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Changes in the Recovery Efficiency, Nutritional and Safety Quality of Dried Sergestid Shrimp (*Acetes* species) during Commercial Production

Ngoc Duc Vu[a], Nguyen Hong Khoi Nguyen[a], Thanh Truc Tran[b], Tran Bach Long[b], Lam Van Tan[a,c], and Tran Thi Yen Nhi[a*]

[a] Institute of Applied Technology and Sustainable Development, Nguyen Tat Thanh University, Ho Chi Minh City, 700000, Vietnam
[b] Institute of Biotechnology and Food Technology, Can Tho University, Can Tho City, 94000, Vietnam
[c] Ben Tre Department of Science and Technology, Ben Tre Province, 86000, Vietnam
[*]Corresponding author
ttynhi@ntt.edu.vn
Tel: +84-369-592-577

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Abstract

The sun-dried method is popular for producing dried Sergestid shrimp in Vietnam, but maintaining consistent product quality across seasons is challenging due to its dependence on weather conditions. A previous study used convection drying at a laboratory scale. In this study, the laboratory scale was upgraded to a commercial scale, and recovery efficiency and Sergestid shrimp images were recorded during production stages. Parameters were adjusted for economic efficiency and convenience. Results showed a decrease in recovery efficiency on the laboratory scale, while the commercial scale improved with washing and blanching. Overall, there was no significant difference in recovery efficiency between the commercial production (15.76 %) and laboratory scale (16.29 %). The commercial-scale dried Sergestid shrimp exhibited better colour than the laboratory-scale product. The product met food safety and quality criteria according to Vietnamese standards. Microorganisms such as *Coliforms*, *E. coli*, *B. cereus*, *C. perfringens* and salmonella, and total number of yeast and mold spores, were not detected in the product. On the other hand, the product of commercial production contained 256 kcal 100 g^{-1} of energy and a protein content of 55.50 ± 0.33 %. These findings form a foundation for scaling up production and assessing economic feasibility. Adjusting production parameters using larger equipment contributes to achieving optimal production efficiency and economic benefits.

Keywords: Organoleptic Quality; Dried Sergestid shrimp; *Acetes*; Commercial Production

1 Introduction

Traditionally, fresh products have always had a low shelf life because they contain a very high water content (>80 %), which is a favorable environment for the growth of harmful microbes (such as yeast and mold...). The nutritional quality or some of the bioactive ingredients in fresh products are also significantly damaged. Previous nutrition studies have shown that products with low moisture content have a significantly longer shelf life than fresh produce. Biologically active substances and nutrients are also changed less during storage. Drying methods have been used in many foods in the past to extend the shelf life of foods (apple cashew slices (Dao et al., 2022), soursop slices (Vu et al., 2022) ...).

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For fresh Sergestid shrimps, traditional sun drying is a common drying solution. However, this method has affected food hygiene and safety due to inadequate handling conditions. At the same time, the quality of each production crop is not uniform because it is highly dependent on climatic conditions.

Sergestid shrimp (*Acetes* species) belongs to the family Sergestidae. In Vietnam, they are often called "Ruoc" (Deshmukh, 1991) (Figure 1). In each country, they are called by a different name such as Geragau in Malaysia, Alamang in the Philippines, Rebon in Indonesia and Bubuk in Brunei. Currently, there are few studies on the production process of dried Sergestid shrimp in Vietnam and the whole world. In particular, the scarcity of evaluations of material recovery efficiency in commercial production is worth mentioning. This study has been continued from a previous report on the production of dried Sergestid shrimp on a laboratory scale (Tran et al., 2022). Depending on the equipment conditions and the total volume of materials in each production scale, it is necessary to change the appropriate conditions to improve economic efficiency. A previous review mentioned that changing the blanching parameters in commercial scale production must be based on fundamental research (Xin et al., 2015). Scaling up production can significantly affect the colour and some of the nutritional components of functional foods (Alkandari et al., 2021). A comparison between laboratory and commercial scale production of grape juice indicated that product quality is better at a laboratory than a commercial scale (Kozák et al., 2008). Changing the processing scale and using different mixing equipment can affect the quality of baked goods (Campbell et al., 2008). In general, changing the processing scale is significantly affected by external factors, equipment, and process control capabilities. Therefore, the parameters need to be appropriately adjusted to ensure that the product quality at commercial scale is equivalent to that produced under optimal conditions in the laboratory.

This study scaled up production from the laboratory to the commercial scale and evaluated the effect of the production stages on the product recovery efficiency. At the same time, some commercial-scale production process parameters were changed to bring high economic efficiency and product quality. In this study, a trial production of 25 kg of product corresponding to 160 kg of raw materials was carried out on a commercial scale using automatically/semi-automatically operated equipment and machines. Recovery efficiency was calculated, and descriptions by a trained sensory panel and images of Sergestid shrimp were recorded, through the processing stages. The product was evaluated using 19 quality criteria, covering food safety, chemical composition and nutrition, as prescribed by Vietnamese standards. The research results were expected to be the basis for the development of mass produced dried Sergestid shrimp products ($>$ 25 kg of product batch^{-1}), and to promote the concentrated production of dried Sergestid shrimp on a commercial scale (25 kg of product batch^{-1}).

Figure 1: Sergestid shrimp (*Acetes* species).

2 Materials and Methods

2.1 Materials

Approximately 170 kg of raw material (fresh Sergestid shrimp) was harvested along the coast of Thanh Phu district, Ben Tre province (9^{o}56´53´´N 106^{o}30´51´E). Raw materials, with the following quality standards, were purchased directly from fishermen: Moisture content (84.22 - 87.92 %) and average length (6.43 - 10.89 mm). The maximum time from harvest to transport to the processing facility is less than 4 hours. Fresh Sergestid shrimp after exploitation is less

crushed, firm, has a salty taste, a typical fishy smell like fish and shrimp, and the level of contamination is less than 1 %. Raw materials are processed as soon as they are transported to the factory.

2.2 Chemicals and equipments

Peptone from animal proteins, peptone from glycine max (soybean), bovine bile, boron trifluoride (96 %), casein from bovine milk, anhydrous glucose (96 %), yeast extract (*Saccharomyces*), peptone from animal tissue, KH_2PO_4 (99 %), $C_{21}H_{39}N_7O_{12}P$, $C_{12}H_{22}O_{11}.H_2O$, bile salts, neutral red (> 90 %), crystal violet (> 90 %), dimethyl sulfoxide, 5-bromo-4-clo-3-indolyl-β-D-glucuronid, tryptone, D-mannitol ($\geq$ 98 %), phenol red, polymyxin B sunfat, egg yolk emulsion, sodium disulfite (97 %), Ammonium iron(III) citrate (Fe = 16.5 - 18.5 %), magnesium sulfate monohydrate (97 %), 2,6-dicloro-4-nitroanilin (97 %), glycerol anhydrous (99.5 %), chloramphenicol (98 %), disodium hydrogen phosphate dodecahydrate (> 99 %), potassium dihydrogen phosphate (99 %), Potassium phosphate dibasic (98 %), blue brilliant, xylose, lactose, sucrose (99 %), sodium thiosulfate (98 %), cupric sulfate (99 %), potassium sulfate (99 %), sulfuric acid (99.999 %), phenolphtalein, lead(II) acetate (99.99 %), oxalic acid potassium salt (98.5 %), potassium sodium tartrate (99 %), Iron(III) sulfate (97 %), potassium permanganate (> 99 %) and nitric acid (69 - 72 %) were purchased from Merk.

Plate count agar (PCA) and D-Xycloserin (99 %) were purchased in India. Beef extract was purchased in Italy. Sodium hydroxide (99 %), hydrochloric acid (36 - 38 %), sodium chloride (99 %), di-sodium hydrogen phosphate dodecahydrate (98 %), soy peptone, D-Glucoza (95 %), potassium dihydro phosphat (99 %), L-lyzin hydroclorua, sodium deoxycholate (97 %) and diethyl ete were purchased in China.

The equipment used in this study was as follows: Moisture analyzer (MB120, Ohaus, Parsippany, NJ, USA), electronic scales (JZC-TSE-30KG, Kendy, Hiroshima, Japan), vacuum-packaging equipment (DZ-650, Trung Dung, Ho Chi Minh, Vietnam), atomic absorption spectrophotometer (US), water activity meter with touch screen (LabTouch-aw, Novasina AG, Lachen, Switzerland) and furnace (LT 40/11/B410, Nabertherm, Hamber, Germany).

2.3 Total aerobic microorganisms

Dissolve 5 g of casein from bovine milk, 9 - 18 g of plate count agar, 1 g of anhydrous glucose and 2.5 g of yeast extract (*Saccharomyces*) in 1000 mL of water, and bring to a boil while stirring continuously until completely dissolved, to create agar A medium. Adjust the pH to 7.0 $\pm$ 0.2 at 25 °C after sterilization (using NaOH or HCl). Sterilize the medium in a pressure cooker at 121 °C for 15 minutes. Then, cool and maintain a temperature of 44 °C to 47 °C. Mix 9 mL of peptone salt solution (consisting of 10 g of peptone from animal tissue, 5 g of NaCl, 9 g of $Na_2HPO_4.12H_2O$, 1.5 g of KH_2PO_4 and 500 mL of water) with 1 mL of sample to dilute the sample to a dilution factor of 10 : 1. Further dilute as necessary to obtain 10 to 300 colony-forming units on a plate (at least 2 plates corresponding to 2 different dilution levels). Add 15 mL of medium and 1 mL of diluted sample to each petri dish. Invert the petri dishes immediately after the medium has solidified. Incubate the sample for 24 hours at 35 °C and then count the colony-forming units (Directorate for Standards, Metrology and Quality, 2015a).

2.4 Coliforms

Perform the same procedure as for determining total aerobic microorganisms, but replace the A medium with neutral red lactose agar (consisting of 7 g of casein from bovine milk, 3 g of yeast extract, 10 g of lactose, 5 g of NaCl, 1.5 g of bile salts, 0.03 g of neutral red, 0.002 g of crystal violet, 18 g of PCA and 1000 mL of water) (Directorate for Standards, Metrology and Quality, 2007).

2.5 *Escherichia Coli (E. coli)*

Perform the same procedure as for determining total aerobic microorganisms, but replace the agar A medium with tryptone-glucuronide

broth (consisting of 20 g of casein from bovine milk, 3 mL of dimethyl sulfoxide, 1.5 g of bile salts, 144 μmol of 5-bromo-4-chloro-3-indolyl-β-D-glucuronide acid, 18 g of PCA and 1000 mL of water). Incubate the sample after inoculation at 44 °C (Directorate for Standards, Metrology and Quality, 2008).

2.6 *Bacillus cereus (B. cereus)*

Perform the same procedure as for determining total aerobic microorganisms, but replace the agar A medium with Mannitol Egg Yolk Polymyxin (MYP) agar. To prepare the MYP agar, mix 1 g of beef extract, 10 g of tryptone, 10 g of D-mannitol, 10 g of NaCl, 0.025 g of phenol red, 18 g of PCA and 90 mL of water. Add 1 mL of polymyxin B solution (consisting of 106 IU of polymyxin B sulfate and 100 mL of water) and 10 mL of egg yolk emulsion to the mixture (AOAC International, 1981).

2.7 *Clostridium perfringens (C. perfringens)*

Perform similarly to the method of determining total aerobic microorganisms. However, replace the agar A medium with the sunfit cycloserin (SC) medium made from a basic medium mixture (including 15 g, peptone from animal proteins, 5 g soy peptone, 5 g yeast extract, 1 g sodium disulfite, 1 g iron (III) ammonium citrate, 18 g PCA and 1000 mL water) and D-Xycloserin solution (including 4 g D-Xycloserin solution and 100 mL water) at a ratio of 10:1 (v v^{-1}) (Directorate for Standards, Metrology and Quality, 2005).

2.8 Total number of yeast and mold spores

Perform the same procedure as for determining total aerobic microorganisms. However, replace the agar medium A with the agar medium dicloran glycerol 18 % (DG 18) (consisting of 5 g casein from bovine milk, 10 g D-Glucoza, 1 g potassium dihydrogen phosphate, 0.5 g magnesium sulfate, 0.002 g dichloran (2,6-dichloro-4-nitroaniline), 220 g glycerol, 15 g PCA, 10 mL chloramphenicol solution 1 % (diluted in ethanol) and 1000 mL distilled water) (Directorate for Standards, Metrology and Quality, 2010).

2.9 Salmonella

Mixture B is prepared by diluting 25 g of the sample in 225 mL of peptone buffer (BPW) (containing 10 g peptone, 5 g NaCl, 9 g $Na_2HPO_4.12H_2O$, 1.5 g KH_2PO_4, and 1000 mL water) and incubating at 35 °C for 18 ± 2 h. To enhance growth in selective media, each 0.1 mL of mixture B is mixed with 10 mL of Rappaport-Vassiliadis soy broth (RVS) (containing 5 g peptone from glycine max (soybean), 8 g NaCl, 1.4 g KH_2PO_4, 0.2 g K_2HPO_4 and 1000 mL water), and then incubated at 41.5 °C for 24 ± 3 hours. Each 1 mL of the mixture is then mixed with 10 mL of Muller-Kauffmann tetrathionate/novobiocin broth (MKTTn) (containing 4.3 g meat extract, 8.6 g casein from bovine milk, 2.6 g NaCl, 38.7 g $CaCO_3$, 47.8 g $Na_2S_2O_3.5H_2O$, 4.78 g bovine bile, 9.6 g blue brilliant and 1000 mL water) and incubated at 37 °C for 24 ± 3 h. Each 10 μl of the inoculum in RVS and MKTTn broth is spread on the surface of xylose lysine deoxycholate (XLD) agar (containing 3 g yeast extract, 5 g NaCl, 3.75 g xylose, 7.5 g lactose, 7.5 g sucrose, 5 g L-lysine hydrochloride, 6.8 g sodium thiosulfate, 0.8 g ammonium iron (III) citrate, 0.08 g phenol red, 1 g sodium deoxycholate, 18 g PCA and 1000 mL water). The XLD plates are then inverted and incubated at 37 °C for 24 ± 3 hours (Directorate for Standards, Metrology and Quality, 2017).

2.10 Water activity (a_w)

The water activity determination is based on the principle of comparing the weight of a sample in a dry state to that when the sample is immersed in a high humidity environment. A water activity meter with touch screen (LabTouch-aw, Novasina AG, Lachen, Switzerland) is used to determine the water activity (Directorate for Standards, Metrology and Quality, 2009b). Each 3 g of sample is used for analysis, and the analysis process is carried out at 25 °C.

2.11 Moisture content

Determination of moisture content is based on the principle of the difference in moisture content between the initial sample and the dried sample. Each 5 g of sample is used for analysis and the moisture analyzer (MB120, Ohaus, Parsippany, NJ, USA) is used in the evaluation (Directorate for Standards, Metrology and Quality, 1990a).

2.12 Protein

Protein is determined based on the principle of inorganic conversion of the sample with concentrated sulfuric acid, whereby nitrogen in the sample is converted into ammonium sulfate. Alkaline is used to drive ammonia out of ammonium sulfate in a Kjeldahl flask, forming ammonium hydroxide, which is then quantified by acid titration.

The Kjeldahl flask contains a mixture of 0.5 g sample, 1 mL catalyst mixture ($CuSO_4$: K_2SO_4) (1 : 10 w w^{-1}) and 10 mL concentrated H_2SO_4. Inorganic conversion is performed until a clear solution is obtained. Then, 50 mL distilled water, 5 drops of 1 % phenolphthalein and 33 % sodium hydroxide solution are added until the solution in the flask turns pink. The mixture is continuously distilled for 40 minutes. Sodium hydroxide 0.1N is used to titrate the excess acid in the receiving flask until the solution in the flask changes from purple to green (Directorate for Standards, Metrology and Quality, 1990b). The blank sample is determined similarly, but without the participation of the analyte sample. Nitrogen content (X)% in food samples:

$$x(\%) = \frac{(V - Vo) \times C \times 14 \times 100}{m \times 1000} \quad (1)$$

$$\%CrudeProtein = X \times 6.25 \quad (2)$$

Where: V: Volume NaOH 0.1N used for sample titration (14mL); V_0: Volume NaOH 0.1N used for titration of blank sample (mL); C: Concentration of NaOH used for titration; and m: Sample weight used for analysis (g)

2.13 Total fat

The fat content in the sample is extracted using diethyl ether solvent by the Soxhlet system. The amount of fat is determined based on the difference in sample weight before and after the extraction process. Each 5 g of sample is used for analysis and the extraction is carried out at a temperature below 60 °C for 6 hours (Directorate for Standards, Metrology and Quality, 2009a).

$$\%Fat = \frac{m_2 - m_1}{m_1} \times 100 \quad (3)$$

Where: m_1 and m_2 are the sample weight before and after the Soxhlet extraction process (g), respectively.

2.14 Carbohydrate

Carbohydrate content is determined by subtracting the total of protein, fat, moisture and ash from the total weight of the sample (AOAC International, 2002).

2.15 Energy

Energy values need to be calculated using the following conversion factors (Directorate for Standards, Metrology and Quality, 2015b) Table 1.

Table 1: Conversion factors (kcal g^{-1}).

Nutrition	Conversion factor (kcal g^{-1})
Carbohydrate	4
Protein	4
Total fat	9
Ethanol	7
Organic acids	3

2.16 Total ash

The ash content is determined by weighing the remaining mass after ashing the sample at 525 °C ± 25 °C for 4 hours in a muffle furnace, and each 10 g of sample is used for analysis (TCVN 10691:2015, 2015).

2.17 Total sugar

Total sugar is extracted from the sample by hot water and then hydrolyzed into glucose by hydrochloric acid. Glucose content is determined by reactions with Fehling's solution, iron (III) sulfate and potassium permanganate. 20 g of the sample and 125 mL of water are boiled in a water bath at 80 °C for 15 minutes. 10 mL of 10 % lead acetate solution is added and shaken to precipitate protein. Then, 10 mL of saturated potassium oxalate solution is added and shaken to remove excess lead. The filtrate is collected and made up to 500 mL (V_1). 100 mL (V_2) of the filtrate and 15 mL of HCl are boiled on a water bath for 15 minutes. The mixture is neutralized with 30 % NaOH and made up to 250 mL (V_3). Each 25 mL (V) of sample is mixed with Fehling's A (dissolve 69.2 g of $CuSO_4$ and 10 mL of H_2SO_4 in 1000 mL of distilled water) and Fehling's B (dissolve 346 g of potassium sodium tartrate and 100 g of NaOH in 1000 mL of distilled water). The mixture is boiled for 3 minutes. The precipitate is filtered and dissolved in 20 mL of 5 % iron (III) sulfate solution. The solution is titrated with 0.1N potassium permanganate until the solution turns into a stable dark pink colour (Directorate for Standards, Metrology and Quality, 1988).
From the volume (mL) of 0.1N KMnO4 used, consult the Bertrand table to determine the corresponding amount of glucose (a). Calculate the sugar content (A) as a percentage using the formula:

$$A\% = \frac{a \times V_1 \times V_3 \times 100}{m \times V \times V_2 \times 1000} \quad (4)$$

Where: a: Mass of glucose (mg) corresponding to the volume of $KMnO_4$ consumed; V_1: Volume of the volumetric flask used for protein reduction (mL); V_2: Volume of the sample used for hydrolysis (mL); V_3: Volume of the volumetric flask containing sample solution after hydrolysis (mL); V: Volume of the sample solution taken for the Fehling reaction (mL); and m: Sample weight (g).

2.18 Crude fibre

Each 20 g of sample was used for the analysis. After grinding and removing the fat, the sample is boiled in sulfuric acid solution at a concentration of 0.255 ± 0.005 mol L^{-1}, followed by separation and washing of the insoluble residue. The remaining residue is then boiled with sodium hydroxide solution at a concentration of 0.313 ± 0.005 mol L^{-1}. This is followed by separation, washing, drying at 103 ± 20 °C for about 3 to 4 hours, ashing at 500 ± 25 °C for 1 hour and weighing the insoluble residue (Directorate for Standards, Metrology and Quality, 1990c).

$$Y(\%) = \frac{m_3 - m_1}{m_2 - m_1} \times 100 \quad (5)$$

Where: m_1: Weight of the empty crucible (g); m_2: Weight of the crucible containing the initial sample (g); and m_3: Weight of the crucible containing the sample after ashing (g).

2.19 Calcium (Ca)

The sample is ashed and cooled. Then, 10 mL of 3M HCl is added and left for 10 minutes, filtered, and made up to 100 mL with distilled water. 0.5M HCl is used to dilute the sample to a range of acceptable analysis for calcium. Atomic absorption spectrophotometer is used to determine calcium. Setting the main parameters: Wavelength: 422.7 nm; Slit width: 0.7 nm; Measuring peak height; Reading time: 3 seconds; Number of repetitions: 5 times; and Flame mode: C_2H_2; Flow rate, air/acetylene ratio (Air/C_2H_2 approximately 8/2)
Setting the standard curve parameters: Calcium standard solutions: 0; 1; 2; 4; 6; 8; and 10 mg L^{-1} (AOAC International, 1999).

2.20 Iron (Fe)

The sample is ashed with a gradual increase of temperature at a rate of less than 50 °C $hour^{-1}$ and then cooled. 5 mL of 6M HCl is added and evaporated to dryness. The residue is dissolved in 30 mL of 0.1N HNO_3. The sample is then measured using an atomic absorption spectrophotometer with flame AAS, and with the equation of the standard curve: y = 0.0996x + 0.0016 (R^2 = 0.9996).
Analytical conditions: Lamp current: 12.5 mA; Wavelength: 248.3; Slit: 0.2 nm; Burner height:

7.5 nm; Flame: Air-acetylene; Oxidant gas pressure: 160 kPa; and Fuel gas flow rate: 2.2 L min^{-1} (AOAC International, 1999).

2.21 Trans fat

Each 10 g sample is hydrolyzed with acid to extract the fatty acids. Pyrogallic acid is used to minimize the oxidative degradation of fatty acids during the analysis process. In this process, triundecanoin (C11:0) is used as an internal standard to measure the quality of the analysis process. After extracting the fatty acids, they are converted to esters and further processed into methyl esters of fatty acids (FAMES) using Boron trifluoride in methanol. The results are measured and quantified by gas chromatography (GC). C18:1 9trans, C18:2 9c12t, and C18:2 9t12c are identified as the most common trans isomers in the sample, while C18:3 tct, cct, ctc, and tcc 9,12,15 isomers are also found in some samples at lower ratios (AOAC International, 1996).

2.22 Calculation of recovery efficiency

The recovery efficiency of the stages was determined by the following formula:

$$H(\%) = \frac{S_1}{S_2} \times 100 \quad (6)$$

Where: S_1: Total weight of Sergestid shrimp before processing (kg); and S_2: Total weight of Sergestid shrimp after processing (kg).

2.23 Descriptive sensory evaluation method

The sensory evaluation method was conducted by 40 trained individuals in food sensory analysis (students, research staff and lecturers, aged between 22 - 40 years old). Samples were encoded and evaluated simultaneously in the sensory evaluation area with consistent external conditions. The samples were evaluated by describing the product through the following questions: What is the colour of the product? What is the structure of the product? How does the colour and structure differ between two production scales in the same stage? The results were summarized, synthesized, and then described in general about the colour and structure of the product.

2.24 Data analysis

Data in this study was stored, and calculations carried out, using microsoft excel software (Redmond, WA, USA). Each experiment was repeated 3 times (n = 3). IMB® SPSS® Statistics software version 25 was used to compare statistical analyzes at the 95 % confidence level (TurkeyHSD^{a,b}).

3 Results and Discussion

3.1 Effect of the production scale on the recovery efficiency of dried Sergestid shrimp

Laboratory- and commercial-scale production has been carried out in five stages (Table 2). Statistically significant differences in product recovery efficiency at the production stages of the two production scales are shown in Table 2 ($p < 0.05$). On the laboratory scale, 7 kg of fresh and clean Sergestid shrimps, which had been pretreated to remove impurities, was used for blanching. After the washing process, the total weight of the material was reduced by 18.58 % due to the removal of small impurities and small Sergestid shrimp particles. The significant presence of impurities after shrimp harvesting was previously reported (Liu et al., 2016). On the laboratory scale, the total quantity of materials is small and is handled manually by dividing the Sergestid shrimp weight for inspection. Impurities were easily detected and removed. Sergestid shrimps, which are large, uniform and unbroken, were selected. The process of absorbing water into the mass on a laboratory scale was negligible because the material was broken down into small blocks for washing. After removal from the washing water tank, the water contained in the small block of material was easily and quickly drained out. The Van der Waals law explains

Table 2: The difference in recovery efficiency between the stages of production of dried Sergestid shrimp at laboratory scale and commercial scale.

Stage	Laboratory scale				Commercial scale			
Raw materials	Conditions -	H (%) -	Weight (kg) 7.00 ± 0.22	Method -	Conditions -	H (%) -	Weight (kg) 160.00 ± 2.10	Method -
Washing (1)	Water (l) : Materials (kg) = 2:1 Number of washes: 2 Level of water absorption: 0 % Total time: 60 minutes	81.42 ± 1.28Bb	5.70 ± 0.09	- Handmade - Raw materials were washed with water tank.	Water (kg) : Materials (kg) = 2:1 Number of washes: 2 Level of water absorption: 10 % Total time: 60 minutes	110.00 ± 0.69Aa	176.00 ± 3.41	Conveyor washing machine capacity 160 (kg hour-1)
Blanching (2)	Salt 4 % Time: 2 minutes Temperature: 70 ± 2 °C Level of water absorption: 0 % Total time: 60 minutes	83.32 ± 0.79Bb	4.75 ± 0.12	- Handmade - Materials were divided into many small blocks of Sergestid shrimp to perform blanching	Salt 4 % Time: 2 minutes Temperature: 70 ± 2 °C Level of water absorption: 10 % Total time: 60 minutes	110.00 ± 0.26Aa	193.60 ± 4.21	Blanching equipment capacity 180 (kg hour-1)
Drying -3	Temperature: 70 ± 2 °C Time: 56.67 minutes	25.98 ± 0.61Ca	1.23 ± 0.06	Convection drying cabinet	Temperature: 85 ± 5 °C Total time: 45 minutes	15.25 ± 0.67Db	29.52 ± 1.93	Conveyor drying equipment capacity 200 (kg 45 minutes-1)
Filtering (4)	Normal	96.8 ± 2.29Aa	1.19 ± 0.03	Handmade	Total time: 30 minutes	89.92 ± 0.60Cb	26.55 ± 1.56	Screening equipment capacity 60 (kg hour-1)
Packaging (5)	Normal	95.2 ± 0.36Aa	1.14 ± 0.03	Handmade	Total time: 60 minutes	94.98 ± 0.31Ba	25.22 ± 1.40	Packing equipment capacity 30 (kg hour-1)

Noted: The results are expressed as mean ± standard deviation and the (n = 3) number of replicates in each experimental parameter determined. a, b indicates statistically significant differences between 2 production scales in the same period, and A, B indicates statistically significant differences between processing stages at the same production scale.

this by the increase in the interaction force between two or more materials when the contact space between them is reduced, and the time for them to separate is increased (Margenau, 1939). Therefore, the results showed that the mass after washing was lower on a laboratory scale than on a commercial scale. In contrast, on a commercial scale, about 160 kg of material is washed with the help of continuous conveyor washing equipment. Dried plants, rocks and other seafood have been removed.

However, whole materials of all sizes were retained during this stage because of the difficulty of manual sorting in large quantities, and reported as fresh Sergestid shrimp after death, easy denaturation of proteins and microbial invasion (Ge et al., 2020).

The implementation of manual sorting in large quantities will affect the quality of Sergestid shrimps and negatively affect the economic efficiency of the enterprise due to the prolonged time of material sorting. The effect of extended pre-processing time on protein denaturation in seafood is similarly reported (Cartagena et al., 2021). The production process must be continuous, leading to increased labour costs. The washing process has been fixed for a maximum time of 60 minutes for both production scales to avoid affecting the quality of raw materials and to optimise economic efficiency for businesses. After washing the material on a commercial scale, the weight of the material was significantly increased by 1.1 times compared to the material before washing. This increase is due to the large absorption of water into the total material. The drainage in the raw material is low due to the interference of many interwoven Sergestid shrimp layers (Margenau, 1939). After this period, the shrimp recovery efficiency reached 110 %, corresponding to 193.6 kg of Sergestid shrimp. Furthermore, both production scales used twice as much rinsing water compared to the weight of the material (2:1), and the same was repeated twice to remove enough impurities on the surface of Sergestid shrimps.

The recovery efficiency of the Sergestid shrimps during blanching at both production scales had a similar change to that of the washing process. However, on the laboratory scale, the recovery efficiency was higher after blanching than after washing, which achieved 83.32 % corresponding to a reduction of 0.95 kg of material. A previous report indicated that the blanching process resulted in a reduction of protein, crude fat and ash content in seafood, particularly due to significant water loss (Omodara & Olaniyan, 2012). The blanching process, with the effect of temperature, increased the swelling rate. The muscles of Sergestid shrimp were stretched (Shi et al., 2019) and some proteins were denatured (Ge et al., 2020), affecting the contraction of muscle fibers and the meat tissue, and resulting in loss of elasticity or breakage of muscle fibers (Binsi et al., 2014; Shi et al., 2019). This increased the water storage and drainage space in Sergestid shrimp. The degree of attraction of free water in the material to the environment increases at the end of the blanching process. On the other hand, in laboratory-scale production, the material has been broken down into small blocks to perform the blanching process. This further increases the level of water loss in the material because the material layers are not thick enough to store water inside the block material (Margenau, 1939).

For commercial scale, large groups of Sergestid shrimp have been involved in the blanching process, where the amount of water in the material has increased due to the absorption of water inside the Sergestid shrimp and the retention of water in the group of Sergestid shrimp large (Margenau, 1939). Recovery efficiency after blanching on a commercial scale increased by 1.1 times compared to washing, which reached 110 % corresponding to 193.6 kg of Sergestid shrimp. The drying process of Sergestid shrimp at both production scales, to reach a moisture content of 18 - 20 %, showed a large difference in recovery efficiency. The drying equipment was upgraded from a batch tray convection dryer to a continuous conveyor convection dryer, which affected the recovery efficiency of the Sergestid shrimp.

During the drying process on the laboratory scale, the released amount of water in the material was lower than in the commercial drying process. Therefore, the moisture content of the Sergestid shrimps on a laboratory scale is also significantly lower. The practice of drying to remove the water of the material to the same moisture content resulted in more mass loss in commercial than laboratory scale drying. There-

fore, the commercial scale recovery efficiency of 15.25 % is 10.73 % lower than that of the laboratory scale. However, in the drying process by conveyor drying equipment, Sergestid shrimps were moved by the impact of the conveyor belt's movement, which caused a significant loss of total weight when Sergestid shrimps dropped off the conveyor belt while in motion. On a commercial scale, drying at 85 ± 5 °C showed no major difference in organoleptic colour when compared with drying at 70 ± 2 °C. However, the drying time on a commercial scale was shortened by about 15 minutes. This may be due to differences in the movement of the drying tray and drying temperature (Dao et al., 2022; Topuz et al., 2009; Vu et al., 2022). The filter process classifies the size of the dried Sergestid shrimps to remove broken Sergestid shrimps. During the drying process, the movement of the conveyor belt had a physical impact on Sergestid shrimps, resulting in the beards and legs of a number Sergestid shrimps being broken. This results in a lower recovery efficiency of the filtration process at the commercial scale (89.92 %) compared to the laboratory scale (96.8 %). The packaging process was carried out manually for the laboratory scale and semi-automatically for the commercial scale. Both production scales had Sergestid shrimp losses, with a total weight loss ranging from 5 to 6 %. The recovery efficiency of the whole process was not significantly different between the laboratory scale (16.29 %) and the commercial scale (15.76 %). A recovery efficiency of 14.13 ± 0.17 % for small shrimps (Acetes), after drying at 80 °C, was similarly reported (Tran et al., 2022).

3.2 The colour of the Sergestid shrimps in both laboratory and commercial scale production

Fresh Sergestid shrimps were used in the production of dried Sergestid shrimps on a commercial and laboratory scale, which were harvested from the Ben Tre province. Standard fresh Sergestid shrimps have a white colour covering the whole body and a tail which is light pink (Vereshchaka et al., 2016). On both production scales, the washing process made Sergestid shrimps slightly opaque but they still retained their characteristic white colour. As a result of the long processing time, after Sergestid shrimps die, the process of protein breakdown (autolysis) in their bodies begins (Huang et al., 2021). In this process, enzymes in the Sergestid shrimps' bodies start to break down their protein networks, leading to the breakdown and dispersal of proteins, which changes the original colour and transparency of the Sergestid shrimps. During autolysis, the Sergestid shrimps' cells are also broken down, causing water and other substances to leak out of the cells. This leakage contributes to the Sergestid shrimps becoming more opaque. Furthermore, when Sergestid shrimps die, they no longer have the mechanism to maintain the transparency of their outer shell. Therefore, the loss of the original colour is also a contributing factor to the opacity of the Sergestid shrimps (Gokoglu, 2021). Evaluation of the colour difference between the two production scales in the washing process did not find a significant difference. After the blanching process, Sergestid shrimps are ivory-grey and opaque, and the muscles of Sergestid shrimp become softer and easily crushed or broken (Fernandez-Segovia et al., 2003; Gavahian et al., 2019). Significant differences in the colour of Sergestid shrimps at the two production scales were not found. After the drying process, the Sergestid shrimps produced on a laboratory scale were much broken and the colour tended to turn more orange than on a commercial scale. This may be due to the influence of the conveyor drying device, which helps the material to be moved all the way in the drying chamber, with the heat source acting evenly on all the materials to be dried. A previous report on dried Acetes showed a similar colour at the laboratory scale (Lu et al., 2011). After filtration at both production scales, parts such as antennae, legs and small fragments of Sergestid shrimps were removed. The colour was not affected by filtration at the production scale (Figure 2). Finally, Sergestid shrimps were vacuum sealed and labeled.

Stage	Laboratory scale	Description	Commercial scale	Description
Raw Materials		Fresh Sergestid shrimps have a white color covering the whole body, and the tail is light pink		Fresh Sergestid shrimps have a white color covering the whole body, and the tail is light pink
Washing		Slightly opaque but still retains their characteristic white colour		Slightly opaque but still retains their characteristic white colour
Blanching		Ivory-grey and opaque, and the muscles of Sergestid shrimp become softer and easily crushed or broken		Ivory-grey and opaque, and the muscles of Sergestid shrimp become softer and easily crushed or broken
Drying		Dark orange color, uniform color, few light streaks, many crumbs, small-sized crumbs cling to Sergestid shrimps		The color is light orange, the color is uneven, there are white streaks on the product, few crumbs.
Filtering		The color is similar to the product after the drying process. The are less crumbs of Sergestid shrimps.		The color is similar to the product after the drying process. The crumbs of Sergestid shrimps are few.
Packaging				

Figure 2: The difference in appearance of Sergestid shrimp through the processing stages at two production scales

Table 3: The quality of dried Sergestid shrimp products as tested according to Vietnamese standards

No.	Evaluation criteria	Results	Units
1	Total aerobic microorganisms	8.8×10^2	CFU g^{-1}
2	*Coliforms*	Not Detected (LOD=10)	CFU g^{-1}
3	*E. coli*	Not Detected (LOD=10)	CFU g^{-1}
4	*B. cereus*	Not Detected (LOD=10)	CFU g^{-1}
5	*C. perfringens*	Not Detected (LOD=10)	CFU g^{-1}
6	Total number of yeast and mold spores	Not Detected (LOD=10)	CFU g^{-1}
7	*Salmonella*	Not Detected	CFU 25 g^{-1}
8	Water activity (25^{o}C)	0.6260 ± 0.002	-
9	Moisture	20.80 ± 0.21	%
10	Protein	55.50 ± 0.33	%
11	Total fat	3.76 ± 0.04	%
12	Carbohydrate	Not Detected (LOD=0.1)	%
13	Energy	256 ± 5	kcal 100 g^{-1}
14	Total ash	15.60 ± 0.13	%
15	Total sugar	Not Detected (LOD=0.33)	%
16	Crude fibre	3.31 ± 0.17	%
17	Calcium (Ca)	3 366 ± 56	mg kg^{-1}
18	Iron (Fe)	20.70 ± 0.12	mg kg^{-1}
19	Trans fat	Not Detected (LOD=0.005)	g 100 g^{-1}

Noted: The results are expressed as mean ± standard deviation and the (n = 3) number of replicates in each experimental parameter determined.

3.3 Quality inspection of dried Sergestid shrimp products according to Vietnamese standards

The results of the nutritional quality and microbial content tests in the dried Sergestid shrimp products according to Vietnamese standards are shown in Table 3. Nineteen important criteria were evaluated according to the regulations set out in the Vietnamese standards. Microorganisms such as *Coliforms, E. coli, B. cereus, C. perfringens and Salmonella*, and the total number of yeast and mold spores, were not detected in the dried samples (LOD = 10 CFU g^{-1}). A regulation on the level of *Coliforms* in food requires it to be less than 10 CFU mL^{-1} to ensure food safety (Martin et al., 2016). According to the standards of the US Food and Drug Administration (FDA), the maximum allowed level of E. coli in seafood is 230 CFU g^{-1} (Colony Forming Unit $gram^{-1}$) (United States Public Health Service, 2017). According to Vietnamese standards and Codex Alimentarius, the allowable levels of *B. cereus* and *C. perfringens* in food are not more than 10^5 CFU g^{-1} and 103 CFU g^{-1}, respectively (CODEX STAN 234-1999). Total aerobic microorganisms were found to be 8.8×10^2 (CFU g^{-1}), which is lower than the total number of anaerobic bacteria in previous dried seafood samples (5×105 CFU g^{-1}) (Bandara et al., 2019).

Several nutritional parameters, such as carbohydrates, total sugar and trans-fat, were not found. The water activity (25 °C) and the moisture content are 0.6260 and 20.8 %, respectively. Some reports have indicated that water activity levels from 0.52 to 0.64 may limit the growth of microorganisms in food environments (Habib et al., 2014). The indicators of protein, total fat, energy, total ash, crude fibre, calcium and iron are shown in Table 3. A report on Acetes species at Versova, which shares similar properties with Sergestid shrimps, revealed quite similar physic-

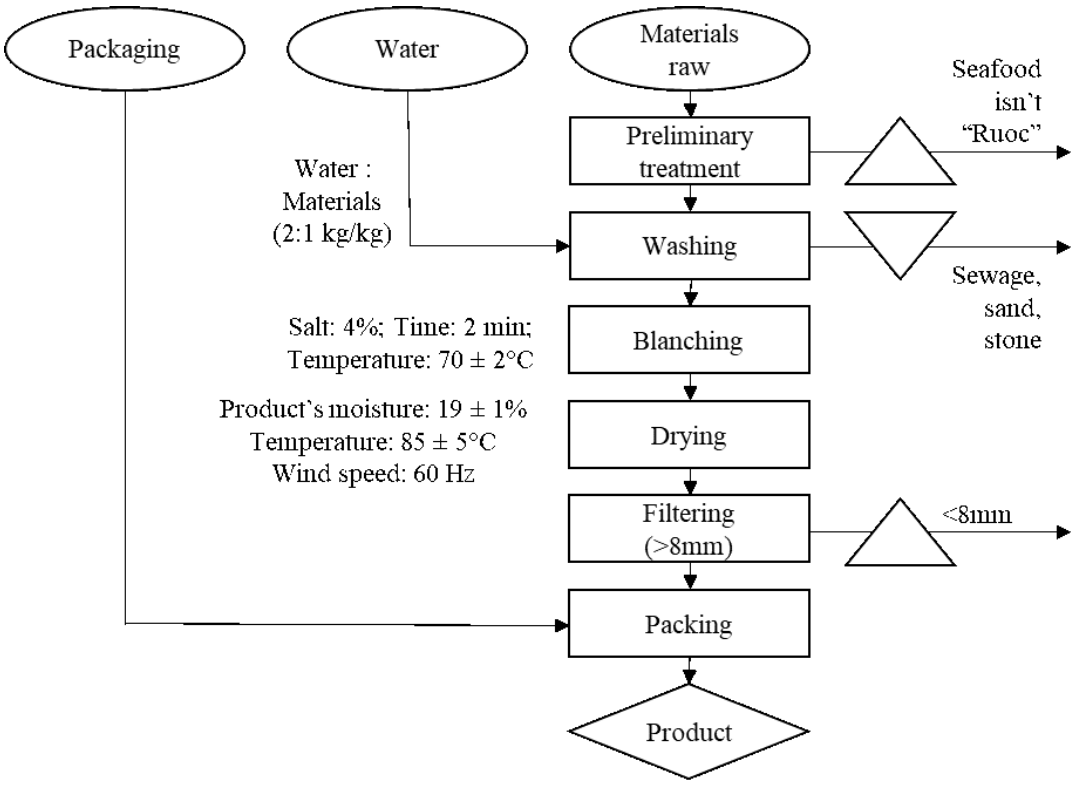

Figure 3: Technological process for commercial production of dried Sergestid shrimp (160 kg).

ochemical values to the results of this study. The moisture content after the drying process was 15.55 %, and the content of protein, ash and fat were 63.76 %, 13.62 % and 6.03 %, respectively (Keer et al., 2018). This difference may be due to variations in their natural habitats, growth conditions, and differences in family but belonging to the same genus (Fry et al., 2016). The results of the food safety quality assessment according to Vietnamese standards were within the maximum allowable number of microorganisms in the food specified. At the same time, the results also indicate the main nutrient content of the product, which is produced on a commercial scale.

3.4 Commercial scale production of dried Sergestid shrimp

Impurities associated with the harvesting process (fish, crab, hay, stone particles...) were manually removed after the Sergestid shrimps were transported to the factory. The technological process of commercial production is shown in Figure 3. The fresh Sergestid shrimps, after the removal of impurities, were washed with water. A ratio of water (kg): Sergestid shrimp (kg) of 2:1) was used to maintain economic efficiency, by limiting wastewater treatment, whilst removing most of the impurities present on the material. The fresh Sergestid shrimps were added to the tank and stabilised for 30 seconds. The air valve system was located at the bottom of the tank to conduct aeration of the mix of materials. The washing process was repeated 2 times to remove the maximum impurities that have adhered to the material. The blanching process is intended to remove some microorganisms present on the Sergestid shrimps (Fellows, 2022). At the same time, rapid cooking minimises the change in nutrients and the chemical composition of the mate-

rial due to the reduction of harmful microorganisms and chemical changes in Sergestid shrimps (Fellows, 2022). The washed Sergestid shrimps were blanched with water at 70 ± 2 °C, and the concentration of the saline solution was 4 % for 2 minutes with a water: material ratio of 2:1. Zavadlav et al. (2020) reported the preprocessing of seafood through a blanching process at 70 °C for 2 minutes, (and the addition of 5 % salt to the blanching process was reported to help maintain the colour of shrimp after drying (Cyprian et al., 2017). The material was quickly removed and drained by high-speed air blowing, to remove blanching water, and thereby reduce drying time. Then, it was placed on the highest floor dynamic conveyor, with a drying layer thickness of 1-1.5 cm. After blanching, materials are soft and easy to break (Fernandez-Segovia et al., 2003; Gavahian et al., 2019) so continuous drying equipment should be designed in conjunction with the appropriate blanching equipment to limit losses. Floor drying equipment, with a continuous motion conveyor, accelerates moisture drainage of the fly and limits adhesion. Convection drying is carried out at a temperature of approximately 80 - 90 °C (Sappati et al., 2017). The drying time depends heavily on the quantity of input materials for each batch and the desired moisture content of 18-20 % for stoppage of the drying process. Adeyeye et al. (2017) reported a fish drying process that reduced the final moisture content to 15-18 %. After drying, the sorting process selected Sergestid shrimps with a size > 8mm. Then, the Sergestid shrimps were cooled to room temperature, weighed and placed in vacuum bags, with a weight of 100 - 500 g depending on the order. Cooling before packaging helps to prevent moisture condensation inside the packaging, as moisture separation will still occur when the material is hot and thus affect the shelf life (Ergun et al., 2010). A single-chamber vacuum device was used. The packages were then labelled with product information and stored at a temperature of 5 - 10 °C. A kinetic study of the dried shrimp preservation process (10 °C) reduced the degradation of astaxanthin and colour (Niamnuy et al., 2008).

4 Conclusions

This study successfully evaluated the difference in recovery efficiency between laboratory-scale and commercial-scale production of dried Sergestid shrimp during processing stages. A proposed processing procedure for 160 kg of dried Sergestid shrimp (commercial scale) was developed with processing parameters and equipment specified. The commercial scale dried Sergestid shrimp (160 kg) met the food safety and hygiene requirements according to the Vietnamese standards (for microbial and heavy metal content in food). Nutritional values such as energy, protein, ash, fat, fiber, calcium and iron were evaluated. The product was suitable for use as a food for humans, and had an acceptable flavour and guaranteed quality. However, the 160 kg production scale is only suitable for processing at small and medium-sized facilities. With increasing consumer demand, there is a need for upgrading to larger production scales. Upgrading the production scale requires strict process control to minimize the occurrence of heavy metals and microbes during processing. The processing losses at the commercial scale are greater than those at the laboratory scale. However, these losses are not significant because the parameters have been adjusted to minimize the reduction in recovery efficiency. The research results help enhance knowledge about the process of producing dried Sergestid shrimp at a 160 kg scale. The issues causing material losses have been analysed, and provide a basis for optimising the production process, and thus improving the recovery efficiency of dried Sergestid shrimp. The commercial scale parameters have been adjusted to achieve recovery efficiency equivalent to ideal laboratory production conditions, which is the basis for protecting the product's economic value. At the same time, it provides consumers with a product produced at a commercial-scale, which ensures food safety and hygiene.

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References

Adeyeye, S. A. O., Oyewole, O. B., Obadina, O. A., Omemu, A. M., Adeniran, O. E., Oyedele, H. A., Olugbile, A., & Omoniyi, S. A. (2017). Effect of smoking methods on quality and safety of traditional smoked fish from Lagos state, Nigeria. *Journal of Culinary Science and Technology*, *15*(1), 17–35. https://doi.org/10.1080/15428052.2016.1185072

Alkandari, S., Al-Hassawi, F., Aldughpassi, A., Sidhu, J. S., Al-Amiri, H. A., Al-Othman, A., Ahmed, N., & Ahmad, A. (2021). Pilot scale production of functional foods using red palm olein: Antioxidant, vitamins' stability and sensory quality during storage. *Saudi Journal of Biological Sciences*, *28*(10), 5547–5554. https://doi.org/10.1016/j.sjbs.2021.06.032

AOAC International. (1981). AOAC 980.31-1981: Bacillus cereus in foods. Enumeration and confirmation microbiological methods. In *AOAC Official Methods* (p. 20).

AOAC International. (1996). AOAC 968.08-1969: Minerals in animal feed and pet food. Atomic absorption spectrophotometric method. In *AOAC Official Methods* (p. 19).

AOAC International. (1999). AOAC 999.11: Determination of lead, cadmium, copper, iron, and zinc in foods. Atomic absorption spectrophotometry after dry ashing. In *AOAC Official Methods* (p. 3).

AOAC International. (2002). AOAC 986.25-1988: Proximate analysis of milk-based infant formula. In *AOAC Official Methods* (p. 2).

Bandara, G. M. W. R., Hewage, H. S., & Arampath, P. C. (2019). Development of high nutritious fish powder mixture using Chirocentrus dorab, Selaroides leptolepis and Stolephorus indicus for bakery industry. *Journal of Food and Agriculture*, *12*(1), 29–39. https://doi.org/10.4038/jfa.v12i1.5218

Binsi, P. K., Ninan, G., Zynudheen, A. A., Neethu, R., Ronda, V., & Ravishankar, C. N. (2014). Compositional and chill storage characteristics of microwave-blanched sutchi catfish (Pangasianodon hypophthalmus) fillets. *International Journal of Food Science and Technology*, *49*(2), 364–372. https://doi.org/10.1111/ijfs.12308

Campbell, G. M., Ross, M., & Motoi, L. (2008). Expansion capacity of bran-enriched doughs in different scales of laboratory mixers. In G. M. Campbell, M. G. Scanlon, & D. L. Pyle (Eds.), *Bubbles in food 2: Novelty, health and luxury* (pp. 323–336). Elsevier. https://doi.org/10.1016/B978-1-891127-59-5.50036-5

Cartagena, L., Puertolas, E., & Martinez De Maranon, I. (2021). High-pressure pretreatment in albacore (Thunnus alalunga) for reducing freeze-driven weight losses with minimal quality changes. *Journal of the Science of Food and Agriculture*, *101*(7), 2704–2711. https://doi.org/10.1002/jsfa.10895

Cyprian, O. O., Nguyen, M. V., Sveinsdottir, K., Tomasson, T., Thorkelsson, G., & Arason, S. (2017). Influence of blanching treatment and drying methods on the drying characteristics and quality changes of dried sardine (Sardinella gibbosa) during storage. *Drying Technology*, *35*(4), 478–489. https://doi.org/10.1080/07373937.2016.1187161

Dao, T. P., Vu, D. N., Nguyen, D. V., Pham, V. T., & Tran, T. Y. N. (2022). Study of jelly drying cashew apples (Anacardium occidentale L.) processing. *Food Science and Nutrition*, *10*(2), 363–373. https://doi.org/10.1002/fsn3.2565

Deshmukh, V. D. (1991). Utilisation of paste shrimp Acetes: A review [Publisher: CMFRI; Kochi]. *Marine Fisheries Information Service, Technical and Extension Series*, *110*, 7–8. Retrieved October 25, 2023, from http://eprints.cmfri.org.in/2910/

Directorate for Standards, Metrology and Quality. (1988). TCVN 4594 : 1988: Canned foods - Determination of total sugar and starch content. TCVN.

Directorate for Standards, Metrology and Quality. (1990a). TCVN 3700:1990: Aquatic products - method for the determination of moisture content. TCVN.

Directorate for Standards, Metrology and Quality. (1990b). TCVN 3705:1990: Method for determination of total nitrogen and protein contents. TCVN.

Directorate for Standards, Metrology and Quality. (1990c). TCVN 5103 : 1990: Agricultural food products - Determination of crude fibre content. General method. TCVN.

Directorate for Standards, Metrology and Quality. (2005). TCVN 4991:2005 (ISO 7937:2004): Microbiology of food and animal feeding stuffs - horizontal method for the enumeration of Clostridium perfringens - colony count technique. TCVN.

Directorate for Standards, Metrology and Quality. (2007). TCVN 6848:2007 (ISO 4832:2007): Microbiology of food and animal feeding stuffs - horizontal method for the enumeration of coliforms - colony-count technique. TCVN.

Directorate for Standards, Metrology and Quality. (2008). TCVN 7924-2:2008 (ISO 16649-2:2001): Microbiology of food and animal feeding stuffs - horizontal method for the enymeration of B-glucuronidase-positive Escherichia coli. TCVN.

Directorate for Standards, Metrology and Quality. (2009a). TCVN 3703 :2009: Fish and fishery products - determination of fat content. TCVN.

Directorate for Standards, Metrology and Quality. (2009b). TCVN 8130:2009 (ISO 21807:2004): Microbiology of food and animal feeding stuffs - determination of water activity. TCVN.

Directorate for Standards, Metrology and Quality. (2015a). TCVN 4884-1:2015 (ISO 4833-1:2013): Microbiology of the food chain - horizontal method for the enumeration of microorganisms. TCVN.

Directorate for Standards, Metrology and Quality. (2015b). TCVN 7088 : 2015: Guidelines on nutrition labelling. TCVN.

Directorate for Standards, Metrology and Quality. (2017). TCVN 10780-1:2017 (ISO 6579-1:2017): Microbiology of the food chain - horizontal method for the detection, enumeration and serotyping of Salmonella. TCVN.

Ergun, R., Lietha, R., & Hartel, R. W. (2010). Moisture and shelf life in sugar confections. *Critical Reviews in Food Science and Nutrition*, *50*(2), 162–192. https://doi.org/10.1080/10408390802248833

Fellows, P. J. (2022). Blanching. In P. J. Fellows (Ed.), *Food Processing Technology* (5th ed., pp. 317–326). Elsevier. https://doi.org/10.1016/B978-0-323-85737-6.00009-1

Fernandez-Segovia, I., Camacho, M. M., Martinez-Navarrete, N., Escriche, I., & Chiralt, A. (2003). Structure and color changes due to thermal treatments in desalted cod. *Journal of Food Processing and Preservation*, *27*(6), 465–474. https://doi.org/10.1111/j.1745-4549.2003.tb00530.x

Fry, J. P., Love, D. C., MacDonald, G. K., West, P. C., Engstrom, P. M., Nachman, K. E., & Lawrence, R. S. (2016). Environmental health impacts of feeding crops to farmed fish. *Environment International*, *91*, 201–214. https://doi.org/10.1016/j.envint.2016.02.022

Gavahian, M., Tiwari, B. K., Chu, Y.-H., Ting, Y., & Farahnaky, A. (2019). Food texture as affected by ohmic heating: Mechanisms involved, recent findings, benefits, and limitations. *Trends in Food Science and Technology*, *86*, 328–339. https://doi.org/10.1016/j.tifs.2019.02.022

Ge, Y., Li, Y., Wu, T., Bai, Y., Yuan, C., Chen, S., Gakushi, I., & Hu, Y. (2020). The preservation effect of CGA-Gel combined with partial freezing on sword prawn (Parapenaeopsis hardwickii). *Food Chemistry*, *313*, Article 126078. https://doi.org/10.1016/j.foodchem.2019.126078

Gokoglu, N. (2021). Crustacean Shellfish. In N. Gokoglu (Ed.), *Shellfish Processing and Preservation* (pp. 7–127). Springer. https://doi.org/10.1007/978-3-030-60303-8_2

Habib, H. M., Al Meqbali, F. T., Kamal, H., Souka, U. D., & Ibrahim, W. H. (2014). Physicochemical and biochemical properties of honeys from arid regions. *Food Chemistry*, *153*, 35–43. https://doi.org/10.1016/j.foodchem.2013.12.048

Huang, X., Xiong, G., Chen, X., Liu, R., Li, M., Ji, L., Zhang, X., Geng, Y., Ou, Y., Chen, D., Yin, L., Li, L., & Yang, S. (2021). Autolysis in crustacean tissues after death: A case study using the Procambarus clarkii Hepatopancreas (R. Chaturvedi, Ed.). *BioMed Research International*, *2021*, 1–8. https://doi.org/10.1155/2021/2345878

Keer, U., Alim, H., Xavier, M., & Balange, A. K. (2018). Quality changes during ice storage of Acetes species. *International Journal of Current Microbiology and Applied Sciences*, *7*(1), 2063–2071. https://doi.org/10.20546/ijcmas.2018.701.248

Kozák, Á., Bánvölgyi, S., Vincze, I., Kiss, I., Békássy-Molnár, E., & Vatai, G. (2008). Comparison of integrated large scale and laboratory scale membrane processes for the production of black currant juice concentrate. *Chemical Engineering and Processing: Process Intensification*, *47*(7), 1171–1177. https://doi.org/10.1016/j.cep.2007.12.006

Liu, Z., Cheng, F., & Hong, H. (2016). Identification of impurities in fresh shrimp using improved majority scheme-based classifier. *Food Analytical Methods*, *9*(11), 3133–3142. https://doi.org/10.1007/s12161-016-0497-3

Lu, F., Zhang, J.-Y., Liu, S.-L., Wang, Y., & Ding, Y.-T. (2011). Chemical, microbiological and sensory changes of dried Acetes chinensis during accelerated storage. *Food Chemistry*, *127*(1), 159–168. https://doi.org/10.1016/j.foodchem.2010.12.120

Margenau, H. (1939). Van der waals forces. *Reviews of Modern Physics*, *11*(1), 1–35. https://doi.org/10.1103/RevModPhys.11.1

Martin, N. H., Trmčić, A., Hsieh, T.-H., Boor, K. J., & Wiedmann, M. (2016). The evolving role of coliforms as indicators of unhygienic processing conditions in dairy foods. *Frontiers in Microbiology*, *7*, Article 1549. https://doi.org/10.3389/fmicb.2016.01549

Niamnuy, C., Devahastin, S., Soponronnarit, S., & Raghavan, G. S. V. (2008). Kinetics of astaxanthin degradation and color changes of dried shrimp during storage. *Journal of Food Engineering*, *87*(4), 591–600. https://doi.org/10.1016/j.jfoodeng.2008.01.013

Omodara, M. A., & Olaniyan, A. M. (2012). Effects of pre-treatments and drying temperatures on drying rate and quality of african catfish (Clarias gariepinus). *Journal of Biology, Agriculture and Healthcare*, *2*(4), 1–10. Retrieved October 25, 2023, from https://www.iiste.org/Journals/index.php/JBAH/article/view/1728

Sappati, P. K., Nayak, B., & Walsum, G. P. v. (2017). Effect of glass transition on the shrinkage of sugar kelp (Saccharina latissima) during hot air convective drying. *Journal of Food Engineering*, *210*, 50–61. https://doi.org/10.1016/j.jfoodeng.2017.04.018

Shi, H., Zhang, M., & Yang, C. (2019). Effect of low-temperature vacuum frying assisted by microwave on the property of fish fillets (Aristichthys nobilis). *Journal of Food Process Engineering*, *42*(4), e13050. https://doi.org/10.1111/jfpe.13050

Topuz, A., Feng, H., & Kushad, M. (2009). The effect of drying method and storage on color characteristics of paprika. *LWT - Food Science and Technology*, *42*(10), 1667–1673. https://doi.org/10.1016/j.lwt.2009.05.014

Tran, T. Y. N., Nguyen, N. L., Nguyen, T. N. A., Le, D. T., Phan, D. A., Tran, T. T., & Dao, T. P. (2022). Effectsof blanching

and drying condition on the quality of small shrimp (Acetes) [Publisher: Hindawi]. *Journal of Food Quality*, *2022*, Article e3996787. https://doi.org/10.1155/2022/3996787

United States Public Health Service. (2017). *Food code 2017: Recommendations of the United States public health service food and drug administration* (tech. rep.). US Food and Drug Administration. College Park. https://www.fda.gov/food/fda-food-code/food-code-2017

Vereshchaka, A. L., Lunina, A. A., & Olesen, J. (2016). Phylogeny and classification of the shrimp genera Acetes, Peisos, and Sicyonella (Sergestidae: Crustacea: Decapoda). *Zoological Journal of the Linnean Society*, *177*(2), 353–377. https://doi.org/10.1111/zoj.12371

Vu, N. D., Tran, N. T. Y., Le, T. D., Phan, N. T. M., Doan, P. L. A., Huynh, L. B., & Dao, P. T. (2022). Kinetic model of moisture loss and polyphenol degradation during heat pump drying of soursop fruit (Annona muricata L.) [Number: 10 Publisher: Multidisciplinary Digital Publishing Institute]. *Processes*, *10*(10), Article 2082. https://doi.org/10.3390/pr10102082

Xin, Y., Zhang, M., Xu, B., Adhikari, B., & Sun, J. (2015). Research trends in selected blanching pretreatments and quick freezing technologies as applied in fruits and vegetables: A review. *International Journal of Refrigeration*, *57*, 11–25. https://doi.org/10.1016/j.ijrefrig.2015.04.015

Zavadlav, S., Blažić, M., Velde, F. v. d., Vignatti, C., Fenoglio, C., Piagentini, A. M., Pirovani, M. E., Perotti, C. M., Bursać Kovačević, D., & Putnik, P. (2020). Sous-vide as a technique for preparing healthy and high-quality vegetable and seafood products [Number: 11 Publisher: Multidisciplinary Digital Publishing Institute]. *Foods*, *9*(11), Article 1537. https://doi.org/10.3390/foods9111537