Fishery Technology
2001, Vol. 38(2) pp : 87 - 91

Changes During Frying of Mackerel at Different Temperatures

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Rate of heat penetration to the centre of fish piece (mackerel) during frying was studied at two selected temperatures of 120°C and 160°C by inserting needle type thermocouple. Heat penetration rate to the centre of fish piece was slower at 120°C than at 160°C. At 120°C, centre temperature did not reach 100°C even after prolonged frying; whereas at 160°C, it crossed 100°C after 16 min of frying. Effect of variation in frying temperature and time on frying loss, moisture content and moisture loss of fried fish were studied in detail. Biochemical changes in fish during frying and the oil consumption rate were estimated at four treatments viz., 120°C for 18 min, 140°C for 10 min, 160°C for 5 min and 180°C for 5 min. Parameters like moisture, crude protein, crude fat, total ash, salt, TVB-N, TMA-N, PV, FFA and caloric values were analysed. There was a sharp increase in TVB-N, TMA-N, PV and FFA content in fish during frying.

Key words: Heat penetration, deep frying, biochemical characteristics, mackerel

Frying fish in oil is an age-old culinary practice in all parts of our country and one of the best methods for preparing the fish for direct consumption (Chand & Maragal, 1990). In India, where taste, food habit, culture and preference of people are so diverse, the development of various products from fried fish is likely to increase the consumer appeal. Frying is also adopted as a method of pre-cooking in fish canning and it is being practised in several countries. According to Cheftel (1965), frying is the traditional way of preparing sardine for canning.

Since fish is subjected to severe heat treatment during frying, it has several effects on the physical and biochemical characteristics of the fish. Temperature and time are the two critical factors that should be carefully controlled during frying. In this experiment, attempt was made to study the heat penetration rate and changes in biochemical characteristics during deep-fat frying of mackerel.

Materials and Methods

Fresh mackerels (*Rastrelliger kanagurta*) were dressed by removing fins, head and viscera. The dressed fish were cut into 5 cm pieces and washed properly. Pieces were brined for 1 min in saturated solution. After a quick wash, the pieces were deep fried in groundnut oil at four time-temperature treatments, viz., 120°C for 18 min, 140°C for 10 min, 160°C for 5 min and 180°C for 5 min. Temperature during frying was maintained by adjusting the flame of the gas stove. During frying, constant temperature was maintained for most of the time, except a maximum temperature variation of 5°C during the initial part of frying in each batch. Up to 500 g of fish were fried in each batch and care was taken to fry both body pieces and tail pieces almost in equal proportion in each batch.

The rate of heat penetration to the centre of fish pieces during frying was

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studied at 120°C and 160°C by inserting the needle type thermocouple into the centre of the fish pieces. The thermocouples were provided with suitable lead wires of sufficient length which could be connected to the temperature reading instrument directly through a connection box to an automatic self compensated digital thermometer with a reading accuracy of ±0.1°C and measuring range of –60°C to 199.0°C (Ellab Instruments, Copenhagen, Denmark).

Weight loss during frying (frying loss) was expressed as the percentage of weight of raw fish, whereas moisture loss in fried fish was computed as percentage loss of initial weight of raw fish using the following formula:

$$\text{Frying loss (\%)} = \frac{W_1 - W_2}{W_1} \times 100$$

where W_1 and W_2 are the weight of raw fish and fried fish respectively.

$$\text{Moisture loss (\%)} = M_1 - \frac{M_2\,(100-F)}{100}$$

where M_1 and M_2 are the moisture content (%) of raw fish and fried fish respectively and F is the frying loss (%). Moisture content of the product was estimated by standard hot air oven method. Oil consumption rate during frying was calculated as g of oil consumed to fry 1 kg of fish by using the following formula:

$$\text{Oil consumption rate} = \frac{O_1 - O_2}{W}$$

where O_1 and O_2 are oil quantity (g) in the frying pan before and after frying of fish respectively and W is the weight (kg) of the raw fish fried.

Proximate composition and salt content were estimated by AOAC (1975) method. Total volatile base nitrogen (TVB-N) and trimethyl amine nitrogen (TMA-N) contents of the samples were determined by Conway's micro diffusion analysis as described by Beatty & Gibbons (1937). Peroxide value (PV) was estimated iodometrically by the method described by Jacobs (1958). Free fatty acid (FFA) content was estimated by improved titrimetric method of Takagi *et al.* (1984). Caloric values of meat were calculated by employing the energy factors, 9.3 for fat and 4.1 for protein (Druve & Ball, 1961).

Results and Discussion

Fig. 1 represents the pattern of heat penetration during deep fat frying at 120°C and 160°C. The rate of heat penetration to the centre of the fish piece was faster at 160°C than at 120°C. The centre of fish piece attained temperature of 89.3°C in 4 min time at 160°C, whereas at 120°C it took 10 min to attain the same temperature. Similar trend of temperature development in the centre of meat patties during frying was noticed by Dagerskog & Bengtsson (1974). Zaitsev *et al*, (1969) opined that during frying, the temperature in the middle of the fish pieces did not exceed 100°C. In the present study, the centre temperatures of fish piece at the end

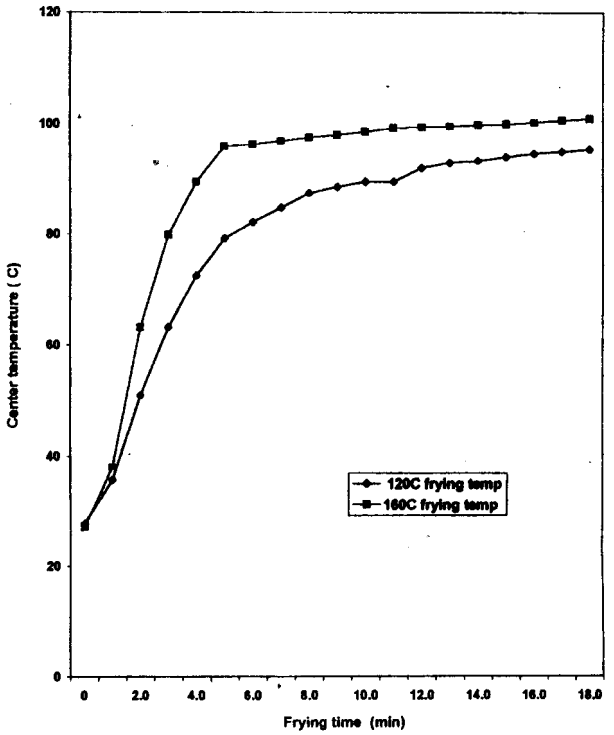

Fig. 1. Rate of heat penetration into the centre of fish piece (5.0 cm long) during frying at 120° and 160°C.

of frying (i.e., after 18 min) were 95.2°C and 100.8°C for frying temperature of 120°C and 160°C respectively.

Fig. 2 depicts the frying loss and corresponding moisture loss under different conditions of time and temperature. Frying loss at a particular temperature increased with increase of frying time. Again, for same frying time, frying losses were more at higher temperatures. At 180°C, the loss was in the range of 27.1 to 43.3% and at 160°C, it varied between 22.1 and 37.1%, depending on the duration of frying. However, the frying losses were comparatively low at 120°C. It varied from 15.3 to 25.1% with variation of frying time from 5 to 20 min. As moisture from the fish flesh was removed during frying, there was weight loss in the fried fish accompanied by a relative increase in the solid content. Moreover, fish also lost weight owing to tiny particles of flesh flaking off during frying. In real sense, frying loss was the difference between the sum of the losses in moisture, fat, flesh and the weight gain due to impregnation of frying oil. According to Zaitsev *et al.* (1969), this loss depends on the oil temperature, frying time, thickness of the pieces and fat content of the fish flesh.

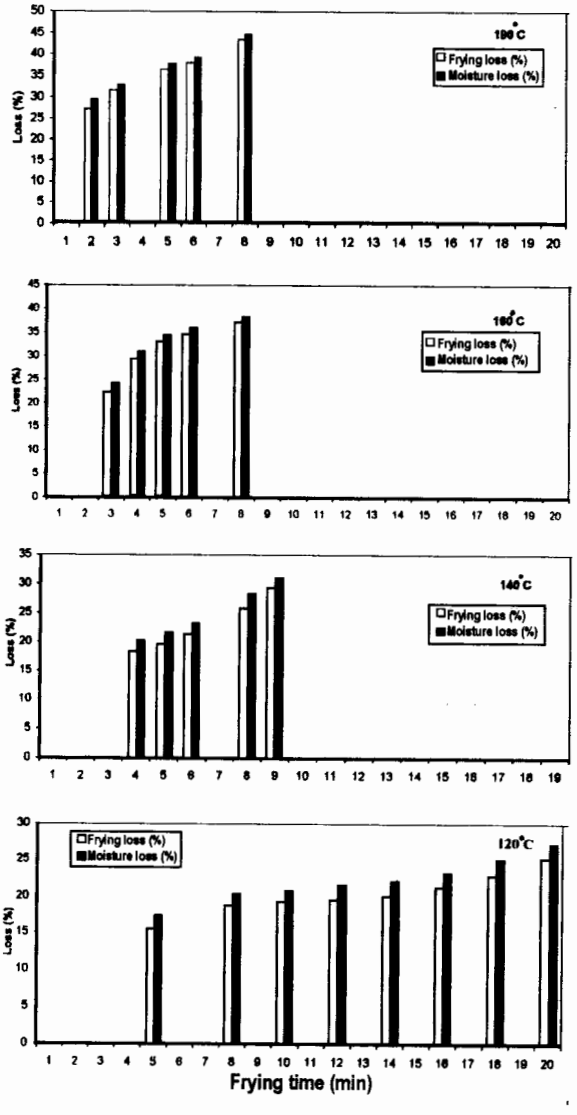

Fig. 2. Frying loss and corresponding moisture loss in fried fish different frying times at 120° and 160°C.

Moisture content of the fried products decreased as the duration of frying increased at a particular temperature. For the same frying time, the moisture content was lower at higher temperatures. The highest moisture content of 66.8% and the lowest moisture content of 52.0% were recorded in the products fried at 120°C for 5 min and at 180°C for 8 min, respectively.

The moisture loss (as percentage loss of initial weight of raw fish) was in the range of 17.3 to 44.4% in this study. The trend was same as that of frying loss. At each frying treatment, the moisture loss was higher than frying loss (Fig. 2). This was due to absorption of some amount of frying oil during frying.

Zaitsev *et al.* (1969) reported that during frying, the flesh of lean fish absorbed 7.0 to 9.0% and that of fatty fish between 3.0 and 5.0% of oil in relation to their flesh weight. In the present study, oil consumption rate during frying at different temperatures was found to vary from 6.45 to 7.05% of the weight of the fish (Table 1). This

Table 1. Oil consumption during frying

Temperature (°C)	Time (min)	Oil consumption g.kg fish^{-1}
180	5	70.5
160	5	67.9
140	10	66.4
120	18	64.5

Table 2. Biochemical characteristics of fresh and fried mackerel

	Fresh fish (raw)	Fried at 120°C for 18 min	Fried at 140°C for 10 min	Fried at 160°C for 5 min	Fried at 180°C for 5 min
Moisture (%)	73.9	63.4	60.8	59.1	56.9
Crude protein (%)	20.4	24.3	25.7	26.5	27.4
Crude fat %	4.4	10.9	11.6	11.7	12.5
Total ash (%)	1.7	3.0	3.2	3.4	3.5
Salt (%)	–	2.3	2.4	2.5	2.6
TVB-N (mg %)	7.4	26.5	27.4	27.3	27.9
TMA-N (mg%)	1.2	4.5	4.9	5.0	5.5
PV (milli equivalents O_2/kg of fat)	1.8	6.8	6.3	6.6	6.4
FFA (as % of oleic acid in total fat)	2.2	2.8	2.9	2.8	2.9
Caloric value (kcl. 100g meat^{-1})	124.4	201.0	212.8	217.1	228.6

included the amount of oil absorbed into the fish flesh during frying and the wastage of oil while transferring the pieces from the frying pan.

The biochemical changes observed during frying are presented in Table 2. Due to the decrease of moisture content, there was an apparent increase in other components of fried fish (on wet weight basis). A marked increase in the fat content of fried fish was noticed due to absorption of oil by the fish during frying. The fat content on dry weight basis increased from 16.8% in fresh fish to about 30% in the fried samples. The important observation was that the fat content on moisture free basis was almost constant for all the treatments. TVB-N and TMA-N contents also increased in fried fish. Such findings have also been reported earlier in various heat treatments of fishery products (Sundsvold *et al.*, 1971). According to these workers, heat treatments lead to increase in the content of ammonia, trimethyl amine (TMA), dimethyl amine (DMA), mono methyl amine (MMA), etc in fish. There was an increase in PV and FFA values in fried fish. This may be the result of high temperature employed during frying. Similar observations were also found in canned mackerel by George (1987). Increase in the caloric value of the fried fish was due to the relative increase in the solid contents and absorption of fat during frying.

For products where distinct fried flavour and crispness are desired, frying treatment at 160°C for 5 min is ideal. But there is toughening of texture in this treatment. Toughening of texture can be reduced by adopting frying treatment at 120°C for 18 min. Such frying treatment can be effectively used as pre-cooking in place of conventional steam pre-cooking in canning with simultaneous increase in the fat content of fish to give better taste to the product.

The first author in grateful to Karnataka State Council of Science & Technology for financial assistance.

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