Aquatic Food Studies 2(1), AFS104
https://doi.org/10.4194/AFS104

RESEARCH PAPER

Influence of Protein Isolates from Pangas Processing Waste on the Quality of Tilapia (GIFT) Patties During Storage at 4°C

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How to cite

Surasani, V.K.R., Khairnar, S.O., Holeyappa, S.A., Tyagi, A., Singh, A., Mandal, A. (2022). Influence of Protein Isolates from Pangas Processing Waste on the Quality of Tilapia (GIFT) Patties During Storage at 4°C. *Aquatic Food Studies*, *2(1), AFS104*. https://doi.org/10.4194/AFS104

Article History
Received 09 July 2022
Accepted 28 July 2022
First Online 28 July 2022

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Keywords
GIFT
Patties
Pangas
Waste and protein isolates

Abstract

GIFT (Genetically Improved Farmed Tilapia) mince and protein isolates obtained from pangas processing waste (fillet frames) were used to prepare fish patties and the quality was evaluated during storage at 4°C. Patties were prepared in three lots i.e. 100% GIFT mince (T1), mince with 5% protein isolate (T2), and mince with 10% protein isolate (T3). An increase in pangas protein isolate content increased the crude protein content of patties, while it decreased the fat and moisture content ($P<0.05$). No significant difference was found in the color values of patties with and without protein isolates throughout the storage period. An increase in protein isolate content to 10% caused a slight decrease in cooking yield and textural quality. All the lots showed a decreasing trend in cooking yield, textural quality, and sensory scores with an increase in storage period. Patties from all the lots had no significant differences in sensory scores and were acceptable for up to 12 days during storage at 4°C. GIFT mince can be used to prepare patties with good quality, and shelf life and pangas protein isolates can be incorporated up to 10% of the mince, without affecting the quality, acceptability and shelf life.

Introduction

Tilapia (*Oreochromis spp*) are now commercially important fish and have become among the most important food fishes in the world (Lim and Webster, 2006). Tilapia and other cichlids totally contribute about 5.6% of total aquaculture production (FAO, 2010). The innovation of production technology to exploit the biological merits of tilapia has played an important role to uplift farming and production as well. On the way to production, technological innovation of tilapia farming practice, the Genetically Improved Farmed Tilapia (hereafter read as GIFT) project has demonstrated that using selective breeding enhance the growth performance of Nile tilapia by 80% from the base population after five generations (World Fish Centre, 2004). Growth performance is further improved through the selective breeding program (Eknath *et al.*, 2007). The GIFT strain is widely available for the farmer in East and South-East Asia. This fish is gaining importance globally due to its huge potential for aquaculture and the culture area of Tilapia has been increasing in the recent past. Despite its good taste and huge culture potential, these fish fetch the low market price and low consumer acceptability. The value addition of GIFT fish can address the issues related to its market value and can increase its consumption.

Pangas have become one of the major cultured and marketed fish species in India. Based on the processing method employed, pangas processing generates

Published by Central Fisheries Research Institute (SUMAE) Trabzon, Türkiye.

considerable amounts of waste, which sometimes may reach 50 percent of the total fish processed (Surasani *et al.*, 2017a). This enormous waste is generally land-filled or dumped into water streams, polluting local water bodies and lands. This processing waste, contains valuable nutrients which can be used for human edible purposes; otherwise, which is a serious loss to humankind (Surasani, 2018). Moreover, fillets of the pangas fish contain a considerable amount of leftover meat, which can be recovered for edible purposes. In order to reduce the pollution problems caused by the discards of pangs fish and to utilize these wastes for human edible purposes, nutritional components from the pangas processing waste should be recovered.

Several studies have been conducted on the utilization of fish and by-products and extracting proteins from fish by-products, fillets, and whole fish (Cortes-Ruis *et al.* 2001; Nolsφe *et al.* 2007; Surasani *et al.*, 2017a, b; Surasani *et al.*, 2018a, b, Surasani et al., 2019, 2020, 2021, 2022a, b). Only limited work has been done (Shaviklo 2008; Surasani, 2017) on the application of recovered proteins and value addition of GIFT Tilapia fish, which necessitates further research in this area. With the view to increase the utilization and marketing of GIFT Tilapia through value addition and to address the pollution problems associated with pangas processing waste, the objectives of the study were set to develop patties from GIFT fish minced meat added with protein isolates recovered from pangas processing waste and to study the quality of patties during storage at 4°C.

Materials and Methods

Raw Material

The raw material, i.e. GIFT fish was procured from the College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, India, and pangas processing waste (fillet frames) were obtained from the local market (Sherpur fish market, Ludhiana, India) and transported to the Department of Harvest and Post-harvest Technology, College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University under iced condition. Pangas fillet frames were processed as it is after the homogenization using the pH shift method (Solubilization at pH 12.5 and precipitation at pH 5.5) to obtain the fish protein isolates (Surasani *et al.* 2018) and GIFT Tilapia fish was filleted, deboned, and minced to obtain minced meat. Prepared fish mince and protein isolates were transferred to zipped plastic bags and kept in storage at 4°C prior to the preparation of patties. All the operations were carried out in controlled conditions by maintaining a temperature <4°C.

Preparation of Patties

The amount of GIFT fish mince, pangas protein isolates, and the composition of other ingredients used for the preparation of patties is given in Table 1. The methodology of Santana *et al.* (2015) with a slight modification was used for the preparation of patties. All the pre-weighed ingredients were mixed finely using a laboratory mixer followed by molding into patties with 2.5 cm x 7.5 cm molds. Patties after molding were carefully taken out of the molds and packed into polythene bags and stored at 4°C until further analysis. Samples were drawn at regular 3 days intervals for physical, bio-chemical, textural, and sensory analysis for 12 days. The analysis of the patties was done after frying them at 180°C in hot vegetable oil for 2.5 min. The fried patties were cooled down to room temperature (25°C) before the analysis.

Proximate Analysis

The proximate composition (%) i.e. moisture, protein, ash, and fat content of the GIFT patties were determined by the method of AOAC (2000) (AOAC 950.46; AOAC 981.10; AOAC 920.153; AOAC 948.15). The protein content (%) of the sample was calculated by multiplying the obtained nitrogen value with factor of 6.25.

Table 1. Composition of the ingredients used for the preparation of GIFT patties incorporated with various levels of pangas protein isolate (0, 5 and 10% of minced meat) (Modified from the composition used by Yerlikaya et al., 2005)

Ingredients in grams	T1 (g/ 1000g mix)	T2 (g/ 1000g mix)	T3 (g/ 1000g mix)
GIFT minced meat	810.0	769.5	719.9
Pangas protein isolate (0, 5 and 10% of 810.0 g minced meat)	-	40.5	90.1
Mashed potatoes	60.0	60.0	60.0
Bread	9.0	9.0	9.0
Onion	40.0	40.0	40.0
Salt	7.0	7.0	7.0
Cumin	6.0	6.0	6.0
Black pepper	8.0	8.0	8.0
Red pepper	45.0	45.0	45.0
Ascorbic acid	5.0	5.0	5.0
Egg	10.0	10.0	10.0

T1: GIFT patties without pangas protein isolate
T2: GIFT patties with 5% pangas protein isolate
T3: GIFT patties with 10% pangas protein isolate

Cooking Yield (%) and Cooking Loss (%)

The method followed by Murphy *et al.* (1975) was used for obtaining the cooking yield of patties. Patties were weighed before and after cooking, the difference in weight was used to calculate cooking yield.

$$Cooking\ yield\ (\%) = \frac{Cooked\ weight}{Uncooked\ weight} \times 100$$

Color Analysis

Color values i.e. L* (lightness), a* (redness/ greenness), and b* (yellowness/ blueness) of the raw material as well as patties were determined using HunterLab (Virginia, U.S.) as described by Lubana *et al.* (2016). Whiteness values were calculated from the obtained L*, a* and b* values using the following formula

$$Whiteness = 100 - \{(100 - L^*)^2 + a^{*2} + b^{*2}\}^{1/2}$$

Expressible Moisture

The expressible moisture content of the patties was determined using the method described by Feng and Hultin (2001) with a slight modification. Patties were uniformly cut into 2.5 cm x 2.5 cm pieces and were placed between five layers of Whatman filter papers followed by keeping a standard weight of 3000 g over it for 1 minute. The difference in the weight before and after weight press was recorded and the expressible moisture content was calculated using the following formula;

$$Expressible\ moisture\ (\%) = \frac{(Pre\ pressed\ wei. of\ patties - after\ pressed\ wei. of\ patties)}{Pre\ pressed\ wei. of\ patties} \times 100$$

Texture Analysis

The shear test of the patties incorporated with various levels of protein isolates was performed using a Taxt-plus Texture Analyzer (Stable Micro Systems Ltd., Surrey, UK), with a 50 kg load cell. A method described by Reddy (2016) and Surasani et al. (2022b) was used for the analysis with a slight modification. A blade set (HDP/BSW) was used with a pre-test and test speed of 2 mm/sec and post-test speed of 10mm/sec. The patties were compressed to a distance of 25 mm at 25°C with a trigger force of 20 g. Every lot was tested to obtain six measurements and the average value was reported for each parameter. A 200 pps data acquisition rate was used to generate a force-time graph and the results were calculated using taxt-plus software provided with the instrument.

Sensory Analysis

The sensory quality of the patties added with various levels of protein isolates was evaluated as per the method described by Peryam and Pilgrim (1957). Sensory attributes were measured by twelve untrained panelists, who had previous experience of eating fish and fish products in terms of appearance, odor, texture, flavor, and overall acceptability based on a 9-point hedonic scale (from 9 - extremely like, 5 - neither like nor dislike, to 1 - extremely dislike). The sensory evaluation panel included both male and female technical staff members from the College of Fisheries, GADVASU, Ludhiana, India. The panelists evaluated the sensory quality of the samples and gave the score without any prior idea about the treatments. Sensory evaluation was performed with all the panelists at the same time in the sensory evaluation room. For sensory evaluation, the patties were heated in the oven at 40°C for 30 seconds before serving them to the panel members. Patties were served to the panelists at room temperature, on white porcelain plates, under natural light.

Statistical Analysis

Results are expressed as means ± SD. One-way analysis of variance (ANOVA), followed by Duncan's multiple comparison was used to determine significant differences (P<0.05) between treatments. All results were analyzed using the SPSS Version 16 software. (SPSS 16.0 for Windows, SPSS Inc., Richmond, CA, USA).

Results and Discussion

Proximate Composition

Proximate composition values of the GIFT patties incorporated with various levels of pangas protein isolates are given in Table 2. An increase in pangas protein isolate content increased the crude protein content of patties, while fat and moisture content

Table 2. Proximate composition GIFT patties incorporated with various levels of pangas protein isolate (0, 5 and 10% of minced meat)

Attribute	T1	T2	T3
Moisture (%)	74.28 ± 1.32^{a}	72.35 ± 0.57^{b}	70.89 ± 0.77^{c}
Protein (%)	17.37 ± 0.24^{c}	18.73 ± 0.19^{b}	19.31 ± 0.26^{a}
Fat (%)	2.45 ± 0.18^{ab}	2.38 ± 0.09^{b}	2.57 ± 0.03^{a}
Ash (%)	2.38 ± 0.08^{a}	2.40 ± 0.05^{a}	2.36 ± 0.04^{a}

Mean ± SD, n=3; Values in the same row with different superscripts $^{a\text{-}c}$ are significantly different (P<0.05)

T1: GIFT patties without pangas protein isolate
T2: GIFT patties with 5% pangas protein isolate
T3: GIFT patties with 10% pangas protein isolate

decreased with an increase in the protein isolate content (P<0.05). No significant difference was found in the ash content.

Shaviklo *et al.* (2016) reported that the protein content of the burgers increased significantly with an increase in tuna protein isolates content, compared to the burgers incorporated with silver carp mince. Protein isolate incorporated burgers were found to have high protein content and low moisture content compared to the control sample. Similar findings were also reported by Hussain *et al.* (2007) during their studies on Khitchri, incorporated with various levels of fish protein concentrate. The findings in the present study were in agreement with the previous reports. The differences in the proximate composition of GIFT patties are attributed to the quantity used and the nutritional composition of the raw materials used, i.e. composition of GIFT mince and pangas protein isolates.

Cooking Yield

Cooking yields of GIFT patties incorporated with various levels of pangas protein isolates are given in Table 3. On the 0th day, patties from the T3 batch had low cooking yield (88.40±0.27%) compared to the patties from the T1 and T2 lots (P<0.05) with cooking yields of 92.13±0.12 and 91.88±0.66%, respectively. The cooking yield of the patties of all three lots was reduced during the storage and at the end of the 12th-day storage, the cooking yield obtained for the patties from T1, T2, and T3 lots was 89.63±0.09, 89.55±0.15, and 87.58±0.25%, respectively.

Shaviklo (2008) reported that the addition of haddock protein isolate did not cause any significant differences in the cooking yield values of the haddock mince balls. Tolasa *et al.* (2011) also reported that the addition of soy protein isolates to sea bass mince resulted in a low cooking loss than sea bass mince without soy protein isolate. The cooking yield of the patties with 5% protein isolates was found similar to the patties without protein isolate, while a further increase in protein isolate content caused a little decrease in the cooking yield (T3 lot). Water retention during cooking could be due to hydrogen bond formation, which weakens with the cooking temperature and water cannot be bound easily (Ang, 1993). This reduction in the cooking yield of patties added with protein isolates might be due to the denaturation of fish protein isolates during the extraction resulting in the low water holding capacity of proteins during cooking. A decrease in the cooking yields with an increase in the storage period is attributed to the biochemical changes in the patties resulting in the decomposition of the proteins and associated low water holding capacity.

Expressible Drip

Expressible drip values of GIFT patties incorporated with various levels of pangas protein isolates are given in Table 4. On the 0th day, expressible drip was found to be maximum for patties from the T3 lot (2.08±0.06%) compared to patties from the T1 and T2 lots (1.27±0.10 and 1.54±0.08), respectively (P<0.05). The expressible drip value of patties from all the lots showed a

Table 3. Cooking yield of GIFT patties incorporated with various levels of pangas protein isolate (0, 5 and 10% of minced meat) during storage at 4°C

Days	T1	T2	T3
0	92.13 ±0.12^{a}	91.88±0.66^{a}	88.40±0.27^{b}
3	91.62 ±0.08^{a}	90.56±0.19^{b}	88.22±0.22^{c}
6	91.31±0.39^{a}	89.75±0.23^{b}	88.02±0.14^{c}
9	91.21±0.18^{a}	89.72±0.25^{b}	87.95±0.54^{c}
12	89.63±0.09^{a}	89.55±0.15^{a}	87.58±0.25^{b}

Mean ± SD, n=3; Values in the same row with different superscripts $^{a-c}$ are significantly different (P<0.05)

T1: GIFT patties without pangas protein isolate
T2: GIFT patties with 5% pangas protein isolate
T3: GIFT patties with 10% pangas protein isolate

Table 4. Expressible drip of GIFT patties incorporated with various levels of pangas protein isolate (0, 5 and 10% of minced meat) during storage 4°C

Days	T1 (%)	T2 (%)	T3 (%)
0	1.27±0.10^{c}	1.54±0.08^{b}	2.08±0.06^{a}
3	1.56±0.08^{b}	1.70±0.07^{b}	2.27±0.08^{a}
6	1.86±0.09^{c}	2.24±0.12^{b}	2.83±0.05^{a}
9	2.56±0.20^{b}	2.44±0.07^{b}	3.09±0.05^{a}
12	2.82±0.14^{b}	2.76±0.11^{b}	3.60±0.15^{a}

Mean ± SD, n=3; Values in the same row with different superscripts $^{a-c}$ are significantly different (P<0.05)

T1: GIFT patties without pangas protein isolate
T2: GIFT patties with 5% pangas protein isolate
T3: GIFT patties with 10% pangas protein isolate

decreasing trend with an increase in storage time. At the end of 12th-day of storage, the expressible moisture content of the patties from the T1, T2, and T3 lots was 2.82±0.14, 2.76±0.11, and 3.60±0.15%, respectively.

An increase in expressible moisture is a sign of a reduction in the water holding capacity due to protein denaturation (Rostamzad *et al.* 2011). Tolasa *et al.* (2011) reported that the addition of soy protein isolates to sea bass mince resulted in a low expressible drip indicating a high water holding capacity than sea bass mince without soy protein isolate. The similarity was observed in the values of expressible moisture content and cooking yield. In both cases, an increase in protein isolate content reduced the cooking yield and expressible moisture, indicating the possible denaturation of proteins during the extraction process that caused the low water holding capacity of patties on cooking. A decrease in the expressible moisture content with an increase in the storage period is attributed to the biochemical changes in the patties resulting in the decomposition of the proteins and associated low water holding capacity.

Color

Color values of GIFT patties incorporated with various levels of pangas protein isolates are given in Table 5. Before cooking, patties from different lots did not show any significant differences in L*, a*, and b* values and whiteness values. On the 0th day patties from the T1, T2 and T3 lots had whiteness values of 33.83±0.15, 33.34±0.34, and 33.77±0.92, respectively. An increase in the storage period caused a significant increase in L* values and a decrease in 'a' and 'b' values, resulting in the whiter patties at the end of 12th-day compared to the patties on the 0th day (P<0.05).

Color characteristics of the patties after cooking were found to vary from the color characteristics of patties before cooking (Table 6). L* values reduced significantly after the cooking, resulting in lesser white patties, compared to the patties before cooking. On the 0th day no significant differences were observed in L*, a*, b*, and whiteness values of the patties from different lots. On the 0th day, whiteness values of 29.26±0.22, 29.62±0.37, and 28.92±0.46 were registered for the patties from the T1, T2 and T3 lots, respectively. Whiteness values at the end of 12th-day of storage were found to be 26.69±0.63, 29.65±0.42, and 24.47±2.21 for patties from the T1, T2 and T3 lots, respectively.

Differences in the lightness and whiteness values of the cooked and uncooked patties might be due to the heat that causes the red pigment of the meat to darken due to increased concentration of pigments and surface dehydration (Ahn *et al.*, 1999). Hussain (2007) while studying the effect of fish protein isolates on tilapia muscle quality reported that the addition by injection or coating did not affect the color of the tilapia muscle. Akesowan (2008) also found that the addition of soy protein isolates did not cause any significant color changes in light pork sausages. Similar observations were made in the present study. Insignificant differences in color values of patties from different lots might be due to the similarities in color values of raw materials i.e. GIFT mince and protein isolates, used for the preparation of patties.

Table 5. Color values before cooking of GIFT patties incorporated with various levels of pangas protein isolate (0, 5 and 10% of minced meat) during storage at 4°C

Days	Attributes	T1	T2	T3
0 days	L *	39.12 ± 1.33^{a}	38.68 ± 0.69^{a}	38.61 ± 2.30^{a}
	a*	13.28 ± 1.13^{a}	13.16 ± 0.34^{a}	13.38 ± 1.35^{a}
	b*	22.13 ± 2.47^{a}	22.56 ± 0.78^{a}	20.71 ± 2.85^{a}
	Whiteness	$33.83\pm.15\,0^{a}$	33.34 ± 0.34^{a}	33.77 ± 0.92^{a}
3 days	L *	37.36±0.42a	37.94 ± 0.45^{a}	36.16 ± 0.29^{b}
	a*	11.89 ± 0.58^{a}	12.37 ± 0.42^{a}	11.83 ± 0.06^{a}
	b*	19.37 ± 1.65^{a}	20.62 ± 1.13^{a}	19.07 ± 0.89^{a}
	Whiteness	33.35 ± 1.04^{a}	33.43 ± 0.36^{a}	32.32 ± 0.05^{a}
6 days	L *	37.34 ± 0.8^{b}	39.26 ± 0.93^{a}	38.08 ± 1.03^{ab}
	a*	11.80 ± 1.41^{a}	12.11 ± 0.65^{a}	11.91 ± 0.25^{a}
	b*	20.21 ± 1.08^{a}	20.18 ± 1.45^{a}	20.18 ± 1.13^{a}
	Whiteness	33.08 ± 1.14^{a}	34.84 ± 0.87^{a}	33.79 ± 1.25^{a}
9 days	L *	38.34 ± 0.33^{b}	39.29 ± 0.47^{a}	38.08 ± 0.43^{b}
	a*	12.01 ± 0.25^{ab}	12.70 ± 0.78^{a}	11.69 ± 0.57^{b}
	b*	20.30 ± 0.49^{a}	20.72 ± 1.06^{a}	18.25 ± 0.72^{b}
	Whiteness	33.98 ± 0.46^{a}	34.58 ± 0.44^{a}	34.38 ± 0.25^{a}
12 days	L *	43.32 ± 2.74^{a}	42.78 ± 1.24^{a}	42.30 ± 2.47^{a}
	a*	8.19 ± 0.91^{a}	8.69 ± 0.72^{a}	8.05 ± 1.28^{a}
	b*	11.86 ± 2.50^{a}	11.96 ± 1.58^{a}	12.02 ± 0.86^{a}
	Whiteness	41.48 ± 3.09^{a}	40.88 ± 1.56^{a}	40.50 ± 2.66^{a}

Mean ± SD, n=3; Values in the same row with different superscripts $^{a\text{-}c}$ are significantly different (P<0.05)

T1: GIFT patties without pangas protein isolate
T2: GIFT patties with 5% pangas protein isolate
T3: GIFT patties with 10% pangas protein isolate

Textural Quality

Shear test results of GIFT patties incorporated with various levels of pangas protein isolates are given in Table 7. Maximum shear force (Kg force) was found to be minimum for patties from the T3 lot (2.88±0.09) compared to patties from the T1 and T2 lots (3.16±0.08, and 2.92±0.03), respectively. Shear force showed an increasing trend with an increase in storage period reaching the values of 6.45±0.37, 5.79±0.25, and 4.45±0.02 for patties from the T1, T2, and T3 lots, respectively.

Akesowan (2008) found that the addition of soy protein isolates caused an increase in the firmness with the addition of soy protein isolates to light pork sausages, which might be due to the water-binding property of SPI with liquid component to form a gel-like network to modify the texture of the sausages (Yao *et al.,* 1988). The protein content in cooked beef heart surimi frankfurters was not significantly correlated with rupture force, suggesting that the increased gen strength is due to the type of protein and its functional performance rather than the protein content (Wang and Xiong 1999). Similarly in the present study, the shear force of patties decreased with an increase in the protein isolate content, which might be due to the effect of protein denaturation during the extraction process that caused a weak protein-protein networking. An increase in the shear force of the patties with an increase in the storage period might be due to the reduction in moisture content due to drying, making it more firm compared to patties on 0^{th}-day of storage.

Table 6. Color values after cooking of GIFT patties incorporated with various levels of pangas protein isolate (0, 5 and 10% of minced meat) during storage at 4°C

Days	Attributes	T1	T2	T3
0 days	L *	34.31±0.65^a	34.72±0.45^a	33.46±0.30^a
	a*	15.13±0.35^a	15.12±0.26^a	14.08±0.79^a
	b*	21.42±1.19^a	21.49±0.42^a	20.62±0.28^b
	Whiteness	29.26±0.22^a	29.62±0.37^a	28.92±0.46^a
3 days	L *	34.52±0.34^b	36.01±0.55^a	35.91±0.44^a
	a*	15.66±0.34^a	15.71±0.07^a	15.12±0.63^a
	b*	21.44±0.99^a	21.54±1.36^a	22.79±0.45^a
	Whiteness	29.33±0.56^a	30.65±1.96^a	30.32±0.53^a
6 days	L *	32.73±0.67^a	29.97±2.04^b	31.40±1.34^{ab}
	a*	15.06±0.35^a	14.71±0.50^{ab}	14.23±0.23^b
	b*	19.91±1.01^a	17.36±0.97^b	17.95±0.57^b
	Whiteness	28.24±0.20^a	26.35±1.59^b	27.67±1.15^{ab}
9 days	L *	33.38±3.03^a	29.21±1.81^{ab}	28.96±1.26^b
	a*	14.25±2.05^a	14.15±1.18^a	14.28±0.53^a
	b*	20.09±3.08^a	15.01±1.17^b	16.47±1.70^{ab}
	Whiteness	28.88±3.27^a	26.24±1.38^b	25.66± 2.06^b
12 days	L *	30.45±1.12^b	35.91±1.25^a	27.36±2.51^c
	a*	14.72±0.69^b	15.80±0.33^a	13.44±1.05^c
	b*	17.80±1.04^b	24.24±2.09^a	15.59±1.10^c
	Whiteness	26.69±0.63^b	29.65±0.42^a	24.47±2.21^c

Mean ± SD, n=3; Values in the same row with different superscripts $^{a\text{-}c}$ are significantly different (*P*<0.05)

T1: GIFT patties without pangas protein isolate
T2: GIFT patties with 5% pangas protein isolate
T3: GIFT patties with 10% pangas protein isolate

Table 7. Textural quality of GIFT patties incorporated with various levels of pangas protein isolate (0, 5 and 10% of minced meat) during storage at 4°C

	Maximum Shear Force (kg force)			Work of Shear (kg.sec)		
Days	T1	T2	T3	T1	T2	T3
0	3.16±0.08^a	2.92±0.03^b	2.88±0.09^b	28.94±0.92^a	28.59±0.64^a	25.63±1.04^b
3	4.28±0.07^a	4.22±0.46^a	3.43±0.22^b	33.94±0.09^a	30.39±1.87^b	28.98±1.44^b
6	3.29±0.01^c	4.06±0.31^a	3.37±0.14^b	26.77±1.94^b	33.33±2.70^a	27.14±0.08^b
9	5.09±0.32^a	4.03±0.07^b	3.12±0.06^c	36.95±0.68^a	33.06±1.12^b	26.94±1.45^c
12	6.45±0.37^a	5.79±0.25^b	4.45±0.02^c	53.68±5.21^a	46.82±3.89^a	39.48±0.86^b

Mean ± SD, n=3; Values in the same row with different superscripts $^{a\text{-}c}$ are significantly different (*P*<0.05)

T1: GIFT patties without pangas protein isolate
T2: GIFT patties with 5% pangas protein isolate
T3: GIFT patties with 10% pangas protein isolate

Sensory Quality

Sensory scores for the GIFT patties incorporated with various levels of pangas protein isolates are given in Table 8. No significant difference was observed in any of the sensory attributes among the patties from different lots on the 0th day (P>0.05). The average overall acceptability scores obtained for patties from the T1, T2, and T3 lots were 8.2±1.3, 8.6±0.54, and 8.0±1.0, respectively. The sensory scores for all the attributes decreased gradually with increase in the storage period. At the end of 12th-day of storage patties from all the lots were found to be acceptable with overall acceptability scores of 6.6±1.14, 6.8±1.09, and 6.6±0.89 for patties from the T1, T2, and T3 lots, respectively. No significant difference was found throughout the storage period in any of the sensory attributes among the patties from different lots. All the patties got sensory acceptability, indicating that the addition of fish protein isolates did not cause any adverse change in the sensory attributes of the patties. Similar observations were made by Ibrahim (2009) in biscuits incorporated with fish protein concentrate.

The sensory quality of the anchovies patties under storage at 4°C decreased significantly with an increase in storage time, indicated by the decreased sensory scores (Yerlikaya *et al.,* 2005), which reached below the acceptable limits (5.0) after 6 days of storage at 4°C. Kaba *et al.* (2012) also found that anchovies patties were in acceptable condition up to 7 days at 4°C. They stated that factors such as the used ingredients, hygienic conditions during the process and the initial condition of the fish may be listed for the reason of longer shelf life. In the present study, the patties with and without fish protein isolates did not have significant differences in sensory quality and were found to be acceptable up to 12 days with an average acceptability score of 6.66. Reddy and Rao (1997) also reported a decrease in overall palatability scores of chicken and duck meat patties incorporated with Bengal gram and egg albumin during refrigerated storage. The decrease in the sensory quality and acceptability with an increase in storage time is attributed to the biochemical and microbiological changes in the patties.

Despite a little reduction in cooking yield and textural quality, GIFT patties incorporated with pangas protein isolates were nutritionally rich and had similar acceptability compared to the patties without protein isolates.

Conlusions

Results from the present study indicate that the patties from GIFT mince had good sensorial acceptability and shelf life. Hence, the market value and acceptability of GIFT can be improved by developing various value-added products like fish patties sausages, cutlets, etc. from GIFT. The study also revealed that the protein isolates from pangas processing waste can be used for incorporating into fish patties without negatively affecting the quality, sensorial acceptability, and shelf life of the product. Despite the enormous research on fish protein isolates, the information on the application of fish protein isolates into edible food products is still scanty. Hence, further research in this field is needed to increase the utilization of fish protein isolates in edible food products.

Ethical Statement

There is no need for ethical declaration in this study.

Funding Information

Not applicable.

Conflict of Interest

On behalf of all the authors, corresponding author declares that we do not have any conflict of interest related to the submission and publication of this manuscript.

Acknowledgements

The authors wish to express their sincere thanks to the Dean, College of Fisheries and University Authorities of Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, India, for the support during the work period.

Table 8. Sensory quality of GIFT patties incorporated with various levels of pangas protein isolate (0, 5 and 10% of minced meat) during storage at 4°C

	APPEARANCE			ODOR			TEXTURE			FLAVOR			OVERALL ACCEPTABILITY		
DAYS	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
0	8.2±0.44^a	7.8±0.83^a	8±1.0^a	8±0.7^a	8.2±0.83^a	8±1.0^a	7.8±0.83^a	8.2±0.44^a	8.2±1.0^a	8.4±0.54^a	8.8±0.44^a	8.4±0.54^a	8.2±1.3^a	8.6±0.54^a	8±1.0^a
3	8.6±0.54^a	8.4±0.54^a	8.2±0.83^a	8±0.7^a	8±0.7^a	8.2±0.83^a	7.8±0.59^b	8.2±0.83^{ab}	8.8±0.44^a	7.8±1.09^a	8.4±0.89^a	8.4±0.54^a	8±1.22^a	8.6±0.89^a	8.6±0.54^a
6	8.2±0.44^a	8±0.70^{ab}	7.6±0.54^b	8.2±1.09^a	7.4±0.89^a	7.2±0.83^a	8.4±0.54^a	7.8±1.09^{ab}	7.4±0.39^b	7.8±0.83^a	7.6±1.14^a	7.2±0.83^a	8±0.7^a	7.6±0.89^a	7.4±0.89^a
9	8±0.41^a	7.4±0.89^{ab}	7.2±0.44^b	7.8±0.44^a	7.6±0.54^a	7.4±0.89^a	8.0±1.0^a	7.4±0.54^a	7.8±0.44^a	8.6±0.34^a	7.8±0.44^b	8.2±0.44^{ab}	8.2±0.33^a	7.4±0.43^b	7.4±0.54^{ab}
12	6.8±0.83^a	6.4±1.14^a	6.6±0.89^a	6.6±1.34^a	6.4±1.51^a	6±1.22^a	6.4±0.54^a	6.2±1.3^a	6.4±0.54^a	6.4±0.89^a	6.4±1.51^a	6.6±0.89^a	6.6±1.14^a	6.8±1.09^a	6.6±0.89^a

Mean ± SD, n=3; Values in the same row for each attribute with different superscripts $^{a\text{-}c}$ are significantly different (P<0.05)

T1: GIFT patties without pangas protein isolate
T2: GIFT patties with 5% pangas protein isolate
T3: GIFT patties with 10% pangas protein isolate

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