A RESEARCH STUDY ON THE CHEMICAL QUALITY OF SARDINE FISH COOKED BY MICROWAVE

M. K. I. Ragab

Food Hygiene Department, Animal Health Researeh Institute,

Agricultural Research Center, Alexandria, Egypt

ABSTRACT

The effect of microwave cooking upon chemical quality of sardine fish (sardina pilchardus) was studied. [The chemical quality parameters include both nutritional (proximate composition, mineral composition and cholesterol content) and hygienic (fat quality indicators, protein quality indicator, contaminant levels)]. A total of 100 samples of fresh (locally produced) and frozen (imported) sardine fish (50 samples for each) were collected from different retail stores in Alexandria. Samples were subjected to microwave cooking and were analyzed for chemical quality parameters before (raw state) and after (cooked) microwave cooking. Results revealed that the proximate composition (fat, protein contents) had significantly (P ≤ 0.05) increased after microwave cooking with mean values of 12.610±0.13 and 6.206±0.183 for fat content in fresh and frozen microwave cooked samples while the mean values in raw samples were 5.503±0.148 and 2.600±0.164 for fresh and frozen samples; respectively. however, the mean concentration of protein in raw samples were 17.8±1.200and 16.1±.0.800; for fresh and frozen; and in microwave cooked were20.120±1.80 and 17.23±0.40; respectively. Concerning mineral composition, microwave cooking of sardine fish had insignificant effect upon nickel (Ni) and copper (Cu) levels in fresh samples (mean values: 0.006±0.001; for raw and 0.007±0.002 for cooked for Ni; 0.015±0.007 for raw, 0.018±0.004 for cooked for Cu; respectively). at the same time, chromium (Cr) was not detected in both raw and microwave cooked fresh fish. In case of frozen samples, both nickel (Ni), chromium (Cr) was not detected in both raw and cooked samples. While in case of copper (Cu), there was insignificant effect of microwave cooking. At the same time, all the microwave cooked fresh samples showed significantly (P ≤ 0.05) higher mean concentrations of zinc (Zn), calcium (Ca), manganese (Mn), sodium (Na), iron (Fe) (0.292±0.020, 71±0.400, 0.110±0.030, 42.800±0.140 and 0.496±0.010; respectively) than raw samples (176±0.070, 55±0.300, 0.008±0.005, 35.8±0.200 and 0.438±0.050; respectively). in case of microwave cooked frozen samples, there was a significant increase in zinc lev-

els from 0.170±0.090 to 0.320±0.010, while in case of calcium (Ca), there was a significant decrease from 74.500±0.840 to 15.600±0.829. concerning manganese (Mn), both raw, microwave cooked samples showed non detectable values. Regarding sodium (Na) there was a significant increase from 98.200±1.800 to 110±1.440 while in case of iron there was no significant influence of microwave cooking (0.090±0.020 for raw, 0.094±0.020 for microwave cooked). It was also reported that in case of potassium (K), both fresh and frozen microwave cooked samples showed significantly lower levels (108±1.500; for fresh and 178±1.380,; for frozen; respectively) than raw ones (119±1.600 and 208–0.400; respectively).

In case of cholesterol content, it was significantly ($P \leq 0.05$) increased after microwave cooking of sardine fish from 53.500±0.819 and 58.500–1.500 for raw samples (fresh and frozen) to 58.700±1.680 and 64.600±1.900 for microwave cooked samples (Fresh and frozen); respectively. Microwave cooking also influences the fat and protein quality indicators, where the thiobarbeturic acid reactive substances (TBAR s), acid number (AN), Free fatty acids (FFA's) and Total volatile nitrogen (TVN) were significantly ($P \leq 0.05$) increased after microwave cooking in all samples, while in case of peroxide value and contaminant levels [cadmium (Cd), lead (Pb), mercury (Hg)], there was no significant effect. The mean concentrations of fat and protein quality indicators in raw fish samples were as follows: 0.420±0.010, 0.480±0.010, 1.580±0.693 and 0.996–0.090 for fat quality indicators (PV, TBAR s, AN, FFA s) and 19.230±0.300 for protein quality indicator (TVN), meanwhile, the mean concentrations of the same parameters in microwave cooked fresh samples were 0.470±0.080, 1.174±0.090, 2.560±0.493 and 1.610±0.200 for fat quality indicators and 24.800±0.450 for protein quality indicator (TVN); respectively. Regarding frozen samples; the mean concentrations were 0.319±0.090, 2.404±1.193, 5.219±1.7 and 2.609±0.840 for fat quality indicators and 28±0.64 for TVN; respectively in raw samples and 0.406±0.111 ,3.9321±1.111, 8.318±1.620, 3.84 ±0.97 and 36.050±0.340; for cooked; respectively. it was also found that Cd levels were reduced after microwave cooking to be non detectable, while in case of lead, it was insignificantly increased after cooking from 0.010±0.002 to 0.030 ± 0.010 in fresh samples and it was non detectable in all frozen samples. Mercury levels were insignificantly increased after cooking in both fresh, frozen sample. Results of this study also showed that there was a negative correlation between fat and fat quality indicators in fresh microwave cooked samples while in frozen samples, there was a significant positive correlation. Concerning, the correlation between protein, TVN, it was positive perfect one in microwave cooked fresh, frozen sam-

ples meanwhile, the correlation between total mineral composition and fat quality indicators, it was a negative one in fresh cooked samples and a positive correlation in frozen microwave cooked. It was also found that the correlation between cholesterol and peroxide value (primary oxidation product) (PV) was positive in frozen microwave cooked samples. At the same time, all the microwave cooked samples showed negative correlation between cholesterol, and secondary oxidation products (TBAR s) and an opposite correlation between PV, TBAR s.the contaminant levels were negatively correlated with fat quality indicators in all microwaved samples .

INTRODUCTION

Sardine (sahr-deen) is a generic term applied broadly to any of the various small soft boned salt water fish such as sprat, young pilchard and herring. (Sardines used to be abundant just off the coast of sardinia, an island in the Mediterranean, hence the name sardine). Recently, interest has been growing in sardine fish as sources of high quality protein and healthy combination of fatty acids **(Yamamoto andImosek 1989)**. This interest stems, in large part, from those studies, who suggested that, fatty acids in sardine fish play an important role in prevention, management of cardiovascular disease and decreasing the risk of cancer development at certain sites **(Lee andLip 2003)**. Further, studies suggested that eating sardine fish helps in reducing diabetes risk, in reducing the risk of incidence of Alzheimer disease, acting as a natural anticoagulants, lowering the risk for nerves and muscles and in preventing heart arrhythmias that can lead to sudden cardiac death **(Lichtenstein, 2003 and Morris etal..,2003)**.

Today, microwave cooking is an established feature in millions of kitchens through out the world. In a microwave oven, foods is heated by microwaves (bigh energy radiation) which heats water particles within food. So water molecules in food change polarity or vibrate very rapidly. This rapid vibration creates friction, which in turn produces heat. Thus, food is cooked by heat generated internally (heating occurs from inside to the outside) **(Rohrmann et al., 2002, Banks et al., 2003)**. Food heated in a microwave oven is subjected to a heterogenous temp pattern with the potential for hot and cold spots. In a microwave heated foods, the inner food core may be either at a higher or at a lower temperature than that the outer parts, depending on the size and shape of the product and on it s water and salt contents **(Judy Stone 2000)**. Improvements in a microwave oven design have minimized the problems of heterogenous heating allowing the heated product to stand for a short time before consumption . Other improvements include humidity and heat sensors, which are effective in controlling the heating process to avoid both under and overcooking/overheating **(FDA/CFSAN 2000)**. A positive feature of microwave ovens with regard

to food safety is that food can be taken from the freezer, thawed quickly, cooked and served without it spending long periods of times in the dangerous temperature zone between 4°C and 60°C which provides favourable conditions for the growth of dangerous microorganisms **(Finot and Merabet 1993)**. Microwave cooking of fish is more effietent, where fish is cooked on request (minimum storage), low handling costs due to continuous cooking, cheaper where cooking time is four to eight times shorter compared with low temperature cooking, energy consumption reduced by 40%.The microwave cooked fish had the advantages that no add oils need to be added and the heat sourec can be standardized **(Kondo-Man et al., 1997, Noverman et al.,1995)**.

It was stated that microwave cooking does not induce more chemical modifications in fats than do conventional cooking methods. In particular, microwave cooking does not generate free radicals, because it does not result in more lipid oxidation **(Richardson 1990)**.

Most published reports indicated that microwave cooking resulted in higher moisture losses compared with conventional. Overall, the nutritional effects of microwaves on protein, lipid and minerals appear minimal **(Cross andFung 1982)**.

Cholesterol forms the building blocks of several compounds (e.g., bile, sex hormones, vitamin D, etc.) with important physiologial functions and is a major structural component of cell membranes. It was found that the method of food preparatinn will affect cholesterol levels. Deep frying compared with dry heat cooking, increased cholesterol levels of fish fillets by approximately 10% **(Nourooz-Zadeh andAppelqvist 1988)**.

It was showed that the highest temperatures (shortest cooking times) resulted in the lowest malonaldhyde (MA) content, possibly due to shorter period of contact with molecular oxygen during cooking and increased losses of MA, perhaps due to increased volatility or destruction. The lower cooking temperature (longer cooking times) resulted in higher concentrations of malonaldhyde possibly because the rate of formation exceeds the rate of loss **(Conchillo et al., 2003)**.

It was reported that the way the fish is prepared and cooked ean modify the amount of chemical contaminants eonsumed. The degree to which the contaminants bioaccumulate in different fish species is dependent on their methods of feeding, the ability of the fish to metabolize the contaminants, and the fat content of the fish **(U.S. EPA1997)**.

Consumer surveys and market analysis have concluded that the reliable nutrient composition data on sardines in the form in which they are eaten (cooked) is necessary as the importance of sardines in our diets increases and the nutrient composition of raw sardines has been widely studied but data on the nutrient composition of sardines cooked by either conventional or microwave methods are sparse **(USDA1998)**. So the purpose of this study was to give an idea on the chemical quality of microwave cooked sardine fish.

MATERIAL AND METHODS

A total of 100 samples of fresh (locally produced) and frozen (imported) sardine fish (Sardina Pilchardus) (50 for each) were chosen at random from Alexandria retail stores; then samples were transported in an insulated ice box to the laboratory and analyzed in it's raw state for chemical quality parameters.

Samples were subjected to microwave cooking of 970 MHz frequency at full power (600 w), and according to the manufacturer's instructions, then, they were analyzed for chemical quality parameters, immediately after cooking.

Determination of chemical quality parameters

Nutritional quality parameters

Proximate analysis

Fat content

It was determined according AOAC standard method **(AOAC 1970)**.

Protein content

It was estimated according to AOAC standard method **(AOAC 1970)**.

Mineral composition (Ni, Cr, Cu, Zn, K, Mg, Ca, Mn, Na, Fe)

The principle of the minerals determination involved the production of acidic solution of the inorganic elements, after removing interfering materials by chelation solvent using ammonium pyrrolidine di-thio carbamate (APDC) and isobutyl methyl ketone (MIBK).

After that minerals concentrations were determined by using flame atomic absorption spectrophotometer at wave length's specific to each element **(Richard 1986)**.

Cholesterol content was determined principally by using chloroform/methanol mixture, then aliquot of lipid extract prepared by folch procedure was evaporated to dryness in a water bath under a steam of nitrogen **(Folch etal., 1957)**. The saponified lipid was added to alcohol (KOH) in a shaker water bath. After cooling, distillate water was added. Then, the unsaponifiable material was extracted with hexane after that aliquot of hexane extract was dried and cholesterol concentration was determined-colorimetrically using ferrous sulfate ($FeSO_4$) - acetic acid and concentrated sulfuric acid (H_2SO_4) as a developing agent **(Bohac etal ., 1988)**.

Hygienic quality parameters

Fat quality indicators

Peroxide value

It was determined by using a mixture of glacial acetic acid and chloroform with a ratio of 3:2, and saturated potassium iodide (KI) and Starch as indicator according to the following equation

(AOCS 1998).

$$PV = \frac{(S)\ (N)\ (1000)}{W}$$

Where;

S = ml of titration.

N = normality of sodium thiosulfate ($Na_2S_2O_3$)

W = weight of fat.

Peroxide value is expressed as milliequivalents of O_2/kg of fat.

Thiobarbeturic acid reactive substances

It was determined using cold extraction method according to **(LI, CT etal., 2001)**.(27)

Acid value

Acid value is defined as the number of milligrams of potassium hydroxide required to neutralise the free acid in 1 gm of the sample. It was determined by using a mixture of diethylether, ethanol, phenolphathaline as indicator and neutralized by alkali according to the following equation:

$$\text{Acid value} = \frac{\text{Titration (ml0.1N) x 5.61}}{\text{Weight of sample used}}$$ (Pearson 1970)

Free fatty acids

According to Pearson 1970

Protein quality indicator [Total volatile nitrogen (TVN)]

It was determined by macrokejldhal Method **(Pearson 1970)**.

Contaminant levels (Cd, Pb, Hg)

Cadmium and lead were determined by Hydrochloric-nitric (HCl-HNO3) acid leaching method using flame atomic absorption spectrophotometer **(Richard 1986)**. The principle of Hg determination method depends on the conversion of all the Hg present in the sample into the inorganic form by wet oxidation and it's reduction to the metallic state. Then, the realse of Hg from the solution as vapour using a stream of air followed by it's determination by flameless atomic absorption spectrophotometer **(APHA/AWWA1992)**.

RESULTS

Changes in chemical quality parameters of sardine fish following microwave cooking were shown in Table (1-6). Results revealed that the highest mean fat content was found in microwave

cooked samples with mean values (12.610±0.132, 6.206±0.185 for fresh and frozen: respectively) and the lowest was in raw samples (5.503±0.148, 2.6±0.164; for fresh and frozen; respectively) with a signifleant difference between them. Regarding protein content, all the mierowave eooked samples showed significantly higher levels (20.120±1.800, 17.23±0.4 00; for fresh and frozen: respectively) than raw samples (17.8±1.20, 16.1±0.80 for fresh and frozen; respeetively). Concerning mineral composition, both Nickle (Ni) and Chromium (Cr) levels were nearly similar in raw and mierowave cooked samples. In ease of copper, it was reported that the microwave cooked frozen samples showed mean concentration of 0.020±0.005, while raw frozen had mean coneentration of 0.006±0.003 with no signifleant difference between them, both raw and mierowave cooked fresh samples had mean values of (0.015±0.007, 0.018±0.004; respectively). All the microwave cooked fresh samples showed significantly higher levels of Zinc (Zn), Calcium (Ca), Manganese (Mn), Sodium (Na), Iron (Fe) (0.292±0.020, 71±0.400, 0.110±0.030, 42.800±0.140, 0.496 ± 0.010; respectively) than raw fresh (176±0.070, 55±0.300, 0.008±0.005, 35.8±0.200, 0.438±0.050; respectively).

At the same time, all the microwave cooked frozen samples had significant higher levels of Zinc (Zn), Sodium (Na) (0.320 ± 0.010, 110 ± 1.400; respectively) than raw frozen ones (0.170 ± 0.090, 98.200 ± 1.800; respectively). While in case of Calcium (Ca) the microwave cooked frozen samples had significantly lower values (15.600 ± 0.829) than raw frozen samples (74.500 ± 0.840). Concerning manganese (Mn), both raw microwave cooked frozen samples showed non detectable values and in case of Fe, samples showed similar values. Regarding of Potassium (K) , the microwave cooked fresh samples had mean concentrations of 108 ± 1.500; respectively while that of raw ones were 119 ± 1.600, however, the microwave cooked frozen samples showed mean concentrations of 178 ± 1..380 while that of raw frozen samples were 208 ± 0.400.

It was also found that the eholesterol content was signifieantly increased in all samples after microwave cooking from 53.500 ± 0.819, 58.500 ± 1.500 for raw samples (fresh, frozen) to 58.700 ± 1.680, 64.600 ± 1.900; for microwave cooked samples; respectively.

Regarding hygienic quality parameters, both fat and protein quality indicators (TBAR S, AN, FFA S and TVN) were significantly increased in all mierowave cooked samples (fresh, frozen) and PV was in significantly increased in all microwave cooked samples. While in case of contaminant levels (Cd, Pb, Hg), there was no significant differences between raw and microwave cooked .

Table (4) presented the correlation between fat content and peroxide valuc, thiobarbeturic acid reactive substances, acid number and frec fatty acids in raw and mierowave cooked sardine fish (fresh, frozen). It was found table that, there was a perfect positive correlation between parameters in raw, microwaved frozen fish while in fresh, there was negative eorrelation. It ean

also be noted that in all raw samples, the correlation was significant.

(Table 5) indicated the correlation between TVN and protein content of raw and microwave cooked sardine fish. It was clear that there was a perfect significant positive correlation between parameters examined in all microwave cooked samples (fresh, frozen) while there was a negative correlation between parameters in fresh raw samples.

Table (6) presented the correlation between total mineral composition and PV, TBAR's, AN, FFA s in raw and microwave cooked sardine fish. It was revealed that a positive correlation between parameters in all frozen samples (raw, cooked) while in fresh samples, an opposite correlation was found.

Table (7) indicated the correlation as described by Pearsons correlation coefficient (r) between cholesterol and peroxide value (PV) in raw and microwave cooked sardine fish. Data from this table showed that there was a significant positive correlation at $p = 0.01$ in all frozen sardine fish samples (raw, cooked) while in case of fresh samples, there was a significant negative correlation in raw and positive in cooked .

Results of Table (8) showed the correlation between cholesterol and TBAR'S in raw and microwave cooked sardine fish it was revealed that there was a negative correlation between parameters in all microwave cooked samples while in case of raw fresh samples, there was a significant positive correlation, at $p = 0.05$, at the same time, the raw frozen samples showed significant negative correlation at $p = 0.01$.

DISCUSSION

Fish is a prime candidate for microwave cooking. Most varieties of fish cook very quickly because it has less skeletal matter and connective tissue and is lower in fat than equivalent amounts of red meat and poultry and microwave cooking actually enhances subtle fish flavors. The case of operation of microwave ovens and time saving properties mean that their popularity is likely to increase for domestic use as well as in restaurants and institutions. While few people would dispute their convenience, consumers are sometimes concerned about the safety of microwaves and their effect on nutrients in food **(Severi et al., 1997)**.

The statistical analysis of our results revealed that the microwave cooking of sardine fish had a significant ($P \leq 0.05$) influence up on proximate composition, some mineral composition, cholesterol content, fat quality indicators (TBAR's, AN, FFA's), protein quality indicator (TVN), it showed no significant effect up on peroxide value (primary lipid oxidation product) and contaminant levels (Cd, Pb, Hg) Tables (1-2 and 3).

When food is cooked above 117 degrees for three minutes or longer, the following deleterious changes begin, and progressively cause increased nutritional damage as high temp's are applied over prolonged periods of time, proteins coagulate, high temp's denature protein molecular structure leading to deficiency of some essential amino acids. Overly heated fats generate numerous carcinogens ,natural fibers break down. 100% of enzymes damaged **(Nutritional Research council of the American Academy of Sciencea and FDA 1982)**.

Our results from tables (1&2) indicated that microwave cooking of sardine fish had significantly changed fat content in both fresh, frozen samples by increase. This increase was attributed to the original lipid content of fish and to high moisture losses (30-35% higher than dry or moist heat cooking). It was also found that, there was a negative signifieant correlation between fat, PV, TBAR's, AN, FFA's in fresh microwave cooked sardine fish while in frozen microwave cooked ones, there was a positive significant correlation Table (4).

It was reported that the fat content of raw sardine was significantly increased following microwave cooking from 9.7±0.8 (32.3) to 16.5±1.3 (33.9) **(Hearn etal.,1987)**.

Microwave cooking of sardine fish did not destroy polyunsaturated fatty acids (PUFA). At the same time, the isolated fish oils obtained from sardine, mackerel, for example, are extremely unstable to heating; this instability is mainly attributed to the larger amounts of the glycerides of the highly USFA s that are present **(Billek 1983)**.

It was reported that lipid content of raw fish fillets was 0.88 gm / 100 gm of fillets, on wet wt basis, lipid content of microwave cooked fish was 1.41 g/100 gm **(Gall etal., 1983)**.

The phenomenon of fish losing different amounts of moisture during different cooking methods including microwave, has been reported for a number of different fish species **(Mai etal., 1978 and Njinkoue etal., 2002).Gall etal., (1983)** reported that, as the amount of lipid in fish fillet increased, the amount of absorbed lipid in the cooking medium decreased **(Gall et al., 1983)**. It was found that the microwave cooked sardine fish had significantly ($P \leq 0.05$) higher protein content than raw ones Table (1). This was related to the high moisture loss and not to absolute increase in protein. it was reported that protein content was significantly positive correlated with TVN in all microwave cooked samples (fresh-frozen) Table (5).

Mustafa and Medeiros (1985) reported that the protein content of raw fish fillet was 17.16% (uncooked) and that of microwave cooked was 22.11%.).

Numerous studies using different methodologies have considered how heating protein foods by microwave affects the nutritional value of the proteins. On the other hand no detrimental effects have been shown and neither conventionally nor microwave heating seriously decreased

the nutritive value of protein as measured by chemical analysis and by human and animal trials **(Ahlsson and Bebgtsson 2001, Dahl andMattews, 1980 and Kimura, 1990).**

It was found that there are slight differences in denaturation rates in foods heated in the microwave compared with conventional heating, because of differences in heating time and temperature **(Kimura 1990).**

Microwave cooking of sardine fish had significantly ($P \leq 0.05$) altered some mineral compositions by gain (Zn, Ca, Mn, Na, Fe) in fresh samples and by loss (Ca, K) in frozen samples Table (1). These findings substantiated those reported by **Gall et al (1983).** The gain or loss caused by either having a concentrating or diluting effect of high moisture loss **(Sabry 1990).** It was stated that there was a positive correlation between total mineral contents, PV, TBAR s, AN, FFA s in all microwave cooked frozen samples and negative correlation in all microwave cooked fresh ones Table (6).

However, cooking does not appear to affect the protein or total lipid levels - within the exception of poaching, which may cause a loss of some dissolved minerals when cooking water is discarded, the mineral content of cooked fish is usually not affected by the cooking process(Text Book of Nutrional value of food processing 1985). The fat content of fish may also be altered depending upon how it is prepared and cooked **(USDA 1998).**

Gall et al. (1983) stated that the raw fish fillets had Fe contents of 0.3 mg/100 gm, and that of microwave cooked was 0.4 mg/100 gm, indicating an increase in Fe content of microwave cooked fish fillets Addiationlly raw fish fillets had sodium content (mg/100 gm) of 46.7 and that of microwave cooked fish fillets were 54.5 mg/100 gm **(Gall et al .,1983).**

Table (1) showed that there was a significant increase in cholesterol content of microwave cooked sardine fish. This could be related to the fact that cholesterol was rather stable at temp s conventionally used for cooking, moreover, during microwave cooking, cholesterol was strongly bound to membrane struetures of tissues i.e., coneentrated in tissue. Table (8) presented that all the microwave cooked samples had a negative correlation between cholesterol content, TBAR's, **Kyoichi-Osada et al.,1993.** found that Highly polyunsaturated fatty acids which are relatively rich in fish are unstable and are readily oxidized much more at high temperatures and lipid peroxy radicals is formed, these radicals interact with cholesterol and promote oxidation of cholesterol.

It was found that, since no oxidized cholesterol was found in uncooked fish sardine and squid fish, it is likely that the oxidized cholesterol are formed during processing where the processed seafood products (air dried sardine, air dried squid) contained 11-28.7 mg/100 gm of sample of

oxidized cholesterol. In conclusion, the oxidation of cholesterol was stimulated when fats were present simultaneously. It was found that 6-28 mg/100 gm of oxidized cholesterol exists in processed marine foods, we are commonly consuming. Therefore, more systematic analysis of processed and cooked foods is necessary **(Kyoichi-Osada etal., 1993)**.

The results obtained indicated that there was a positive correlation between protein content and protein quality indicator (Table 5).

Mustafa and Medeiros (1985) observed that the protein nitrogen of fish fillet (cat fish fillet) was lost during cooking either by boiling or microwave.

CONCLUSION

Overall, this investigation indicated that microwave cooking of sardine fish, showed an increase in fat and protein contents, this increase was related to the original lipid content of fish and to high moisture losses (30-35% higher than dry on moist heat cooking). Some minerals were affected by microwave cooking by gain like in case of zinc (Zn), calcium (Ca), sodium (Na), iron (Fe) in fresh samples or by loss like in case of potassium (K) and magnesium (Mg), in frozen samples. This gain or loss was attributed to the high loss of moisture which influences the mineral composition by either having a concentrating or diluting effect. At the same time, some minerals were not significantly affected by microwave cooking as in nickel (Ni) and chromium (Cr). It was also found that cholesterol content was significantly ($P \leq 0.05$) increased by microwave cooking. Moreover, it was positively correlated with PV (primary lipid oxidation product) and negatively correlated with thiobarbeturic acid reactive substances (TBAR's) (secondary lipid oxidation product). This was related to the facts that cholesterol was rather stable at temp s conventionally used for cooking for a short period. During microwave cooking of fish, less cholesterol oxidation occur as a result of the presence of a relatively high degree of bonding of cholesterol to structural membranes of tissue. Oxidation of cholesterol proceeds depending on the coexisting lipids, degree of unsaturation of fats.

RECOMMENDATIONS

The following points should be taken into consideration before, during, after microwave cooking of fish in order to obtain satisfied product from a sensory, safely and nutritional stand point:

1- Arrangement: Before cooking, it is best to arrange the items to be cooked.

2- Rotating: This is done to overcome the effect of any cold spots in the microwave cooking

chamber. Usually, the dish should be rotated one-quarter turn half way through the cooking time.

3- Standing: The dish is allowed to stand without being exposed to microwaves. This allows the heat already built up in the food to finish the cooking process. At the same time, this prevents, over cooking.

4- When cooking large quantities of food, it is more effective to divide it into small portions.

5- Care must be taken to adequately and appropriately refrigerate fish until it is prepared and cooked.

6- In industrial processing to avoid the problem of thermal run away, frozen fish are "tempered", they are bought to a temp of -3°C at which point they can be manipulated rather than thawed through 0°C.

7- Strict international standards control the safety of microwave ovens, and achieved by taking a glass container of water at a known temp and heating it to a higher temp and measuring the time taken, this to prevent eseape of energy of microwave, which can be also absorbed by the human body and damage the body s soft tissues.

8- The problems of dried tough outer layers of microwave cooked fish ean be overcomed by using suspectors to aid the heating process or in some cases, by reducing the product size.

0Table (1): Changes in chemical quality parameters of Sardine fish (Fresh, Frozen) following microwave cooking.

Chemical Quality Parameters	Sardine Fish															
	Fresh								Frozen							
	Raw				Cooked				Raw				Cooked			
	Min	Max	Mean ± S.D	Range	Min	Max	Mean ± S.D	Range	Min	Max	Mean ± S.D	Range	Min	Max	Mean ± S.D	Range
Nutritional:																
Proximate composition																
Fat	5.30	5.71	5.503* ± 0.148	0.41	12.40	12.86	12.61* ± 0.132	0.46	2.40	2.80	2.6* ± 0.164	0.400	6.00	6.43	6.206* ± 0.183	0.43
Protein	17.00	17.91	17.8*± 1.200	0.91	18.32	20.63	20.12* ±1.80	2.31	15.92	16.72	16.10* ±0.800	0.80	16.92	17.88	17.23* ±0.400	0.96
Mineral composition																
Nickel (Ni)	0.00	0.03	0.006 ± 0.001	0.03	0.00	0.03	0.007 ± 0.002	0.03	0.00	0.00	0.000	0.000	0.00	0.00	0.000	0.00
Chromium (Cr)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.00	0.00	0.000	0.00
Copper (Cu)	0.00	0.02	0.015 ± 0.007	0.02	0.01	0.02	0.018 ± 0.004	0.01	0.00	0.02	0.006 ± 0.003	0.020	0.01	0.03	0.02 ± 0.005	0.02
Zinc (Zn)	0.15	0.19	0.176* ± 0.070	0.04	0.26	0.31	0.292* ± 0.020	0.05	0.10	0.24	0.17* ± 0.090	0.140	0.30	0.33	0.32* ± 0.010	0.03
Potassium (K)	116.00	120.00	119* ± 1.600	4.00	106.00	110.00	108* ± 1.500	4.00	206.00	210.00	208.0 * ± 0.400	4.000	176.00	180.00	178* ± 1.380	4.00
Magnesium (Mg)	7.30	9.60	8.8 ± 0.920	2.30	6.10	8.40	7.600 ± 0.920	2.30	27.50	30.40	29.4* ± 1.500	2.900	20.70	23.00	22.3* ± 0.947	2.30
Calcium (Ca)	55.00	56.00	55* ± 0.300	1.00	70.90	72.00	71* ± 0.400	1.10	73.00	75.50	74.5* ± 0.840	2.500	14.00	16.00	15.6* ± 0.829	2.00
Manganese (Mn)	0.00	0.01	0.008* ± 0.005	0.01	0.04	0.13	0.11* ± 0.030	0.09	0.00	0.00	0.000	0.000	0.00	0.00	0.000	0.00
Sodium (Na)	35.60	36.00	35.8* ± 0.200	0.40	42.60	43.00	42.8* ± 0.140	0.40	96.00	100.00	98.2* ± 1.800	4.000	100.00	118.00	110* ± 1.440	18.00
Iron (Fe)	0.42	0.47	0.438* ± 0.050	0.05	0.49	0.52	0.496* ± 0.010	0.03	0.05	0.11	0.09 ± 0.020	0.060	0.06	0.11	0.094 ± 0.020	0.05
Cholesterol	52.00	54.50	53.5* ± 0.819	2.50	56.00	61.00	58.7* ± 1.680	5.00	55.90	60.64	58.5* ± 1.500	4.740	62.00	66.90	64.6* ± 1.900	4.90

* There was a significant difference between Means at $p \leq 0.05$

Table (2): Effect of microwave cooking of Sardine fish (Fresh, Frozen) on fat and protein quality indicators.

Parameter	Sardine fish			
	Fresh		Frozen	
	Raw	Cooked	Raw	Cooked
Fat quality indicators				
Proxide value (PV) (meq/kg)	0.420 ± 0.010	0.470 ± 0.080	0.319 ± 0.090	0.406 ± 0.111
Tbio-Barbeturic acid reactive substances (TBAR's) (mgMA/kg)	0.480* ± 0.010	1.174* ± 0.090	2.404* ± 1.193	3.932* ± 1.111
Acid number (AN) (ml/g)	1.580* ± 0.693	2.560* ± 0.493	5.219* ± 1.700	8.318* ± 1.620
Free fatty acids (FFA) (ml/g)	0.996* ± 0.090	1.610* ± 0.200	2.609* ± 0.840	3.840* ±0.970
Protein quality indicator				
Total volatile nitrogen (TVN) (mg/100gm)	19.230*± 0.300	24.800 *±0.450	28.000 *±0.640	36.050*±0.340

* There was a significant difference between Means at $p \leq 0.05$

Table (3): Contaminant levels (Cadmium, Lead, Mercury) in raw and microwave cooked Sardine fish (Fresh, Frozen).

Contaminant levels (ppm)	Sardine Fish															
	Fresh								Frozen							
	Raw				Cooked				Raw				Cooked			
	Min	Max	Mean ± S.D	Range	Min	Max	Mean ± S.D	Range	Min	Max	Mean ± S.D	Range	Min	Max	Mean ± S.D	Range
Cadmium (Cd)	0.00	0.01	0.003 ± 0.001	0.01	0.00	0.00	0.000	0.00	0.00	0.01	0.004 ± 0.002	0.01	0.00	0.00	0.000	0.00
Lead (Pb)	0.01	0.02	0.01 ± 0.002	0.01	0.02	0.05	0.03 ± 0.010	0.03	0.00	0.00	0.000	0.00	0.00	0.00	0.000	0.00
Mercury (Hg)	0.03	0.10	0.06 ± 0.020	0.07	0.03	0.17	0.07 ± 0.040	0.14	0.04	0.20	0.104 ± 0.050	0.16	0.06	0.30	0.118 ± 0.070	0.24

Table (4): Correlation as described by Pearsons correlation coefficient (r) between fat content and peroxide value (PV), thio-Barbeturic acid reactive substances (TBAR's), acid number (AN), and frec fatty acids (FFA's) in raw and microwave cooked Sardine fish (Fresh, Frozen).

Measure	Sardine fish			
	Fresh		Frozen	
	Raw	Cooked	Raw	Cooked
Fat content (g/100gm)	5.503 ± 0.148	12.610± 0.132	2.600 ± 0.164	6.206 ± 0.183
Peroxide value (PV) (meq/kg)	0.42 ± 0.010	0.470± 0.080	0.319 ± 0.090	0.406 ± 0.111
Thio-Barbeturic acid reactive substances (TBAR's) (mgMA/kg)	0.48 ± 0.010	1.174± 0.090	2.404 ± 1.193	3.9321±1.111
Acid number (AN) (ml/g)	1.58 ± 0.693	2.560 ± 0.493	5.219 ± 1.700	8.318 ± 1.620
Free fatty acids (FFA) (ml/g)	0.996± 0.090	1.6100 ± 0.200	2.609± 0.840	3.840 ± 0.970
r	-0.647**	-0.355	0.613**	0.374

** Correlation is significant at p = 0.01.
r is the correlation coefficient.

Table (5): Correlation as described by Pearsons correlation coefficient (r) between protein content and total volatile nitrogen (TVN) in raw and microwave cooked Sardine fish (Fresh, Frozen).

Measure	Sardine fish			
	Fresh		Frozen	
	Raw	Cooked	Raw	Cooked
Protein content (g/100gm)	17.8± 1.200	20.12±1.800	16.1 ±0.800	17.23±0.40
Total volatile nitrogen (TVN) (mg/100g)	19.23± 0.300	24.8 ±0.450	28.0 ± 0.640	36.050 ± 0.340
r	-0.101	1.000**	0.814**	0.969**

** Correlation is significant at p = 0.01.
r is the correlation coefficient.

Table (6): Correlatioo as described by Pearsons correlation coefficint (r) between total mineral composition, peroxide value (PV), thio-Barbeturic acid reactive substances (TBAR's), acid number (AN), and free fatty acids (FFA's) in raw and microwave cooked Sardine fish (Fresh, Frozen).

Measure	Sardine fish			
	Fresh		Frozen	
	Raw	Cooked	Raw	Cooked
Total mineral composition (p.p.m.)	21.924	23.032	41.370	45.133
Peroxide value (PV) (meq/kg)	0.420	0.470	0.319	0.406
Thio-Barbeturic acid reactive substances (TBAR's) (mgMA/kg)	0.480	1.174	2.404	3.9321
Acid number (AN) (ml/g)	1.580	2.560	5.219	8.318
Free fatty acids (FFA) (ml/g)	0.996	1.610	2.609	3.840
r	-0.061	-0.242	0.098	0.277

r is the correlation coefficient.

Table (7): Correlation as described by Pearsons correlation coefficient (r) between cholesterol content and peroxide value (PV) in raw and microwave cooked Sardine fish (Fresh, Frozen).

Measure	Sardine fish			
	Fresh		Frozen	
	Raw	Cooked	Raw	Cooked
Cholesterol (mg/100gm)	53.500± 0.819	58.700± 1.680	58.500± 1.500	64.600± 1.900
Peroxide value (PV) (meq/kg)	0.420 ± 0.010	0.470 ± 0.080	0.319 ± 0.090	0.406 ± 0.111
r	-0.777**	0.813	0.474 *	0.458 *

* Correlation is significant at p = 0.05.
** Correlation is significant at p = 0.01.
r is the correlation coefficient.

Table (8): Correlation as deseribed by Pearsons correlation coefficient (r) between cholesterol content and thiobarbeturic acid reactive substances (TBAR's) in raw and microwave cooked Sardine fish (Fresh, Frozen).

Measure	Sardine fish			
	Fresh		Frozen	
	Raw	Cooked	Raw	Cooked
Cholesterol content (mg/100gm)	53.500± 0.819	58.700± 1.680	58.500± 1.500	64.600± 1.900
Thio-Barbeturic acid reactive substances (TBAR's) (mgMA/kg)	0.480 ± 0.010	1.174 ± 0.090	2.404 ± 1.193	3.9321 ± 1.111
r	0.502*	-0.105	-0.536* *	-0.149

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الملخص العربى

دراسة بحثية عن الجودة الكيماوية لسمك السردين المطهى بالميكروويف

المشتركون فى البحث

د/ ميرفت كمـال إبراهيـم رجـب

قسم صحة الأغذية - معهد بحوث صحة الحيوان

مركز البحوث الزراعية - الإسكندرية - القاهرة

لقد أجريت الدراسة على سمك السردين الطازج والمجمد وذلك لمعرفة تأثير الطهى بالميكروويف على الجودة الكيماوية (الجودة الغذائية وتشمل : محتوى الدهون، البروتين، المعادن، محتوى الكوليسترول والجودة الصحية وتشمل مؤشرات تحلل الدهون مثل البيروكسيد والثيوباربيتيورك والرقم الحمضى والأحماض الدهنية الحرة ومؤشرات تحلل البروتين مثل معدل النيتروجين الكلى المتصاعد ومؤشرات التلوث بالمعادن الثقيلة) لسمك السردين ولذا فقد تم جمع (١٠٠ عينة) من سمك السردين الطازج، المجمد (٥٠ عينة لكل نوع) وقد أجريت التحاليل الكيماوية للجودة على سمك السردين قبل الطهى وبعد الطهى وقد أسفرت الدراسة عن النتائج التالية :

١- لقد زاد محتوى الدهون بعد الطهى بالميكروويف بدرجة معنوية كبيرة حيث أن متوسط محتوى الدهون فى السردين الطازج والمجمد قبل الطهى : هو ١٤٨ر ± ٥ر٥٠٣، ١٦٤ر٠ ± ٦ر٢ على التوالى وكانت بعد الطهى : ١٣٢ر٠ ± ٦١٠ر١٢، ١٨٣ر٠ ± ٢٠٦ر٦ على التوالى.

٢- كذلك لقد زاد محتوى البروتين بعد الطهى بالميكروويف بدرجة معنوية كبيرة وكان متوسط محتوى البروتين قبل الطهى فى السردين الطازج والمجمد ١ر٢ ± ١٧ر٨، ٠ر٨ ± ١ر١٦ على التوالى وكان بعد الطهى ١ر٨ ± ١٢ر٢٠ ، ٠ر٤ ± ١٧ر٢٣ على التوالى.

٣- فى حالة المعادن كان هناك أيضاً زيادة معنوية فى بعض المعادن وتشمل الزنك، الكالسيوم، المنجنيز، الصوديوم، الحديد وكانت متوسط التركيزات فى السردين الطازج وقبل الطهى هو ٠ر٠٧ ± ١٧٦، ٣ر٠ ± ٥٥، ٠٠٥ر٠ ± ٠٠٨ر٠ ± ٠٢٠ر٠ ± ٣٥ر٨، ٠٠٥ر٠ ± ٤٣٨ر٠ على التوالى وكانت بعد الطهى كالتالى : ٠٠٢ر٠ ± ٢٩٢ر٠٠، ٤ر٠ ± ٧١، ٣٠ر٠ ± ١١ر٠٠، ٨، ١٤ر٠ ± ٤٢، ٠٠١ر٠ ± ٤٩٦ر٠ على التوالى . أما فى حالة السردين المجمد، توجد زيادة معنوية فى متوسط تركيزات الزنك، الصوديوم وكانت كالتالى ٠٠٩ر٠ ± ١٧ر٠٠ ٨ر١ ± ٩٨ر٢ بالنسبة للسردين المجمد قبل الطهى وكانت بعد الطهى كالتالى : ٠٠١ر٠ ± ٣٢ر٠ ٤٠ ± ١١٠، ١.

٤- فى حالة الكالسيوم فى السردين المجمد وجد أن هناك نقص معنوى بعد الطهى عنه قبل الطهى حيث أن متوسط التركيزات فى السردين المجمد قبل الطهى كالتالى : ٥ر٧٤ ± ٨٤ر٠ وكانت بعد الطهى : ٦ر١٥ ± ٨٢٩ر٠ على التوالى.

٥- كما وجد أيضاً أنه فى حالة البرتاسيوم قل تركيزاتهم فى كلاً من السردين الطازج والمجمد بعد الطهى عنه قبل الطهى وكانت التركيزات كالتالى : ١١٩ ± ٦ر١، للسردين الطازج قبل الطهى، ٢٠٨ ± ٠٤ر٠ للسردين المجمد قبل الطهى وكانت بعد الطهى كالتالى : ١٠٨ ± ٥ر١ للسردين الطازج ر١٧٨ ± ٣٨ر١ للسردين المجمد.

٦- لقد زاد محتوى الكوليسترول بدرجة معنوية بعد الطهى فى السردين الطازج والمجمد من ٥ر٥٣ ± ٨١٩ر للسردين الطازج قبل

الطهى إلى ٥٨ر٧ ± ٦٨ر١ بعد الطهى رمن ٥٨ر٥ ± ٥ر١ قبل الطهى للسردين المجمد إلى ٤٦ر٦ ± ٩ر١ بعد الطهى على التوالى.

٧- كما كان للطهى بالميكروويف فى سمك السردين تأثير على مؤشرات تحلل الدهون، البررتين بدرجة معنوية حيث زادت بدرجة معنوية ماعدا مؤشر بيروكسيد لقد زاد بدرجة غير معنوية بعد الطهى فى السردين الطازج والمجمد عنه قبل الطهى بينما لم يكن للطهى تأثير معنوى على متوسط تركيزات الكادميوم، الرصاص، الزنبق. وكانت التركيزات لمؤشرات الدهون، البررتين فى السردين قبل الطهى الطازج كالتالى : ٤٢ر٠ ± ٠١ر٠، ٤٨ر٠ ± ٠١ر٠، ٥٨ر١ ± ٦٩٣ر٠، ٩٩٦ر٠ ± ٠٩ر٠ بالنسبة لمؤشرات الدهون، ٢٣ر١٩ ± ٣٠ر٠ بالنسبة لمؤشرات متوسط النتررچين الكلى المتصاعد بينما كان متوسط تركيزات نفس المؤشرات بعد الطهى كالتالى : ٤٧ر٠ ± ٠٨ر٠، ١٧٤ر١ ± ٠٩ر٠، ٥٦ر٢ ± ٤٩٣ر٠، ٦١ر١ ± ٢٠ر٠ بالنسبة لمؤشرات الدهون، ٨ر٢٤ ± ٤٥ر٠ بالنسبة لمتوسط النيتروچين الكلى المتصاعد.