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Effect of frying time and temperature on physicochemical and sensory quality attributes of batter and breaded Unicorn file (*Aluterus monoceros*) fish fillet

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Abstract
In present study the effect of different frying time and temperatures on physical, chemical and organoleptic characteristics of ready-to-fry batter and breaded fish fillets (*Aluterus monocerus*) were evaluated. The batter and breaded fish fillets fried at different time and temperature were treated as T1 sample was fried at 150° C, T2 sample was fried at 160 °C and T3 sample was fried at 170 °C for a period of 8, 10 and 12 minutes respectively. Parameters evaluated under the study includes proximate composition, physico-functional properties like oil absorption and colour profile and sensory characteristics like colour, taste, odour, texture and overall acceptability. Total of 27 fried samples were judged at different frying temperatures and time combinations. Fried fish fillets at 170°C for 12 minutes showed lower moisture content and also noticed lesser absorption of oil, good texture and over all acceptability in comparison with 150 and 160°C temperature gradient. Increasing the frying time and temperature caused decrease lightness (*L**) and increase redness (*a**) and yellowness (*b**). The observation of fried batter and breaded fish fillets at 170°C for 12 minutes showed the best result for physico-functional and sensory characteristics which can further applied as standard for development of novel ready-to-fry fishery products.

Keywords: Fish fillets, Frying, Batter and Breading, Time and Temperature

Introduction
The demand for ready-to-eat or ready-to-use fish products has led to the development of several products diverse in taste, texture and appearance. A major group among them commanding high consumer appeal is the battered and breaded products that is commonly known as coated or enrobed products (Chudasama *et al*., 2018) [6].

Coated food industry particularly based on fish is highly advanced to produce convenience foods such as ready-to-eat or ready-to-use products meeting international quality standards. Coated products *viz*., fish fingers, squid rings, cuttlefish balls, fish balls and fish fillets form one of the major fishes and shellfish-based items of tread by the (Association of Southeast Asian Nations (ASEAN) countries (Chang *et al*., 1996) [4]. A coated food product, also known as enrobed product, is one, which is coated with another foodstuff. Two types of coatings are in common use, the batter and, the crumb or the breading.

Battered and breaded products are included in this developmental effort because of their diversity and appeal, Battered and breaded products offer a convenient food valued widely by the consumer. Meat, fish, vegetables, fruits and cheese are coatable materials, which are commercially prepared on various forms. Many products are coated and immediately frozen, or they may be pre-fried, and then frozen for distribution and sales to consumers and food service establishments. They can be reconstituted by conventional heating methods. Some products are designed for reheating in microwave ovens. Battering and breading enhance food product's appearance and organoleptic characteristics in addition to improving its nutritional value. The most important function of coating is value addition by increasing the bulk of substrate thereby reducing the cost elements of the final product.

Mallema (2003) [11] reported that deep fat frying is a cooking method including fat is used as a heat transfer medium which is produced food which having good characteristics in terms of texture, taste and appearance. Kita *et al*., (2007) [10] investigated the frying temperature and time of process can be directly effects the physico-functional activities of food products.

The amount of oil absorption depends on the factors such as oil quality, frying time, oil and food temperature, and fish shape, porosity and composition of the food and particular the initial water content, as well as the weight-surface relationship (Fiszman and Salvador, 2003; Chudasama *et al.* 2019) [7, 5].

Materials and Methods

Fresh unicorn filefish (*Aluterus monoceros)* was purchased from Veraval fish landing centre and transported in iced condition with temperature range of 0 to 2 ^{0}C to fish processing laboratory of College of Fisheries, Veraval. Unicorn filefishes (*Aluterus monoceros*) is relatively less preferable for direct consumption in Indian domestic markets. So, this is efficiently utilized as value added form of batter and breaded fish fillets. It was washed thoroughly in potable chilled water to remove all adhering matters. Fresh unicorn filefish was beheaded, descaled and all fins were cut with knife. After dressing the fish was deskinned and filleted. The bones were removed from the fillets. Yield was calculated by differentiating with weight of the raw material. The fillets were pre-dusted using corn flour respectively. After pre-dusting fillets were mix with the egg batter followed by breaded using commercially available bread crumb. The flour of corn flour and all the other ingredients were purchased from local market.

For the development of suitable standard for batter and breaded fishery products, it was further treated with different combination of time and temperature (150 ^{0}C,160 ^{0}C and 170 ^{0}C) gradient so the best combination of fried fish fillets at the end of the study can be achieved.

Methodology

Proximate Composition

The proximate composition *viz*., moisture, crude protein, crude fat and ash content of ring were determined following standard methods (AOAC, 2006) [1].

Sensory Analysis

Sensory characteristics were evaluated for fish using 9-point Hedonic scale (Peryam and Pilgrims, 1957) [15]. Analysis was conducted on randomly selected samples. Then the ranks from each sample were evaluated for texture, color, appearance, odor and overall quality, by 5 panelists using 9-point of Hedonic scale. The score for each attribute were presented. Score of 6 and above indicated good quality. Limit of acceptability was score of 4.

Physical Characteristics

Instrumental Colour Profile

Colour profile was determined by using a colour reader (CR-10, Konica Minolta Sensing, Inc., made in Japan). Values corresponding to *L**, *a** and *b** were measured. Measurement was carried out in single for each treatment replication. Colour value *L** (100 = white; 0 = black) is an indication of lightness; *a** measures chromaticity, with positive values indicating redness and negative values indicating greenness; while *b** also measures chromaticity, with positive values indicating yellowness and negative values indicating blueness. The equipment was standardized with a white colour standard.

Determination of Oil Absorption

The percentage oil absorption was calculated according to the standard method (Mohamed *et al.*, 1988) [12] which is given below:

$$\text{Oil absorption (\%)} = \frac{\text{Weight of sample after frying - Weight of sample before frying x 100}}{\text{Weight of sample before frying}}$$

The batter and breaded fish fillet were weighted before and after frying in groundnut oil, using a digital balance. This was done in three replicates and the average weight was taken.

Results and Discussion

In the present study, the effect of time and temperatures on ready-to-fry batter and breaded Unicorn filefish (*Aluterus Monoceros*) fish fillet has been studied. Further, the quality determination of the products during estimating the proximate composition, physico-chemical and organoleptic parameters were made and the results of the analysis are discussed in detail.

Proximate Composition

In present study, the proximate analytical results for raw and fried with different time and temperature samples are listed in Table 1. In present study, moisture content of effect of different time and temperature for ready to fry fish fillets, T1t1 to T3t3 were found to be 55.7±1.9% to 51.63±1.19% respectively (Table 1). The moisture content was higher T1t1 (T1= 150 ºC and t1 = 8min.) treatment as compared to all treatment. In (T1t1) treatment was given, 55.7±1.9% moisture content higher. Moisture contents decreased with frying process. The moisture ratio in pre-frying fish finger decreased with pre-frying processing as reported by Cakli *et al.* (2005) [3]. Pawar (2011) [14] reported moisture content in flash fried cutlet was 65.71% respectively. During all samples frying with different time and temperature the moisture contents loss and fat uptake (Table 4.). The biggest moisture loss and fat uptake was reported at temperature 150 ºC and frying time 8 minutes in treatment (T1t1) compare to all treatment samples. protein content of ready to fry fish fillets by different treatment of time and temperature T1t1 to T3t3 were found to be 22.66±0.68% to 23.9±1.05% respectively (Table 1). The protein content was higher at T3t3(T3= 170 ºC and t3 = 12min.) treatment as compared to all treatment. The ash content of ready to fry fish fillets by different treatment of time and temperature T1t1 to T3t3 were found to be 5.15±0.35% to 5.15±0.67% respectively (Table 1). The ash content was lower at (T2t1) 3.92±0.33% treatment as compared to all 27 treatments.

Table 1: Proximate composition of batter and breaded fish fillets fried at different time and temperatures

Parameter	T1 (150ºC)			T2 (160ºC)			T3(170ºC)		
	t1 (8min)	t2 (10min)	t3 (12min)	t1 (8min)	t2 (10min)	t3 (12min)	t1 (8min)	t2 (10min)	t3 (12min)
Moisture	55.7±1.9^c	55.5±1.5^c	54.3±1.1^{bc}	52.3±0.9^b	52.0±2.9^b	50.9±1.4^a	52.9±1.5^b	51.8±2.1^a	51.6±1.2^a
Protein	22.7±0.7^b	23.4±1.4^a	22.4±0.7^b	22.7±0.8^b	23.5±0.9^a	23.3±1.1^a	23.4±0.9^a	23.6±0.6^a	23.9±1.1^a
Fat	8.7±0.5^a	8.9±0.2^b	8.6±1.3^a	9.7±0.7^c	9.3±0.6^{bc}	8.9±0.2^b	8.5±0.5^a	8.9±0.2^b	9.2±0.9^{bc}
Ash	5.2±0.4^b	5.3±0.5^b	5.1±0.4^b	5.0±0.3^b	4.4±0.6^a	4.9±0.3^a	5.4±0.5^b	4.9±0.5^a	5.2±0.7^b

Values are in mean ± SD, n=3. ^{a,b,c} Value with different superscripts in a row for each parameter differ significantly (p<0.05).

Sensory Evaluation

In the present study, the organoleptic score for effect of different time and temperature for ready to fry batter and breaded fish fillets (i.e., based on organoleptic characteristics like colour, odour, taste, texture and overall acceptability) was taken as the main criteria for judging the quality of ready to fry product. The best result found to be treatment (170 ºC for 12 minutes) compare to all 27 treatment (Based on organoleptic evaluation by T3 (170 ºC for 12 minutes) score 8.7 was showed in (Table 2). It indicate that T3 (170 ºC for 12 minutes) treatment had effect on increasing demand for market. Garcia *et al.* (2002) [8] reported that edible coatings affected the colour differences between coated and uncoated dough fried samples but did not modify the textural characteristics. Sensory characteristics were evaluated using a 9-point hedonic scale as described by Peryam and Pilgrims (1957) [15].

Table 2: Sensory evaluation of ready to fry batter and breaded fish fillets with different time and temperatures

Parameter	T1 (150ºC)			T2 (160ºC)			T3(170ºC)		
	t1 (8min)	t2 (10min)	t3 (12min)	t1 (8min)	t2 (10min)	t3 (12min)	t1 (8min)	t2 (10min)	t3 (12min)
Colour	5.00±0.35^{c}	5.40±0.42^{c}	6.00±0.35^{b}	5.90±0.55^{bc}	6.5±0.35^{b}	7.10±0.22^{ab}	6.20±0.27^{b}	7.00±0.35^{ab}	8.20±0.27^{a}
Taste	5.10±0.22^{c}	5.50±0.35^{c}	5.70±0.27^{c}	6.00±0.35^{b}	6.5±0.35^{b}	7.00±0.35^{ab}	6.60±0.22^{b}	7.00±0.35^{ab}	8.60±0.22^{a}
Odour	5.06±0.26^{c}	5.28±0.44^{c}	6.00±0.35^{b}	6.00±0.35^{b}	6.2±0.45^{b}	7.00±0.35^{ab}	6.70±0.27^{b}	7.20±0.27^{a}	8.70±0.27^{a}
Texture	5.00±0.35^{c}	5.50±0.35^{c}	5.90±0.55^{bc}	5.90±0.42^{bc}	6.1±0.22^{b}	6.80±0.21^{b}	7.00±0.35^{ab}	7.60±0.22^{a}	8.80±0.28^{a}
Overall acceptability	5.10±0.22^{c}	5.50±0.35^{c}	6.10±0.22^{b}	6.00±0.35^{b}	6.1±0.22^{b}	7.10±0.26^{ab}	6.80±0.27^{b}	7.50±0.35^{a}	8.70±0.21^{a}

Values are in mean ± SD, n=5. ^{a,b,c} Value with different superscripts in a row for each parameter differ significantly (p<0.05).

Physical Characteristics

Colour Profile

In the present experiment, the *L** value of for effect of different time and temperature for ready to fry batter and breaded fish fillets. The result of *L** value *a** and *b**for different time and temperature of T1t1 to T3t3 were 41.67±0.76 to 30±0.89, 11.43±3.06 to 8.4±1.92 31.23±2.16 to 16.2±2.42 and respectively. Among all combinations, the best result of *L** value *a** and *b** for different time and temperature of T1t1 observed in this treatment. Bechtel *et al.* (2018) [2] fried catfish at 177 ºC by using corn flour, wheat flour and rice flour for one minute. They observed for the rice batter, the par fried batter was lighter. Within the par fried treatments, the *L** value for the rice batter was significantly higher (p< 0.05) than both the corn and wheat batters. *L**. *a**, *b** values of approximately 70, 9 and 5, respectively. The *a** values of the catfish strips for all batters were lower, indicating less red in all samples. Others have reported that silver carp nuggets were par fried and the oil temperature increased, the *L** value decreased and *a** and *b** values increased (Ojagh *et al*., 2013) [13].

Table 3: Colour profile of ready to fry batter and breaded fish fillets before frying with different time and temperatures

Whiteness before frying			
	*L**-value (lightness)	*a**-value	*b**-value
T1t1	54.23 ± 0.81^{c}	10.86 ± 0.74^{a}	27.66 ± 1.79^{a}
T1t2	53.23 ± 2.06^{c}	10.23 ± 0.95^{ab}	25.33 ± 2.91^{a}
T1t3	53.37 ± 4.62^{c}	10.03 ± 0.84^{ab}	21.86 ± 0.66^{b}
T2t1	60.57 ± 1.00^{a}	10.87 ± 0.67^{a}	18.70 ± 0.36^{c}
T2t2	60.33 ± 0.85^{a}	10.83 ± 0.40^{a}	19.23 ± 0.91^{bc}
T2t3	57.90 ± 2.88^{ab}	9.73 ± 1.81^{c}	22.33 ± 2.52^{b}
T3t1	57.03 ± 1.72^{b}	10.17 ± 0.57^{ab}	28.20 ± 3.44^{a}
T3t2	58.10 ± 3.01^{ab}	10.53 ± 0.95^{a}	21.70 ± 1.56^{b}
T3t3	60.50 ± 0.34^{a}	11.23 ± 0.60^{a}	19.50 ± 1.15^{bc}
Whiteness after frying			
	*L**-value (lightness)	*a**-value	*b**-value
T1t1	41.67 ± 0.76^{a}	11.43 ± 3.05^{a}	31.23 ± 2.16^{a}
T1t2	43.96 ± 3.31^{a}	8.90 ± 0.40^{c}	34.13 ± 3.46^{a}
T1t3	41.77 ± 1.33^{a}	10.37 ± 0.85^{b}	31.83 ± 3.51^{a}
T2t1	38.47 ± 2.15^{b}	11.70 ± 1.13^{a}	27.20 ± 1.35^{b}
T2t2	36.47 ± 1.53^{bc}	8.93 ± 1.50^{c}	26.43 ± 2.57^{b}
T2t3	36.33 ± 1.84^{bc}	12.43 ± 1.86^{a}	27.27 ± 1.06^{b}
T3t1	33.83 ± 0.64^{c}	10.50 ± 2.36^{b}	26.03 ± 1.16^{b}
T3t2	31.73 ± 0.86^{cd}	10.30 ± 0.72^{b}	24.87 ± 1.42^{c}
T3t3	30.00 ± 0.89^{d}	8.40 ± 1.92^{c}	16.20 ± 2.42^{d}

Values are in mean ± SD, n=3. ^{a,b,c,d} Value with different superscripts in a column for each parameter differ significantly (p<0.05).

Oil Absorption

In present study, the oil absorption percentage of effect of different time and temperature for-ready to fry batter and breaded fish fillets. T1t1 to T3t3 found to be 32.67±0.58% to 30.67±2.52% respectively (Table 4). The similar study demonstrated by Bechtel *et al.*, (2018) [2], that par frying for 1 min at 177 ºC result in a oil absorption of corn and wheat 23.3% to 26.9% batters respectively. Lowest percentage of oil absorption showed in T3t1 (T3= 170 ºC and t1 = 8min. interaction shows oil absorption 30.00±1.00%). as compared to all treatments. Joseph *et al.* (1984) [9] reported that fat content in flash fried and raw cutlet was 5.92% and 3.74% respectively. The crude fat of Pangasius fish cutlet was found to be 4.43% respectively. The increase in fat content of the

fried fish fillets is related to oil absorption during the cooking process. Further the increase of fat content can be attributed to the oil penetration on the food after water is partially lost by evaporation Sanz *et al*., (2007) [16].

Table 4: Oil absorption of ready to fry batter and breaded fish fillets before frying with different time and temperatures

Oil absorption			
	t1 (8 min.)	t2(10 min)	t3(12 min)
T1 (150ºC)	32.67 ± 0.58^{ab}	33.67 ± 0.58^{c}	33.00 ± 1.00^{b}
T2(160ºC)	33.33 ± 0.57^{c}	30.00 ± 1.00^{a}	32.00 ± 1.00^{ab}
T3(170ºC)	30.00 ± 1.00^{a}	31.33 ± 1.15^{a}	30.67 ± 2.52^{a}

Values are in mean ± SD, n=3. ^{a,b,c} Value with different superscripts in a row for each parameter differ significantly ($p< 0.05$).

Conclusion

The above-stated studied for the effect of different time and temperature for ready-to-fry batter and breaded fish fillets was notably affected on physical, chemical and sensory quality attributes. The result of the study indicates, 170 °C temperature for 12 minutes frying time were observed to be the best in terms of physico-funcational, chemical and organoleptic qualities like odour, taste, texture and overall acceptability point of view.

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