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Production of Honey-Curcumin-Dry-Salted Snakeheah Fish (*Channa striata*)

Nguyen Phuoc Minh[1,*], Tan Thanh Vo[2], Ta Thi Ngoc Hoai[3], Huynh Duy Khang[4], Truong Cam Hong[5], Thach Diem Phuc Nguyen[6]

[1]*Faculty of Chemical Engineering and Food Technology, Nguyen Tat Thanh University, Ho Chi Minh, Vietnam*
[2]*NTT Hi-Tech Institute, Nguyen Tat Thanh University, Ho Chi Minh City, Vietnam*
[3]*Can Tho University, Can Tho City, Vietnam*
[4]*Kien Giang University, Kien Giang Province, Vietnam*
[5]*Bac Lieu University, Bac Lieu Province, Vietnam*
[6]*Vinh Long Technology Education University, Vinh Long Province, Vietnam*

Abstract.

Snakehead fish (*Channa striata*) is a very important food due to high protein compostion and nutritional component. Snakehead fish (*Channa striata*) was a product of high value, for local consumption as well as export. However, the quick deterioration of snakehead fish was caused owing to high moisture and protein content. Loss of quality in seafood has been considered hazardous to consumers due to the proliferation and colonization of pathogenic bacteria. Drying was one of the best choices to process this seafood. Besides the preservation purposes, the demand for dried fish has also been driven by the flavour of the products. Curcumin has been used in traditional medicine to prevent bacterial and fungal growth. It has been used as an ingredient in food recipes. Honey has great potential as an antioxidant source to prevent negative health implications of oxidized fishes. Objective of this research focused on different technical aspects such as the effect of salt, curcumin and honey concentration during soaking; temperature of drying to chemical, microbial and sensory characteristics during the processing of honey-curcumin-dry-salted snakehead fish. The present study also evaluated shelf life extension of honey-curcumin-dry-salted snakehead fish under storage conditions. It has been proved that this snakehead fish was highly acceptable level in honey-curcumin-dry-salted condition and also maintained best quality. Dried fishs are popular and widely acceptable.

Keywords: *Snakehead fish, honey, curcumin, salting, drying, vacuum, shelf-life*

I. INTRODUCTION

Snakehead fish (*Channa striata*) is an obligatory air-breather and predaceous fish that resides in swamps, slow-flowing streams and in crevices near riverbanks. It is consumed for its dietary proteins and a remedy for healing of wound (Lay-Harn Gam et al., 2005). The fish is carnivorous and consumes fish, frog, snakes, insects, earthworms and tadpoles, therefore its flesh claimed to be rejuvenating, particularly for those recuperating from a serious illness (M Aminur Rahman et al., 2012). Snakehead fish is largely used for food, traditional medicines and pharmacological therapeutics including anti-microbial, anti-inflammatory, cell proliferation, induction of platelet accretion and anti-nociceptive activities. Snakehead extract contains high levels of essential amino acids and a good profile of fatty acids that could directly improve tissue growth, wound healing, nutraceutical supplements and pharmaceutical products. From the view point of food sources, they are playing as the role of functional foods, which provide health benefit beyond basic nutrition (MohdShafri MA & Abdul Manan MJ, 2012). It contains essential fatty acids, indicating the abundant presence of 30% C16:0 along with other major fatty acids of C20:4 (19%), C18:0 (15%), C22:6 (15%) and C18:1 (12%). It also contains 19.0% of arachidonic acid (C20:4), a precursor for prostaglandin and thromboxane biosynthesis, which represents the best composite for wound healing processes (Tan, B. H. and Azhar, M. E., 2014). Individually in fillet and mucus extracts of snakehead is found to exhibit a concentration dependent antinociceptive activity. Recently snakehead fish has been used as biomedical and nutraceutical products for clinical trials, treatment of several chronic diseases as well as improvement of human health and therapeutics to a greater extent (Rahman MA et al., 2018).

Turmeric is an essential spice all over the world with a distinguished human use. Apart from the use as spice, it is used as traditional medicine because of its beneficial properties. Current traditional medicine claims its powder against gastrointestinal diseases, especially for biliary and hepatic disorder, diabetic wounds, rheumatism, inflammation, sinusitis, anorexia, coryza and cough (Shekhar Kumar Sinoriya et al., 2018).The coloring principle of turmeric is called curcumin, which has yellow color and is the essential component of this plant (Ammon HP et al., 1992). One of the major problems associated with the lengthy sun-drying of fish is the infestation of the products by the blowfly and beetle larvae. To avoid such infestations and microbial contaminations salt and salt-turmeric was used combined in order to achieve the desire product. Being a safe, antimicrobial and incidental food additive, toxic for some microorganisms, depressor of water activity (aw) of the food, sodium chloride has been used as a seasoning and flavor enhancer as well as a preservative or curing agent (Turan H. et al., 2007; Leroi F. et al., 2000). The active ingredient of turmeric (*Curcuma longa*) having pesticidal action is curcumin.

Honey is a very complex natural product that contains sugars, organic acids, amino acids, proteins, minerals, vitamins, lipids, aromatic compounds, flavonoids,

pigments, waxes, pollen grains, enzymes and other phytochemicals (Gomes et al. 2010; Almeida-Muradin et al. 2013). Honey has distinct and unique flavor, aroma, color and composition that depend on a lot of variables: nectar composition of the flora source, bee species, climate, environmental and seasonal conditions, agricultural practices, geographical origin, and techniques used during honey extraction and storage (Castro et al. 2010; Almeida-Muradin et al. 2013). Honeys may be classified as mono-floral or poly-floral depending on whether a dominating pollen grain, originated from only one particular plant (mono-floral honey) or no dominant pollen type in the sample is found (poly-floral honey) (Moussa et al. 2012).

There were several researches mentioned to the application of turmeric for dried salted fish. Effect of sun-drying on proximate composition and pH of Shoal fish (*C. striatus*; Bloch, 1801) treated with salt and salt-turmeric storage at room temperature (270 - 300C) was examined (Farzana Binte Farid et al., 2014). The experiment was subjected to the difference between biochemical-composition and quality-analysis of sun-dried salted (SDS) and turmeric treated sun-dried salted (SDS+T) Tengra fish product for making a better flavored product with a view to preserve it in laboratory level for a long time (Farid F.B et al., 2015). 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 (Mosarrat Nabila Nahid et al., 2015). A study was to identify the combine effect of turmeric powder and salt (dry) along with sun-drying process on physico-chemical (physical characteristics, proximate and chemical analysis), mineral and bacteriological quality of three fresh water fish products (Farzana Binte Farid et al., 2016). The effect of spices and herb for maintaining microbiological quality and stability of dried oil sardine fish during preservation under ambient temperature was studied (Taniya Alex, 2016). Performance and quality assessment of sun-dried salted *Channa punctatus* (Bloch, 1793) and *Mystus tengra* (Hamilton-Buchanan, 1822) during refrigeration (4 °C) storage was examined (Farzana Binte Farid et al., 2017).

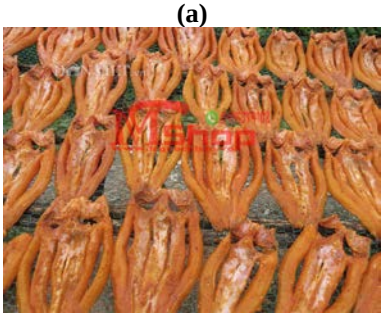
The rate of deterioration in fish is highly temperature dependent and inhibited by reducing the storage temperature (Sivertsvik et al., 2002). Several drying techniques such as freeze-drying (Donsi, G. et al., 2001), superheated steam drying (Prachayawarakorn, S. et al., 2002), jet-spouted bed drying (Niamnuy, C. et al., 2007), and heat pump drying (Zhang, G. et al., 2008) have been applied to process fishs. Traditional solar drying and hot air drying are still the most common approaches of fish processing. Sun drying is one of the most important low cost methods of fish preservation. However, blow flies caused heavy infestation of unsalted dried fish. Curcumin has been used in traditional medicine 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 (Nishant Thakur et al., 2018). Objective of this research focused on different technical aspects such as the effect of salt, curcumin, honey concentration during soaking; temperature of drying to chemical, microbial and sensory characteristics during the processing of curcumin-dry-salted snakehead fish. The present study also evaluated shelf life extension of curcumin-dry-salted snakehead fish under storage conditions.

II. Materials And Method

2.1 Material

We collected snakehead fish (*Channa striata)* from Chau Thanh 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 8 hours for experiments. They were washed and sanitized under washing tank having 50 ppm chlorine with a support of air bubble blowing to remove foreign matters. Besides *Channa striata* we also used another material during the research such as chlorine, salt, curcumin, honey, 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)

Figure 1. (a) Snakehead fish (*Channa striata*), (b) dried fish

2.2 Researching procedure

2.2.1 Effect of salting concentration to physicochemical, microbiological and sensory characteristics of the dry-salted snakehead fish (Channa striata)

Snakehead fishs (*Channa striata*) were treated with salt at different ratio (0%, 0.10%, 0.20%, 0.30% and 0.40%) soaking 20 minutes to create a pleasant taste of dried product. Apart from salt, we also used other ingredients such as sugar (0.15%), mono sodium glutamate (0.01%), galic (0.05%), pepper (0.05%). All samples will then be dried by heat pump dryer at 35^{o}C in 24h. Three dry-salted snakehead fishs were chosen randomly to analyse crude

protein (%), water activity (a_w), total plate count (TPC, cfu/g) and sensory score.

2.2.2 Effect of curcumin addition to physicochemical, microbiological and sensory characteristics of the curcumin-dry-salted snakehead fish (Channa striata)

Snakehead fishs *(Channa striata)* after being treated with salt were treated with curcumin at different ratios (0%, 0.05%, 0.10%, 0.15%, 0.20%) soaking 20 minutes to create a pleasant taste of dried product. Apart from salt, we also used other ingredients such as sugar (0.15%), mono sodium glutamate (0.01%), galic (0.05%), pepper (0.05%). All samples will then be dried by heat pump dryer at 35^{o}C in 24h. Three curcumin-dry-salted snakehead fishs were chosen randomly to analyse crude protein (%), water activity (a_w), TPC (cfu/g) and sensory score.

2.2.3 Effect of honey addition to physicochemical, microbiological and sensory characteristics of the curcumin-dry-salted snakehead fish (Channa striata)

Snakehead fishs *(Channa striata)* after being treated with salt were treated with honey at different ratios (0%, 0.05%, 0.10%, 0.15%, 0.20%) soaking 20 minutes to create a pleasant taste of dried product. Apart from salt, we also used other ingredients such as sugar (0.15%), mono sodium glutamate (0.01%), galic (0.05%), pepper (0.05%). All samples will then be dried by heat pump dryer at 35^{o}C in 24h. Three honey-curcumin-dry-salted snakehead fishs were chosen randomly to analyse crude protein (%), water activity (a_w), TPC (cfu/g) and sensory score.

2.2.4 Effect of drying temperature and time to physicochemical, microbiological and sensory characteristics of the honey-curcumin-dry-salted snakehead fish (Channa striata)

Snakehead fishs *(Channa striata)* after being treated with salt, curcumin and honey were dried by heat pump dryer in different conditions (35^{o}C, 24h; 40^{o}C, 20h; 45^{o}C, 16h; 50^{o}C, 12h; and 55^{o}C, 8h). Three honey-curcumin-dry-salted snakehead fishs were chosen randomly to analyse crude protein (%), water activity (a_w), TPC (cfu/g) and sensory score.

2.2.5 Shelf-life of the honey-curcumin-dry-salted snakehead fish (Channa striata) during storage

Honey-curcumin-dry-salted snakehead fish *(Channa striata)* products were kept in two different packing (zipper top, vaccum) ways in PA bag and two different temperature storage conditions (4±2^{o}C, 28±2^{o}C). Sensory score was evaluated in 3 months interval for 12 months.

2.3 Physico-chemical, microbial and sensory analysis

Crude protein amount in the snakehead fish samples was determined (AOAC, 2000)[19]. Water activity (a_w) was measured by Rotronic instrument. TPC (cfu/g) was analysed by 3M-Petrifilm. Sensory score of *Channa striata* was assessed by a group of panelist using the 9-point hedonic scale.

2.4 Statistical analysis

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

III. RESULT & DISCUSSION

3.1 *Effect of salting concentration to physicochemical, microbiological and sensory characteristics of the dry-salted snakehead fish (Channa striata)*

The raw fish was composed of nearly 80% of water. Snakehead fishs (*Channa striata*) were treated with salt at different ratio (0%, 0.10%, 0.20%, 0.30% and 0.40%) soaking 20 minutes to create a pleasant taste of dried product. Apart from salt, we also used other ingredients such as sugar (0.15%), mono sodium glutamate (0.01%), galic (0.05%), pepper (0.05%). All samples will then be dried by heat pump dryer at 35^{o}C in 24h. Three dry-salted snakehead fishs were chosen randomly to analyse crude protein (%), water activity (a_w), TPC (cfu/g) and sensory score. Results from table 1 showed that snakehead fishs (*Channa striata)* should be soaked with 0.3% salt in 20 minutes to get a pleasant taste of dry-salted snakehead fish.. In another study, effect of sun-drying on proximate composition and pH of Shoal fish (C. striatus; Bloch, 1801) treated with salt and salt-turmeric storage at room temperature (27^o – 30^{o}C) was examined. The study was conducted to obtain a better understanding difference between sun-dried salted (SDS) and turmeric treated sun-dried salted (SDS+T) Shoal fish-product in laboratory-condition by analyzing proximate-composition and pH using standard methods of analyses. Experimentally it has been proved that the fishes preserved in SDS +T has longer shelf life and has found better way for preservation **(**Farzana Binte Farid et al., 2014**).**

3.2 Effect of curcumin addition to physicochemical, microbiological and sensory characteristics of the curcumin-dry-salted snakehead fish *(Channa striata)*

In tropical climate and under humid condition, heavy infestation of salted dried snakehead fish 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. Snakehead fishs *(Channa striata)* after being treated with salt were treated with curcumin at different ratios (0%, 0.05%, 0.10%, 0.15%, 0.20%) soaking 20 minutes to create a pleasant taste of dried product. Apart from salt, we also used other ingredients such as sugar (0.15%), mono sodium glutamate (0.01%), galic (0.05%), pepper (0.05%) to create a pleasant flavor and aroma. All samples will then be dried by heat pump dryer at 35^{o}C in 24h. Three dry-salted snakehead fishs were chosen randomly to analyse crude protein (%), water activity (a_w), TPC (cfu/g) and sensory score. From table 2, the appropriate curcumin concentration should be used at 0.15% to get the highest crude protein content (%), lowest water activity (a_w), lowest microorganism (TPC, cfu/g) while having the highest sensory score of curcumin-dry-salted snakehead fish.

Table 1. Effect of salting concentration to physicochemical, microbiological and sensory characteristics of the dry-salted snakehead fish *(Channa striata)*

Salting concentration	Crude protein (%)	Water activity (a_w)	TPC (cfu/g)	Sensory score
0%	32.21±0.02^{c}	0.43±0.02^{a}	4.2x10^{2}±0.01^{a}	5.03±0.01^{c}
0.1%	32.29±0.01^{bc}	0.41±0.01^{ab}	3.5x10^{2}±0.02^{ab}	5.78±0.02^{b}
0.2%	32.34±0.01^{b}	0.38±0.02^{b}	2.7x10^{2}±0.01^{b}	6.35±0.00^{ab}
0.3%	**32.38±0.03^{ab}**	**0.36±0.03^{bc}**	**1.9x10^{2}±0.03^{bc}**	**6.91±0.01^{a}**
0.4%	32.41±0.02^{a}	0.35±0.00^{c}	1.0x10^{2}±0.02^{c}	6.95±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%).

Table 2. Effect of curcumin addition to physicochemical, microbiological and sensory characteristics of the curcumin-dry-salted snakehead fish *(Channa striata)*

Curcumin	Crude protein (%)	Water activity (a_w)	TPC (cfu/g)	Sensory score
0%	32.38±0.03^{a}	0.36±0.03^{a}	1.9x10^{2}±0.03^{bc}	6.91±0.01^{c}
0.05%	32.38±0.03^{a}	0.36±0.03^{a}	1.5x10^{2}±0.03^{bc}	7.11±0.02^{bc}
0.10%	32.38±0.01^{a}	0.35±0.01^{ab}	1.1x10^{1}±0.01^{b}	7.45±0.01^{ab}
0.15%	**32.38±0.01^{a}**	**0.35±0.02^{ab}**	**0.8x10^{1}±0.00^{bc}**	**7.89±0.01^{a}**
0.20%	32.38±0.02^{a}	0.34±0.01^{b}	0.3x10^{1}±0.02^{c}	7.23±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 = 5%).

Table 3. Effect of honey addition to physicochemical, microbiological and sensory characteristics of the honey-curcumin-dry-salted snakehead fish *(Channa striata)*

Honey	Crude protein (%)	Water activity (a_w)	TPC (cfu/g)	Sensory score
0%	32.38±0.01^{c}	0.35±0.02^{a}	0.8x10^{1}±0.00^{bc}	7.89±0.01^{c}
0.05%	32.40±0.02^{bc}	0.34±0.00^{ab}	0.5x10^{1}±0.01^{ab}	7.95±0.02^{bc}
0.10%	32.41±0.02^{b}	0.32±0.03^{b}	0.3x10^{1}±0.02^{b}	8.05±0.01^{b}
0.15%	**32.43±0.01^{ab}**	**0.30±0.01^{bc}**	**0.1x10^{1}±0.02^{bc}**	**8.34±0.03^{a}**
0.20%	32.44±0.02^{a}	0.29±0.02^{c}	0.1x10^{1}±0.01^{c}	8.22±0.02^{ab}

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%).

Table 4. Effect of drying temperature and time to physicochemical, microbiological and sensory characteristics of the honey-curcumin-dry-salted snakehead fish *(Channa striata)*

Drying condition	Crude protein (%)	Water activity (a_w)	TPC (cfu/g)	Sensory score
35^{o}C, 24h	32.43±0.01^{a}	0.30±0.01^{a}	0.1x10^{1}±0.02^{c}	8.34±0.03^{ab}
40^{o}C, 20h	**32.43±0.01^{a}**	**0.30±0.02^{a}**	**0.3x10^{1}±0.01^{bc}**	**8.65±0.01^{a}**
45^{o}C, 16h	32.43±0.01^{a}	0.30±0.00^{a}	0.8x10^{1}±0.02^{b}	8.21±0.01^{b}
50^{o}C, 12h	32.43±0.02^{a}	0.30±0.01^{a}	1.2x10^{1}±0.02^{ab}	8.04±0.03^{bc}
55^{o}C, 8h	32.43±0.01^{a}	0.30±0.02^{a}	1.7x10^{1}±0.00^{a}	7.89±0.01^{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%).

Table 5. Shelf-life (sensory score) of the curcumin-dry-salted snakehead fish *(Channa striata)* during storage

Storage time (month)	Curcumin-dry-salted snakehead fish (*Channa striata)* by the storage temperature (^{o}C) kept in PA (zipper top)		Curcumin-dry-salted snakehead fish (*Channa striata)* by the storage temperature (^{o}C) kept in PA (vaccum)	
	4±2 ^{o}C	28±2 ^{o}C	4±2 ^{o}C	28±2 ^{o}C
0	8.65±0.01^{a}	8.65±0.01^{a}	8.65±0.01^{a}	8.65±0.01^{a}
3	8.63±0.01^{ab}	8.61±0.01^{ab}	8.64±0.00^{ab}	8.63±0.02^{ab}
6	8.59±0.00^{b}	8.55±0.03^{b}	8.63±0.01^{b}	8.60±0.01^{b}
9	8.53±0.02^{bc}	8.49±0.02^{bc}	8.59±0.03^{bc}	8.52±0.02^{bc}
12	8.45±0.03^{c}	8.42±0.00^{c}	8.47±0.02^{c}	8.47±0.03^{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 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 (Mosarrat Nabila Nahid et al., 2015). Combine effect of *Curcuma longa* (turmeric) powder and dry-salt with sun drying in quality changes of three freshwater fish species of Meghna River was examined. The lowest moisture content of these three dried fish-products indicated that it was more resistant to the enzymatic and microbial activities (Farzana Binte Farid et al., 2016).

3.3 Effect of honey addition to physicochemical, microbiological and sensory characteristics of the honey-curcumin-dry-salted snakehead fish *(Channa striata)*

The main nutritional and health relevant components are carbohydrates, mainly fructose and glucose but also about 25 different oligosaccharides. Although honey is a high carbohydrate food, its glycemic index varies within a wide range from 32 to 85, depending on the botanical source. It contains small amounts of proteins, enzymes, amino acids, minerals, trace elements, vitamins, aroma compounds and polyphenols (Stefan Bogdanov et al., 2008). Snakehead fishs *(Channa striata)* after being treated with salt and curcumin were treated with honey at different ratios (0%, 0.05%, 0.10%, 0.15%, 0.20%) soaking 20 minutes to create a pleasant taste of dried product. Apart from salt, we also used other ingredients such as sugar (0.15%), mono sodium glutamate (0.01%), galic (0.05%), pepper (0.05%). All samples will then be dried by heat pump dryer at 35^{o}C in 24h. Three honey-curcumin-dry-salted snakehead fishs were chosen randomly to analyse crude protein (%), water activity (a_w), TPC (cfu/g) and sensory score. From table 3, the appropriate honey concentration should be used at 0.15% to get the highest crude protein content (%), lowest water activity (a_w), lowest microorganism (TPC, cfu/g) while having the highest sensory score of honey-curcumin-dry-salted snakehead fish.

3.4 Effect of drying temperature and time to physicochemical, microbiological and sensory characteristics of the curcumin-dry-salted snakehead fish *(Channa striata)*

Fish 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.

Snakehead fishs *(Channa striata)* after being treated with salt, curcumin and honey were dried by heat pump dryer in different conditions (35^{o}C, 24h; 40^{o}C, 20h; 45^{o}C, 16h; 50^{o}C, 12h; and 55^{o}C, 8h). Three honey-curcumin-dry-salted snakehead fishs were chosen randomly to analyse crude protein (%), water activity (a_w), TPC (cfu/g) and sensory score. Results from table 3 showed that the drying process should be conducted at 40^{o}C in 20h to get the highest crude protein content (%), lowest water activity (a_w), lowest microorganism (TPC, cfu/g) while having the highest sensory score.

Lipid oxidation is a major deteriorative factor in meats. Sources of natural antioxidants that are as effective as commercially available antioxidants are desired. A research was to investigate honey as an inhibitor of lipid oxidation in ground poultry. The antioxidant content of different varieties of honey was investigated spectrophotometrically and honey's effectiveness in reducing oxidation of ground poultry determined by monitoring thiobarbituric acid reactive substances (TBARS). Buckwheat honey had the highest antioxidant content and acacia honey the lowest. Honeys of different floral sources differed in their protection against lipid oxidation. Buckwheat honey (5%, w/w) reduced TBARS 70%, whereas acacia honey reduced TBARS 34% at 3 days of storage at 4 °C. In comparison to butylated hydroxytoluene and tocopherol (0.02% of total fat), honey (at 5% of the weight of the meat) was much more effective at preventing oxidation (Jason McKibben and Nicki J. Engeseth, 2002).

3.5 *Shelf-life of the honey-curcumin-dry-salted snakehead fish (Channa striata) during storage*

Honey-curcumin-dry-salted snakehead fish *(Channa striata)* products were kept in two different packing (zipper top, vaccum) ways in PA bag and two different temperature storage conditions (4±2^{o}C, 28±2^{o}C). Sensory score was evaluated in 3 months interval for 12 months. Results from table 4 showed that the curcumin-dry-salted snakehead fish *(Channa striata)* still mainted quality during 12 months of storage.

Drying decreases the water activity, so maintaing food stability by eliminating microorganism and enzymatic reactions without deterioration. The spoilage of fish is particularly due to bacteria. In one study, performance and quality assessment of sun-dried salted *Channa punctatus* (Bloch, 1793) and *Mystus tengra* (Hamilton-Buchanan, 1822) during refrigeration (4 °C) storage was examined. The present study was performed to investigate the influence of sun-drying treated with salt (30%) and storage time under refrigeration (4 °C) temperature on the nutritive value (moisture, protein, fat, ash), chemical composition (TVB-N, FFA, pH) and bacteriological analysis (SPC, HBC) of two different size fresh water fish-species (*Channa punctatus* and *Mystus tengra*). Values of moisture, TVB-N, FFA, pH and bacteriological-load increased significantly with the laps of storage period (months), but the values did not exceed the rejection limit. These values increased rapidly in sun-dried salted *C. punctatus* than *M. tengra* and at the end of 24 months of refrigeration-storage, sun-dried salted *C. punctatus* became spoiled whereas sun-dried salted *M. tengra* still remained fresh. No yeast and mould were detected during the storage period. The result of this study indicated that, small sun-dried salted fish like *M. tengra* had longer shelf-life (32 months) than medium-size sun-dried salted fish like *C. punctatus* (Farzana Binte Farid et al., 2017).

IV. CONCLUSION

Snakehead fish 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 or biological reactions that cause food deterioration. Artificial color presented on dried fish in the market was rejected. We were trying to produce honey-curcumin-dry-salted snakehead fish come from turmeric as an alternative. This research aimed to study the possibility to produce dried fish by mixing with turmeric, salt, and honey. Results revealed that 0.3% of salt with addition of 0.15% of curcumin during soaking 20 minutes; drying at 40^{o}C in 20 hours, the honey-curcumin-dry-salted snakehead fish products had the good physicochemical, microbiological and sensory characteristics. By preserving

under vacuum at 4^{o}C, the honey-curcumin-dry-salted snakehead fish could be maintained shelf-life for 12 months without any deterioration. Dried snakehead fish produced from honey, turmeric and salt meet the quality criteria by Vietnamese authority agency. Honey has great potential as an antioxidant source and may result in greater acceptability of fish products and prevent negative health implications of oxidized fishes.

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