

# Effects of Some Technological Parameters in Vacuum Frying on the Quality of Pangasius Snack (*Pangasiidae*)

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**Abstract** – Basic parameters in technological process of pangasius snack processing by vacuum frying technique were studied including frozen pre-processing treatment, frying temperature, frying pressure and frying time. The studying experiments were carried out including: (i) Study on effect of frozen temperatures in the center of pangasius pieces (-10; -20; -30°C) before frying; (ii) Study on effect of frying temperature (100; 110; 120; 130°C); (iii) Study on effect of vacuum frying pressure (200; 400; 600mmHg); and (iv) Study on effect frying time (15, 20 and 25 min). The initial results showed that pangasius pieces were fried in industrial frying oil at temperature of 120°C, frying pressure was 400 mmHg, frying time was 20 min having the physical-mechanical properties expressed as hardness, crispy and spongy, as well as sensory qualities were the best.

**Keywords** – Vacuum Frying, Pangasius, Snack, Hardness, Crispiness, Sponginess.

## I. INTRODUCTION

According to the General Statistics Office of Vietnam and Vietnam Association of Seafood Exporters and Producers [7], [18], in 2019, the total area of pangasius in the Mekong Delta was estimated at 6.6 thousand hectares, and total yield was 1.42 million tons. In 2020, the total yield of pangasius was 1.5 million tons. In which, the yield is concentrated in provinces such as Dong Thap, An Giang, Ben Tre, and Can Tho. In the domestic market as well as in exported markets to other countries, Vietnam's pangasius is still mainly in the form of raw products such as whole pangasius or pangasius fillet, while value-added products are processed from pangasius ready to eat are still very little. Vacuum frying is a frying technology that is carried out in a closed environment containing oil at high temperature and low pressure, with a combination that simultaneously creates two dynamic dehumidification's that are: (i) using oil to transfer heat to the frying material to create a thermal gradient towards from the center to the surface of the material; (ii) increasing the difference of partial pressure from the center of the fried material with the partial pressure at the surface of the frying material and the frying environment. Fried food is a type of dry food, thanks to the sudden water separation process in an oil environment at high temperature and low pressure, while the fat of the frying oil plays a role in enhancing and creating flavor and color. Characteristics of fried foods [8]. Vacuum fried products have high nutritional value, beautiful color, good sensory quality and are very accepted by the market. Humans have enjoyed fried foods so much for thousands of years with their unique properties of crispiness, nutty flavor and palatability [17], [19], [9]. The typical fried flavors are mainly due to lipid degradation having origin from the frying oil [15]. At present, in the market has popularized vacuum fried products from vegetables, fruits and starch [5], but there is a shortage of vacuum fried products which are processed from seafood in general and from pangasius in particular. Therefore, to carry out researches to have a vacuum frying technology to process pangasius snack in order to diversify products from pangasius and improve its added value is necessary. The optimal frying

temperature, pressure and time depend on the properties of the frying oil, the chemical composition and the structure of the frying material [9], [4].

The main purpose of this study was to investigate the effects of some technological parameters in vacuum frying such as frozen temperatures of raw material, frying pressure and frying temperature on the physical-mechanical properties crispy and spongy, and sensory quality of pangasius snack.

## **II. MATERIALS AND METHODS**

### *2.1. Materials*

Whole pangasius with a weight of 1.0 - 1.5kg/fish is purchased at Big C supermarket, then brought immediately to the laboratory to carry out research experiments. Pangasius fishes were then washed, filleted, and cut in to pieces (with the size of length x width x thickness are 1.2 x 1.2 x 1.2cm), prior to use in this experiment.

The cooking oil used for frying pangasius in this study is the Youmy refined vegetable oil produced by PT Asianagro Agungjaya Company, Indonesia.

The frying equipment used in this study is the vacuum frying equipment with a capacity of 01 kg/batch designed and manufactured by Vietnam Institute of Agricultural Engineering and Postharvest Technology.

### *2.2. Experimental Design and Studying Methods*

*Experiment 1: Study on the Effect of Frozen Treatment on the Quality of Pangasius Snack after Frying:*

Pangasius pieces were frozen to reach a product center temperature of -15; -18; -21°C and unfrozen samples were used as control. Then, the fish samples were vacuum-fried at 120°C, the frying pressure was 400 mmHg, the frying time was 20 min.

*Experiment 2: Study on the Effect of Frying Temperature on the Quality of Pangasius Snack after Frying:*

Pangasius pieces were frozen to reach a product center temperature of -18°C, then vacuum fried at 100; 110; 120; 130°C. Frying pressure was 400mmHg, frying time was 20 min.

*Experiment 3: Study on the Effect of Vacuum Frying Pressure on the Quality of Pangasius Snack after Frying:*

Pangasius pieces were frozen to reach a product center temperature of -18°C, then vacuum fried at pressure was 200, 400 and 600 mmHg. Frying temperature was 120°C, frying time was 20 min.

*Experiment 4: Study on the Effect of Frying Time on the Quality of Pangasius Snack after Frying:*

Pangasius pieces were frozen to reach a product center temperature of -18°C, then vacuum fried for 15, 20 and 25 min. Frying temperature was 120°C, frying pressure was 400 mmHg.

Each experiment had three replications. A completely randomized design was used for the experiment.

- The hardness (N) is the maximum compressive force and crispiness (N) is the force that initiates the cracki-

-ng of pangasius snack. The hardness and crispiness were measured by the CT3 Texture Analyzer (AMETEK Brookfield, USA). Samples weight was 25g, number of repetitions was 3 times. The test parameters were: test mode: compression; pre-test speed: 1mm/s; test speed: 2 mm/s; post-test speed: 10mm/s; target mode: distance; distance: 10mm and and trigger force 50g.

- Sponginess of pangasius snack after frying expressed as density was determined as follows:

Weighing a piece of pangasius after frying, put it in a porcelain cup containing molten paraffin and then cooling. Weighing the pangasius piece that has been coated with paraffin. The difference in weight of pangasius piece after and before paraffinization obtained the weight of paraffin. Weighing a hanger in the air, then placing hanger in a cup of distilled water at 20°C to weigh hanger in the water. The difference in weight of hanger in the air and water obtained the volume of hanger. After that put the paraffin-coated pangasius piece in the hanger and weighing it in the same way as above to determine the volume of hanger and the paraffin-coated pangasius piece.

The formula for determining the density (D) of pangasius piece:  $D = m/(A - B - C)$

In there:

m: weight of pangasius pieces (g)

A: volume of hanger and paraffin-dipped pangasius piece (cm<sup>3</sup>)

B: volume of hanger (cm<sup>3</sup>)

C: Volume of paraffin = weight of paraffin/0.9

Pangasius pieces have high sponginess when density is not greater than 0.6g/cm<sup>3</sup>, have medium sponginess when density = 0.63g/cm<sup>3</sup>, have poor sponginess when density > 0.64 g/cm<sup>3</sup>.

- Sensory quality of pangasius snack after frying was evaluated according to the method of scoring by using the 9-point Hedonic scale (1 to 9), where 1 = dislike extremely; 2 = dislike very much; 3 = dislike moderately; 4 = dislike slightly; 5 = neither like nor dislike; 6 = like slightly; 7 = like moderately; 8 = like very much; 9 = like extremely [13]. The sensory evaluation criteria include: hardness, crispiness, sponginess, color and taste.
- Statistical analysis was carried out using the SPSS software (version 20.0) and Duncan's Multiple Range Test ( $P \leq 0.05$ ) was used to determine the significant difference of means between the experimental formulas.

### **III. RESULTS AND DISCUSSION**

#### **3.1. Effect of Frozen Treatment on the Quality of Pangasius Snack:**

Effects of frozen temperature on the quality of pangasius snack after frying are shown in the Table 1. The control sample had the highest hardness and crispiness, and poor sponginess due to density was 0.658 g/cm<sup>3</sup>(> 0.64 g/cm<sup>3</sup>). There was a markedly different in physical-mechanical properties of control sample when compare to frozen samples ( $P \leq 0.05$ ). Comparison of frozen samples at three different temperatures, the obtained data showed that the physical-mechanical properties of -15°C sample significantly differ from -18 and -21°C

samples. This results justified that the frozen temperature has a significant effect on the physical-mechanical properties of including crispy and spongy of pangasius snack after frying. Frozen treatment samples had lower hardness, higher crispiness and higher sponginess as well as medium sponginess than the control samples (Table 1). Samples were frozen at  $-18^{\circ}\text{C}$  have a hardness of 13.8 N, while the hardness of control samples was 19.8 N. The crispiness of samples froze at  $-18^{\circ}\text{C}$  reaches 3.2N, while the least crispiness was the control sample (the force that initiates the cracking was 10.4 N). Similarly, the density of the control sample (without freezing treatment) reached  $0.658\text{ g/cm}^3$  (poor sponginess), which was 1.35 times higher than that of the sample froze at  $-18^{\circ}\text{C}$  (density reached  $0.487\text{ g/cm}^3 < 0.6\text{ g/cm}^3$ , high sponginess). Thus, freezing treatment is highly effective in improving the hardness, crispiness and sponginess of the product after frying. This could be explained by the fact that freezing treatment contributes to the formation of ice crystals in the pangasius pieces. These ice blocks when fried will change phase and leave large gaps. These large gaps that created structure of hollowness and sponginess of the pangasius pieces after frying, thereby contributing to reducing the hardness and increasing the crispiness of the vacuum fried pangasius snack. Reported that frozen samples showed high activation energies for textural parameters during frying as compared to the frozen-thawed and unfrozen samples [10]. Freezing pretreatment increased crispness values of the samples, as compared to control samples. On the other hand, freezing pretreatment also favoured oil absorption. The use of the freezing pretreatments resulted in a feasible approach for improving the nutritional and organoleptic properties of vacuum-fried carrot snacks [11]. Pretreatments such as freezing strongly influence the final quality attributes of the vacuum fried fruit products [3]. Concluded that strong freezing level ( $-30^{\circ}\text{C}$ ) could improve the vacuum fried okra quality especially in points of crispness and sensorial attributes [2]. As seen in the Table 1, there was no significant difference in physical-mechanical properties and sensory score of pangasius snack after frying between  $-18^{\circ}\text{C}$  sample and  $-21^{\circ}\text{C}$  sample. This results can conclude that frozen temperature reaches a product center temperature  $-18^{\circ}\text{C}$  or lower than  $-18^{\circ}\text{C}$  had an effective in improving the physical-mechanical properties and sensory of pangasius snack after frying.

Table 1. Effect of frozen temperature on quality of pangasius snack after frying.

Frozen Temperature ( $^{\circ}\text{C}$ )	Physical-Mechanical Properties			Sensory Score (Following the Hedonic Scale)
	Hardness (N)	Crispiness (N)	Density ( $\text{g/cm}^3$ )	
Control	$19.8 \pm 0.9^a$	$10.4 \pm 0.3^a$	$0.658 \pm 0.05^a$	$6.3 \pm 0.4^c$
-15	$16.4 \pm 0.6^b$	$8.9 \pm 0.5^b$	$0.630 \pm 0.06^b$	$6.8 \pm 0.5^b$
-18	$13.8 \pm 0.5^c$	$3.2 \pm 0.7^c$	$0.487 \pm 0.04^c$	$8.1 \pm 0.7^a$
-21	$13.4 \pm 0.7^c$	$3.1 \pm 0.3^c$	$0.468 \pm 0.09^c$	$8.2 \pm 0.2^a$

Note: In the same column, the formulas with different exponential indexes are significantly different at the level of confidence  $P \leq 0.05$ . Pangasius pieces have high sponginess when density is not greater than  $0.6\text{ g/cm}^3$ , have medium sponginess when density =  $0.63\text{ g/cm}^3$ , have poor sponginess when density  $> 0.64\text{ g/cm}^3$ .

### 3.2. Effect of Frying Temperature on the Quality of Pangasius Snack:

The frying temperature has an effect on the quality of fried products. High frying temperature quickly changes the frying oil and changes the color of the product. The temperature of the frying oil also affects the heat transfer process, mass transfer, and affects the physical-mechanical properties and nutritional changes of the product. The effect of frying temperature on the physical-mechanical properties of vacuum fried pangasius

snack is shown in the Table 2. There was a significant difference in hardness, crispiness and density of pangasius snack after frying at 100, 110°C with 120 and 130°C. The hardness, crispiness and density of pangasius pieces were fried at 120°C did not differ from which were fried at 130°C ( $P \leq 0.05$ ). As shown in the Table 2, when frying temperature increased from 100°C to 130°C, the hardness of pangasius samples after frying decreased from 18.8 to 12.4N respectively, the crispiness expressed as the force that initiates the cracking decreased from 13.2 to 3.6N and the density decreased from 0,695 to 0.428 g/cm<sup>3</sup> respectively, the pangasius pieces were fried at 120°C had the highest sensory score (8.3) and there was a significantly different in sensory score between this four frying temperatures ( $P \leq 0.05$ ). These results can be explained that due to the increasing of frying temperature that increased the kinetic energy of the heat transfer process and vaporization process thence creating sponginess, increasing the crispiness and reducing the hardness of fried pangasius. The results of this study are also consistent with those of [14], [12]. According to these authors the mechanism of spongy development, during frying process, water moves from the inside of the product to the evaporation area before leaving the product through the surfaces and some of these vapors may still are trapped inside of pores and growth becomes superheat, deforming the pore walls and contributing to the development of sponginess. The results of this study also indicated that high frying temperature changed the color of pangasius snack after frying from bright yellow (frying temperature at 100°C) to slightly dark yellow (frying temperature at 130°C), thence reducing the sensory quality of the product. In contrast, low frying temperature (100°C) increased the frying time thereby reducing the productivity of frying equipment. As can be seen in the Table 2, the pangasius pieces were fried at 120°C had the best physical-mechanical properties and sensory score. So, this frying temperature has the best effective on the quality of pangasius snack after frying. Studied the effect of oil temperature on potato quality after frying at 140, 155, 170, and 185°C for a period of 60-240 seconds, the results show that during frying, the sponginess of the product increases reaching its maximum at the end of the frying process [1]. Conducted a study on frying fish tofu at a vacuum frying temperature of 120°C, the results showed that surimi protein was formed by hot steam, creating pressure and breaking the structure to create the spongy pores of fried tofu fish [16]. Frying temperature is important factors affecting the compositional and sensory quality of sweet potato crisps, the frying temperature of 170°C produced the most acceptable sweet potato crisps by consumers [6].

Table 2. Effect of frying temperature on quality of pangasius snack after frying.

Frying Temperature (°C)	Physical-Mechanical Properties			Sensory Score (Following the Hedonic Scale)
	Hardness (N)	Crispiness (N)	Density (g/cm <sup>3</sup> )	
100	18.8 ± 0.1 <sup>a</sup>	13.2 ± 0.1 <sup>a</sup>	0,695 ± 0.04 <sup>a</sup>	7.1 ± 0,7 <sup>c</sup>
110	16.2 ± 0.15 <sup>b</sup>	8.8 ± 0.5 <sup>b</sup>	0,632 ± 0.03 <sup>b</sup>	7.8 ± 04 <sup>b</sup>
120	12.8 ± 0.2 <sup>c</sup>	3.7 ± 0.2 <sup>c</sup>	0,431 ± 0,05 <sup>c</sup>	8.3 ± 05 <sup>a</sup>
130	12.4 ± 0.1 <sup>c</sup>	3.6 ± 0.3 <sup>c</sup>	0.428 ± 0.04 <sup>c</sup>	7.6 ± 0.7 <sup>b</sup>

Note: In the same column, the formulas with different exponential indexes are significantly different at the level of confidence  $P \leq 0.05$ . Pangasius pieces have high sponginess when density is not greater than 0.6 g/cm<sup>3</sup>, have medium sponginess when density = 0.63 g/cm<sup>3</sup>, have poor sponginess when density > 0.64 g/cm<sup>3</sup>.

### 3.3. Effect of Vacuum Frying Pressure on the Quality of Pangasius Snack:

Vacuum pressure affects frying temperature. The low pressure leading to the decreasing of vaporization temp-

-erature of water in the frying chamber, thence can lower the vacuum frying temperature to keep the color and minimize the nutritional loss during the frying process [3]. Research results on the effect of frying chamber pressure on the quality of pangasius snack products are shown in Table 3. The pangasius snack after frying at pressure 400 mmHg had the lowest hardness (12.9N) and it significantly differ from the hardness of pangasius snacks which were fried at pressure 200 and 600 mmHg (13.1 and 18.4N respectively). There was no different in crispiness and density of pangasius snack after frying at pressure 200 and 400 mmHg, and these crispiness and density were lower than that of pangasius snack after frying at pressure 600 mmHg ( $P \leq 0.05$ ). The pressure of the frying chamber lower, the lower the hardness, the more increasing of crispiness and sponginess, and the better the product color (bright yellow). This can be explained by the lower the pressure of the frying chamber, the lower the vaporization temperature of the water, since then, with the same frying temperature, the process dynamics increased crispiness and sponginess, and reduced hardness and product color was improved. According to the Table 3, sensory score of pangasius snack after frying at pressure 400 mmHg was the highest, this result demonstrates that frying pressure at 400 mmHg having the best quality of pangasius snack after frying. Surimi protein was formed by hot steam, creating pressure and breaking the structure to create the spongy pores of fried tofu fish after frying at pressure of 157.5 mmHg [16]. Found that the use of high pressure had significant effects on the final vacuum-fried carrot snacks product [11]. Vacuum frying of fruits enables frying at lower temperatures compared to atmospheric frying, thereby improving quality attributes of the fried product, such as oil content, texture, retention of nutrients, and color [3].

Table 3. Effect of frying pressure on quality of pangasius snack after frying.

Frying Pressure (Mmhg)	Physical-Mechanical Properties			Sensory Score (Following the Hedonic Scale)
	Hardness (N)	Crispiness (N)	Density (G/Cm <sup>3</sup> )	
200	13.1 ± 0.2 <sup>b</sup>	3.4 ± 0.2 <sup>b</sup>	0.431 ± 0.05 <sup>b</sup>	8.3 ± 0.5 <sup>ab</sup>
400	12.9 ± 0.1 <sup>c</sup>	3.3±0.2 <sup>b</sup>	0.434 ± 0.04 <sup>b</sup>	8.5 ± 0.9 <sup>a</sup>
600	18.4 ± 0.2 <sup>a</sup>	10.8 ± 0.5 <sup>a</sup>	0.631 ± 0.07 <sup>a</sup>	7.9 ± 0.4 <sup>b</sup>

Note: In the same column, the formulas with different exponential indexes are significantly different at the level of confidence  $P \leq 0.05$ . Pangasius pieces have high sponginess when density is not greater than 0.6 g/cm<sup>3</sup>, have medium sponginess when density = 0.63 g/cm<sup>3</sup>, have poor sponginess when density > 0.64 g/cm<sup>3</sup>.

### 3.4. Effect of Frying Time on the Quality of Pangasius Snack:

Effect of frying time on physical-mechanical properties and sensory score of pangasius snack after frying is shown in the Table 4. There was a significantly difference on physical-mechanical properties and sensory score of pangasius which were fried for 15 min with 20 and 25 min ( $P \leq 0.05$ ). Pangasius was fried for 15 min had higher hardness (19.3N), and lower crispiness because the force that initiates the cracking was the highest (10.2N) and medium sponginess due to density was 0,630 g/cm<sup>3</sup>, and lower sensory score (7.1) than that frying for 20 and 25 min. In contrast, pangasius was fried for 20 and 25min did not differ on hardness (13.3 and 13.8N respectively), crispiness (3.8 and 3.5N respectively) and sponginess which were expressed as density (0,432 and 0.431g/cm<sup>3</sup> respectively) ( $P \leq 0.05$ ), however, the sensory score of pangasius was fried for 25 min was lower than that of 20 min in frying (7.3 and 8.2 respectively). Results of this research indicated that frying time had a significant effect on quality of pangasius snack after frying. The frying time has an effect on the moisture content, color, and hardness of the product after frying. The longer the frying time leading to product after

frying had lower moisture content and the color of product was darker, this also makes the frying oil is more oxidized leading to reducing the quality of the frying oil as well as the product quality of the following frying batches. Therefore, it is necessary to determine the appropriate frying time. That is, the frying time is just enough for the product after frying to reach a moisture content of <5% to ensure the characteristic color and structure [12], [8], [9]. [10] concluded that higher frying temperature (170°C) was also found to accelerate the textural changes of snack after frying. [6] found that frying time is important factors affecting the compositional and sensory quality of sweet potato crisps, frying time of 8 min produced the most acceptable sweet potato crisps by consumers. As shown in the Table 4, pangasius was fried for 20 min had a higher sensory score and a good physical-mechanical properties than other frying time. This can conclude that frying time for 20 min giving of pangasius snack after frying having a good quality.

Table 4. Effect of frying time on quality of pangasius snack after frying.

Frying Time (Minute)	Physical-Mechanical Properties			Sensory Score (Following the Hedonic Scale)
	Hardness (N)	Crispiness (N)	Density (g/cm <sup>3</sup> )	
15	19.3 ± 0.4 <sup>a</sup>	10.2 ± 0.7 <sup>a</sup>	0,630 ± 0.09 <sup>a</sup>	7.1 ± 0,2 <sup>c</sup>
20	13.3 ± 0.6 <sup>b</sup>	3.8 ± 0.5 <sup>b</sup>	0,432 ± 0.04 <sup>b</sup>	8.2 ± 06 <sup>a</sup>
25	13.8 ± 0.2 <sup>b</sup>	3.5 ± 0.8 <sup>b</sup>	0,431 ± 0,05 <sup>b</sup>	7.3 ± 05 <sup>b</sup>

Note: In the same column, the formulas with different exponential indexes are significantly different at the level of confidence  $P \leq 0.05$ . Pangasius pieces have high sponginess when density is not greater than 0.6 g/cm<sup>3</sup>, have medium sponginess when density = 0.63 g/cm<sup>3</sup>, have poor sponginess when density > 0.64 g/cm<sup>3</sup>.

#### IV. CONCLUSIONS

Whole pangasius weighing from 1.0 - 1.5kg/fish was filled and cut into pieces with size of length x width x thickness were 1.2 x 1.2 x 1.2cm, then pieces were frozen to reach a product center temperature of -18°C and vacuum fried at 120°C, the frying pressure 400 mmHg, frying time for 20 min, which have the best mechanical properties expressed as crispy and spongy, and a good sensory quality.

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