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FEASIBILITY OF FISH IRRADIATION PROCESSING IN EGYPT.

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Egypt is blessed with a long coastline extending for about 2500 Kilometers as well as a continuous shelf of about 53 thousand Kilometers bordering the country from north along the Mediterranean Sea and from the west along the Red Sea. Besides, Egypt possesses various inland water resources including the River Nile, lakes and canals. Nevertheless, the annual fish catch in Egypt is still far from being fully exploited.

The total annual catch of fish in Egypt is presently about 110,000 metric tons. The most important fish source in Egypt is the High Dam Lake at the southernmost part of Egypt south Aswan City (about 1000 km from Cairo). Its potential annual yield is estimated at about 20-30 thousand metric tons, 80 % is constituted by bolti fish **Tilapia nilotica**. The basic problem facing exploitation of the lake is the unadequate transporation of fresh fish on the lake itself (35 km long) and from the lake to main retail markets at Cairo. Usually, transportation takes place in caushed ice and requires not less than 7-10 days. As a result, many fish shipments reach the destination far from being in a satisfactory hygienic state. Trying to solve this problem, a study has been conducted at the National Centre for Radiation Research and Technology aiming at increasing the shelf-life of fish catch.

Fish and fishery products are known to be among the more suitable food stuffs which could be preserved by irradiation at relatively low doses (pasteurizing doses). The purpose of this investigation is to study the feasibility of applying gamma-irradiation for extending the shelf life of Bolti fish **Tilapia nilotica** utilizing three radiation dose levels: 1, 2.5 and 3.5 K GY. Fish portions (100-150 gm) were packed in sealed polyethylene pouches and stored after irradiation at 2°C $\pm$ 1 for 4-5 weeks. Frozen samples were subjected to repeated investigation.

The changes that occurred in total extractable nitrogen (T E N), soluble protein nitrogen (S P N) and soluble non-protein nitrogen (S N P N) were proportional to the dose of irradiation and the time of storage. The results indicated a significant increase in the above mentioned protein fractions which might be due partially to the bacterial breakdown of fish proteins and hence, increasing their solubility.

Irradiation, especially with the high dose level 3.5 K Gy, was capable of keeping both the total volatile bases (T V B) and the trimethylamine (T M A) within the safe level for human consumption even after storage for 32 days at 3 °C $\pm$ 1. These two attributes were found to be reliable indices for detection of spoilage in irradiated fish and correlated highly with the acceptability characteristics.

Irradiation promoted lipids oxidation, as both the free fatty acids percentage and T B A value increased directly after irradiation. This increase was proportional to the dose level used and could be due to both hydrolysis and lipids oxidation.

During storage, the trend of increase of the above mentioned parameters continued linearly with both the dose level and period of storage. However, the fish samples were acceptable as the percentage increase in these values was still far below those reported for the rejected unirradiated fish.

Moreover, irradiation reduced greatly the total viable counts of bacteria, molds and yeasts. The reduction percentage reached 99% especially with the higher dose level of 3.5 K Gy.

Molds and yeasts under investigation were found to have lower resistance to gamma rays than viable bacteria.

Furthermore, the growth rates for the survivors of molds and yeasts organisms during storage were less than those of bacteria under the same conditions.

Unirradiated refrigerated fish samples stored at 2°C $\pm$ 1 were completely rejected by the panelists after 10 days of storage, while on the other hand, irradiated samples kept under the same temperature were not rejected before 24, 28 and 32 days for the does level 1, 2.5 and 3.5 K Gy respectively.

Irradiation with pasteurizing doses extended the shelflife of Bolti fish by about four times its original storage period under the same cooling temperature without any changes in their quality acceptability. (1)

From other studies, it was clear that the combination between irradiation at 2.50 K Gy and dipping in saturated NaCl solution containing 15 ppm chlorotetracyclene for 15 min. was the best treatment which extended the shelf life of whole fish from 5 days for the control to 25 days. For gutted fish, this treatment came with best results and extended the shelf life from 5 days for the control to 39 days. All treatments were stored in polyethylene bags at 3 $\pm$ 1 °C until spoilage. (2)

Unirradiated samples were completely spoiled and rejected by the panelists on the 6th day of storage while the irradiated samples were not rejected before 10, 14 and 18 days storgae for the dose level 0.5 and 3.0 K Gy respectively.

Applying dose levels more than 0.5 K Gy, namely 1.5 and 3.0 K Gy, caused nearly the same percentage reduction of microorganisms but fishy odour could be detected especially with the dose level of 3 K Gy.

It could be concluded that dose level 0.5 K Gy combined by salt or salt + CTC gave the best results for keeping the quality of fish for a reasonably long period of time.

Application of diferent dose levels of gamma radiation (0.25 - 3.00 KGy) on bolti fish resulted in remarkable effect on the pathogenic organisms in contaminated samples. The D_{10} values were 0.31, 0.55 and 0.63 for the **Escherichia coli, Stophylococcus sureus** and **Streptococcus faecalis** respectively. It was found that the dose of 3.0 K Gy is almost sufficient for 5 log cycles reduction of the most resistant species of these organisms.

Irradiation considerably decreased the number of **Salmonella typhimurium** artificially contaminated the whole bolti fish and bolti fillets. The D_{10} value in whole bolti fish (skin) was 0.90 K Gy while in bolti fillets was 0.38 K Gy. For the reduction of 5 log cycles of **S. typhimurium,** radiation doses of at least 4.50 K Gy (3) and 2.0 K Gy are needed for the whole fish and the fish fillets respectively.

Low-dose gamma irradiation of the Red Sea sardine **Sardinella melanura** Cuvier at 0.15 and 0.23 K Gy increased the storage life of fish at 1 °C (4). During storage, the rate of increase in pH value, total volatile nitrogen, tyrosine value and bacterial count was markedly diminished by radiation treatment and more significantly by using the synergistic effect of radiation and chlorotetracycline.

The edibility periods as judged organoleptically, were 4, 8, 11 and 12 days for untreated samples, and samples irradiated with 0.15 and 0.23 K Gy or treated with chlorotetracycline, respectively.

Other studies on improving the keeping qualities of the Red Sea bream fish **Argyrops filamentosus** showed comparable results (5). Irradiation at 0.25 to 0.50 K Gy before storage at 1 °C, diminished the rates of increase in PH, total volatile nitrogen, tyrosine value and bacterial count. The edibility period, as judged organoleptically, has risen from 3 days for control samples to 5 and 7 days for samples irradiated at 0.25 and 0.50 K Gy respectively.The protection factors thus calculated were 1.67 and 3.00.

In another study on the carp **Cyprinue carpio** speculario, in a trial to improve the keeping quality of the fish during ice-cold storage, carp fishes were immersed or/and irradiated in a solution of 3% sodium chloride containing 20 µg./ml.chlortetracycline (CTC). Gamma irradiation was conducted at the dose levels 0.05, 0.15 K Gy.

Four phases of the organoleptic characters were identified. It was noticed that there were significant variations in the duration of each phase due to the type of treatment.

As for phase I, the fishes were in a good condition without any marked spoilage. This phase extended over a period of 4, 8, 9 and 14 days for the control, treatment with CTC, irradiation at 0.15 K Gy and synergistic treatment with CTC and radiation at 0.05 K Gy.

As for phase II, in which first signs of spoilage start to appear and the fish lose its original freshness having a stale appearance, the flesh somewhat softens, the eyes gradually sink and shrunk.

This phase made its appearance 4, 8, 9 and 14 days after treatment for the same fish groups respectively. This phase extended over a period of 3,8, 10 and 11 days for the respective fish groups.

As for phase III, the fish definitely shows signs of staleness both in appearance and texture. The surface of the body becomes covered with thicker slime, the eye pupil becomes clowdy and milky, the flesh is soft while nearly at the end of this stage the "torn belly" case was clear. This phase made its appearance 7, 16, 19 and 25 days after treatment for the same fish groups respectively.

As for phase IV, the fish goes rapid deterioration from staleness to putridity. The surface becomes covered with thicky turbed and lumpy slime. The eye pupil becomes clowdy and milky and the cornea opaque, the gills turn to greyish brown and being covered with a thick slime. The flesh is very easily stripped from the backbone and exudes juce under light pressure. Simultaneously, the elasticity disappears. Strong putrifaction odor becomes evident. This condition was arrived to on 10, 20, 23 and 30 days for the respective fish groups.

As for total volatile nitrogen, in general, it has been noticed that during good storage conditions, there were no marked variations. But as signs of spoilage start to appear, a marked rise in TVN is recorded followed by a sudden and abrupt jump when the fishes reach spoilage condition.

In case of the control fish, the mean values of TVN are nearly constant ranging from 15.4 $\pm$ 0.85 to 14.7 $\pm$ 0.80 mg/ 100 g. fresh muscle during the first 7 days. This value rises significantly during the next 2 days reaching a value of 29.1 $\pm$ 1.6 mg/100 g. fresh muscle. On the 10th day of ice storage, when the fish reached spoilage, a TVN value of 62.3 $\pm$ 3.5 mg/100 g. fresh muscle was recorded.

Fishes treated with CTC showed an almost constant mean value of TVN ranging from 15.4 $\pm$ 0.85 to 16.8 $\pm$ 0.91 mg/100 g. fresh muscle during the first 16 days. During the next 3 days, there was significant rise in the mean values of TVN reaching 29.4 $\pm$ 1.5 mg/100 g followed by a sudden jump to 55.3 $\pm$ 2.9 mg/100 g when the fish reached spoilage 20 days from ice storage.

Fish irradiated at o.15 K Gy showed a mean TVN values of 15.4 $\pm$ 0.85 to 16 $\pm$ 0.91 mg/100 g. fresh muscle during the first 19 days. This value increased significantly reaching 28.7 $\pm$ 1.5 mg/100 g. fresh muscle during the following 3 days and a value of 53.2 $\pm$ 2.85 mg/100 g. fresh muscle 23 days of ice storage.

The group of fishes irradiated at 0.05 K Gy after being treated with CTC showed almost constant mean values of TVN ranging from 15.4 $\pm$ 0.85 to 16.8 $\pm$ 0.93 mg/100 g. fresh muscle during the first 25 days. These values increased significantly during the next 4 days reaching a value of 28.7 $\pm$ 1.63 mg/100 g. after 30 days in ice storage, and a value of up to 66.5 $\pm$ 3.4 mg/100 g. fresh muscle when the fish reached spoilage (6).

Availability of Radiation Sources in Egypt

In Egypt transport of fish from landing to distant consumer districts usually requires only several days. The choice of a suitable treatment for an effective increase in the shelf time of only a few days woul;d avoid the ill-effects encountered with pasteurization or sterilization techniques practiced for long-term storage.

In Egypt modest cobalt-60 gamma cells of a few kilocuries capacity have been in common use for food irradiation experiments since 1963. In 1971 Gamma-top was introduced for large pilot-scale experiments.During 1979 an industrial gamma irradiator of I megacurie capacity was commissioned. The initial activity of the cobalt-60 source in the Egyptian plant was about 400 Kci. Apart from the principal conveyor used for high-dose applications, vize. sterilization of medical products, another auxiliary conveyor system has been installed for us in connection with other sorts of low-dose applications. viz. food irradiation. The irradiation box dimensions are 45 x 20 x 60 cm, This is at present a compromise for the installation of independent full-scale food irradiations, which cannot be fully utilized since economic problems in this field must first be solved before commercialization. (7)

REFERENCES

Ibrahim,A.A..,**M.Sc. Thesis**, Cairo University (1980).

Kcuraiba, H.M.A., **M.Sc.Thesis**, Zagazig University (1981).

Youssef, Bouthainr M., **M.Sc. Thesis**, Zagazig University (1981).

Łashish,S., Hussein,M.F., Abdel-Baki,M.M., Roushdy,H.M., Hassan,Y.M. **J.Fish. Res. Board Can.**, 23,1965, 601.

Hashish,S., Hussein,M.F., Abdel-Baki,M.M., Roushdy,H.M., Hassan,Y.M. **J. Zool. Soc. Egypt.** 201(1965), 47.
Imam,A.K. **Ph.D. Thesis**, Cairo university(1973).
Roushdy,H.M., El-Magoli,S.B. **IAEA - SM -221 / 9.**