101±0.03^{b}	8.64±0.03^{a}
0.75%	36.96±0.00^{a}	0.64±0.01^{ab}	1.1x101±0.02^{bc}	6.34±0.02^{bc}
1.0%	37.03±0.0^{a}	0.63±0.04^{b}	1.0x101±0.01^{c}	6.08±0.02^{c}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

The influence of temperature on convective drying of cooked shrimp was studied. Salting at 5% level followed by cooking for 20 min and drying for 2 h at 70°C was appropriate[21]. The synergistic effect of salt and turmeric powder along with smoke-drying process on the production of high quality smoke-dried fish products from *G. chapra*, *X. cancila*, *M. pancalus* and their nutritive value was evaluated. The data has proved with strong evidence that Salt-turmeric treated smoke-dried three experimental fishes are rich in most of the nutrients essential for proper health maintenance of humans[7].

Effect of steaming temperature and time to physicochemical, microbiological and sensory characteristics of the curcumin-dry-salted white shrimp (*Litopenaeus vannamei*)

White shrimps (*Litopenaeus vannamei*) after being treated with salt and curcumin were steamed at different conditions (100°C, 60 sec.; 105°C, 45 sec.; 110°C, 30 sec. and 115°C, 15 seconds). All samples will then be dried by heat pump dryer at 55°C in 4 hours. Five dry-salted white shrimps were chosen randomly to analyse crude protein (%), water activity (aw), TPC (cfu/g) and sensory score. Results from Table 1. Showed that white shrimps (*Litopenaeus vannamei*) should be steamed at 110°C in 30 sec. to get the highest quality of curcumin-dry-salted white shrimp (*Litopenaeus vannamei*).

The shrimp drying process using a superheated steam drying cabinet within the temperature range

of 140-160°C was performed[22]. The effect of steaming on physical and chemical characteristics white shrimp (*Litopenaeus vannamei*) was determined[13].

Table 3: Effect of steaming temperature and time to physicochemical, microbiological and sensory characteristics of the curcumin-dry-salted white shrimp (*Litopenaeus vannamei*)

Steaming	Crude protein (%)	Water activity (a_w)	TPC (cfu/g)	Sensory score
100°C, 60 sec.	36.90±0.02^{a}	0.65±0.02^{a}	1.2x101±0.03^{a}	8.64±0.03^{ab}
105°C, 45 sec.	36.22±0.01^{ab}	0.64±0.01^{ab}	0.8x101±0.01^{ab}	8.69±0.02^{ab}
110°C, 30 sec.	36.04±0.04^{b}	0.62±0.04^{ab}	0.4x101±0.01^{b}	8.85±0.02^{a}
115°C, 15 sec.	35.74±0.02^{c}	0.60±0.03^{b}	0.3x101±0.00^{b}	8.21±0.00^{b}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α =

Effect of drying temperature and time to physicochemical, microbiological and sensory characteristics of the curcumin-dry-salted white shrimp (*Litopenaeus vannamei*)

Shrimp is a perishable product under hot and tropical regions. Drying is one of the efficient methods for food storage. Salting and drying are traditional ways to improve fish stability during storage. Besides the preservation purposes, the demand for dried fish has also been driven by the flavour of the products[23].

White shrimps (*Litopenaeus vannamei*) after being treated with salt, curcumin and steamed were dried by heat pump dryer in different conditions (35°C, 6 h; 40°C, 5.5 h; 45°C, 5.0 h; 50°C, 4.5 h; and 55°C, 4 hours). Five curcumin-dry-salted white shrimps were chosen randomly to analyse crude protein (%), water activity (aw), TPC (cfu/g) and sensory score. Results from Table 4. Showed that the drying process should be conducted at 50°C in 4.5 h to get the highest crude protein content (%), lowest water activity (a_w), lowest microorganism (TPC, cfu/g) while having the highest sensory score.

Table 4: Effect of drying temperature and time to physicochemical, microbiological and sensory characteristics of the curcumin-dry-salted white shrimp (*Litopenaeus vannamei*)

Drying condition	Crude protein (%)	Water activity (a_w)	TPC (cfu/g)	Sensory score
35°C, 6 h	34.98±0.01^{c}	0.70±0.03^{a}	1.2x101±0.00^{a}	6.80±0.01^{c}
40°C, 5.5 h	35.01±0.02^{bc}	0.69±0.01^{ab}	1.1x101±0.04^{ab}	7.13±0.03^{bc}
45°C, 5.0 h	35.19±0.00^{b}	0.68±0.01^{ab}	0.9x101±0.01^{b}	7.66±0.02^{b}
50°C, 4.5 h	35.26±0.01^{ab}	0.65±0.02^{b}	0.4x101±0.03^{c}	8.90±0.00^{a}
55°C, 4.0 h	36.04±0.04^{a}	0.62±0.04^{c}	0.4x101±0.01^{c}	8.85±0.02^{a}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Quality of dried shrimp performed by microwave vacuum and air and freeze drying was compared. They reported that the shrimp dried by the superheated steam had a higher degree of shrimp quality[4]. Drying of shrimp at hybrid superheated steam and heat pump dryers and reported the same characteristic in shrimp drying was studied[24]. The effects of different parameters on the drying and quality characteristics of dried shrimp under jet–spouted bed dryer were investigated[6]. The influence of drying conditions upon the quality of shrimp has been investigated[25]. Dehydration property of shrimp undergoing heat-pump drying process was investigated[26]. The influence of different drying methods on physical and nutritional characteristics of shrimp muscle was investigated. Different drying ways affected the physical and nutritional quality of shrimp muscle[8]. The dried shrimp was produced by mixing with turmeric and salt under spouted bed technique. The air drying chamber and hot air velocity were noted at 180°C, 4.5 m/s respectively[11].

Shelf-life of the curcumin-dry-salted white shrimp (Litopenaeus vannamei) during storage

Curcumin-dry-salted white shrimp

(*Litopenaeus vannamei*) products were kept in two different packing (zipper top, vaccum) ways in PA bag and two different temperature storage conditions (4±2°C, 28±2°C). Sensory score was evaluated in 3 months interval for 12 months. Results from Table 5 showed that the curcumin-dry-salted white shrimp (*Litopenaeus vannamei*) still mainted quality during 12 months of storage.

Table 5: Shelf-life (sensory score) of the curcumin-dry-salted white shrimp (*Litopenaeus vannamei*) during storage

Storage time (month)	Curcumin-dry-salted white shrimp (*Litopenaeus vannamei*) by the storage temperature (°C) kept in PA (zipper top)		Curcumin-dry-salted white shrimp (*Litopenaeus vannamei*) by the storage temperature (°C) kept in PA (vaccum)	
	4±2°C	28±2°C	4±2°C	28±2°C
0	8.90±0.00^{a}	8.90±0.00^{a}	8.90±0.00a	8.90±0.00a
3	8.66±0.02^{ab}	8.48±0.03^{ab}	8.85±0.01ab	8.75±0.01ab
6	8.48±0.02^{b}	8.33±0.01^{b}	8.71±0.03b	8.50±0.03b
9	8.35±0.01b^{c}	8.17±0.03^{bc}	8.63±0.02bc	8.21±0.01bc
12	7.95±0.00^{c}	7.45±0.01^{c}	8.50±0.01c	7.89±0.02c

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Drying decreases the water activity, so maintaing food stability by eliminating microorganism and enzymatic reactions without deterioration. The spoilage of shrimp is particularly due to bacteria. Styrofoam was seen to be the most effective packaging material for both processed whole and peeled dried shrimp[21]. Nutrition and stability of dry smoked and gamma irradiated shrimps were studied. After 4 months of preservation, there was a significant enhancing in protein and ash contents[12].

CONCLUSION

White shrimp is an excellent source of dietary protein. The principle of drying is to reduce moisture to maximum levels to prevent microorganism growth and also slow down enzymatic/ biological reactions that cause food deterioration. Artificial color presented on dried shrimp in the market was rejected. We were trying to produce curcumin-dry-salted white shrimp come from turmeric as an alternative. This research aimed to study the possibility to produce dried shrimp by mixing with turmeric and salt. Results revealed that 0.75% of salt with addition of 0.5% of curcumin during soaking 15 minutes; steaming at 110°C in 30 seconds; drying at 50°C in 4. 5 h, the curcumin-dry-salted white shrimp products had the good physicochemical, microbiological and sensory characteristics. By preserving under vacuum at 4°C, the curcumin-dry-salted white shrimp could be maintained shelf-life for 12 months without any deterioration. Dried shrimp produced from turmeric and salt meet the quality criteria by Vietnamese authority agency. Dried shrimps are popular and widely acceptable.

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