# EFFECT OF IRRADIATION, PACKAGING AND ANTIOXIDANTS ON THE CONCENTRATION OF MONOCARBONYLS IN CHICKEN ROLLS[1]

K.N. HALL, M.B. FEY, G.J. BUONOPANE, R.G. JENSEN AND E. WIERBICKI*

University of Connecticut, Storrs, Connecticut, U.S.A.

*U.S. Army Natick Research and Development Command, Natick, Massachusetts, U.S.A.

## INTRODUCTION

UNSATURATED lipids in poultry are believed to be the primary source of oxidation products (Lillard, 1978). An accumulation of these products can produce flavors which are unacceptable. Irradiation processing increases the oxidative rate of formation of some of these products, thus reducing the flavor stability of poultry meat. Antioxidants, ascorbic acid and phosphates are frequently added to formulated meat to control lipid oxidation. Ascorbic acid may chelate pro-oxidant metals which initiate oxidation of unsaturated fat or maintain the ability of antioxidants to reduce free radicals by donating hydrogen to phenoxy radicals. (Bauernfeind and Pinkert, 1970).

The purpose of this study was to determine the effects of residual oxygen, antioxidants and irradiation processing on compounds that contribute to the flavor of chicken rolls. The variables in the study were 0, 30 and 60 kGy levels of irradiation, high and low vacuum packaging and the addition of antioxidants.

## MATERIALS AND METHODS

### PREPARATION

White meat, dark meat and skin were separated from broiler chickens. White meat was ground through a plate with 1.3 cm holes and skin with adhering fat through a plate with 0.5 cm holes. A mixture of 82% white meat and 18% skin was mixed with 3% $H_2O$, 0.75% NaCl and 0.3% sodium tripolyphosphate. Antioxidants (0.01% butylated hydroxytoluene, 0.0025% sodium ascorbate and 0.0025% ascorbic acid) were mixed with part of the added water into one-third of the tissue. Sausage casings (10.16 cm diameter) were stuffed with the mixture and heated in a smoke house for approximately 18 h to an internal temperature of 75°C. The rolls were cut into 1.3 cm slices and packaged in flexible retortable pouches, two per pouch. Those with antioxidants were sealed in pouches under low vacuum (approx. 6 ml residual air) and those without antioxidants were sealed under low vacuum and high vacuum (<1 ml residual air). All pouches were flash frozen at -45°C and subsequently irradiated (0, 30 and 60 kGy) at -45°C. Samples were stored at -29°C until analyzed.

### FATTY ACID ANALYSIS

A sample of five grams of tissue was ground with ten grams of Celite 545 using a mortar and pestle. The fluffy mixture was added to a 2.54 cm diameter glass column with a sintered glass filter and eluted with chloroform:methanol (9:1). The solvent was removed from the eluant using a rotary evaporator at 37°C. The resulting fat was streaked onto TLC plates coated with a 0.5 mm film of 2.5% boric acid and silica G and then developed in chloroform:acetone (96:4). After visualization with rhodamine B the free fatty acids were scraped and eluted. A combination of triglyceride and cholesteryl ester band was replated and separated on standard silica gel G plates developed with hexane:ethyl ether:acetic acid (90:30:2). Triglycerides and cholesteryl esters were methylated using sodium methoxide and free fatty acids with methanolic HCl. Methyl esters of the fatty acids were injected into a Hewlett-Packard GLC Model 5730-A gas chromatograph equipped with either an SP-2330 or OV-275 column. Relative amounts of fatty acids were computed by a Hewlett-Packard 3380-A integrator-recorder.

### CARBONYL DERIVITIZATION

A 2.54 cm diameter column layered with Celite 545, impregnated with phosphoric acid and 2,4-dinitrophenylhydrazine (Schwartz et al 1963), was used as a base for an additional layer of Celite 545 into which three grams of sample were ground. When eluted with hexane this two stage column accomplished both extraction of the carbonyl compounds and their derivitization to 2,4-dinitrophenylhydrazones. Hydrazones were quantified on a Guilford Model 240 spectrophotometer at 430 and 460 nm using the equation of Henick et al (1954).

### OTHER ANALYSES

AOAC methods were followed for analysis of moisture, ash, protein and fat. Other assays included NaCl (Quantabs-Ames Co., Div. Miles Labs., Inc.), inorganic phosphorus (Fiske and Subbarow, 1925), thiobarbituric acid test (Tarladgis et al, 1960).

## RESULTS AND DISCUSSION

DURING cursory evaluation of the odor and color of freshly opened pouches, we found that those with antioxidants were more acceptable than those without antioxidants.

Linoleic acid (18:2) and linolenic acid (18:3) have much higher oxidation rates than monosaturated fatty acids and are major substrates for lipid oxidation (Lillard, 1978). The results from the measurements of the free fatty acids and the fatty acid composition of the triglycerides are shown in Table 1. There were decreases in the relative percentage of free polyunsaturated fatty acids with increases in irradiation level

when samples were packaged under high vacuum or low vacuum without added antioxidants. Antioxidants added to samples packaged under low vacuum retarded the breakdown of free polyunsaturated fatty acids. Irradiation

Table 1. Percentages of Free Fatty Acids and Fatty Acid Composition of the Triglycerides From Chicken Rolls at Irradiation Levels and Packaging Conditions

| | FREE FATTY ACIDS | | | | | | | TRIGLYCERIDES | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fatty Acids | 14:0 | 16:0 | 16:1 | 18:0 | 18:1 | 18:2 | 18:3 | 14:0 | 16:0 | 16:1 | 18:0 | 18:1 | 18:2 | 18:3 |
| IRRADIATION DOSE (kGy) | | | | | LOW VACUUM WITH ANTIOXIDANTS | | | | | | | | | |
| 0 | 18.9 | 27.0 | 13.6 | 6.0 | 18.6 | 10.5 | 5.5 | 1.9 | 27.1 | 9.8 | 5.6 | 38.6 | 17.2 | 0.3 |
| 30 | 8.4 | 28.2 | 10.4 | tr | 37.6 | 9.2 | 6.3 | 2.3 | 25.2 | 9.6 | 5.3 | 38.5 | 17.6 | 0.6 |
| 60 | 6.5 | 12.5 | 12.2 | tr | 54.3 | 9.0 | 6.4 | 3.3 | 33.9 | 8.6 | 5.2 | 33.6 | 15.3 | 0.7 |
| | | | | | LOW VACUUM | | | | | | | | | |
| 0 | 32.6 | 7.6 | 9.2 | tr | 20.4 | 9.8 | 8.0 | 5.6 | 34.1 | 11.6 | 4.6 | 31.1 | 13.1 | tr |
| 30 | 16.5 | 9.9 | 14.5 | tr | 43.5 | 8.8 | 6.9 | 2.4 | 35.1 | 10.1 | 4.7 | 36.5 | 11.3 | tr |
| 60 | 23.6 | 15.5 | 23.0 | 3.0 | 26.0 | 7.1 | 4.7 | 4.5 | 36.0 | 9.8 | 4.9 | 34.4 | 10.2 | tr |
| | | | | | HIGH VACUUM | | | | | | | | | |
| 0 | 10.0 | 26.3 | 17.9 | 1.7 | 23.5 | 12.1 | 8.6 | 0.5 | 30.0 | 9.0 | 5.4 | 38.5 | 16.6 | tr |
| 30 | 16.8 | 22.8 | 11.2 | 7.0 | 26.5 | 9.1 | 6.7 | tr | 27.9 | 9.3 | 7.7 | 39.7 | 13.9 | tr |
| 60 | 13.3 | 19.4 | 20.5 | 6.4 | 28.5 | 8.9 | 7.1 | 1.0 | 28.5 | 8.0 | 10.2 | 34.8 | 13.6 | tr |

levels had no apparent effect on these polyunsaturated fatty acids when antioxidants were added.

Similar results were observed for the polyunsaturated fatty acids that were derived from the triglycerides. The trace quantity of 18:3 indicated that nearly all of it had been cleaved. Some protective effect by antioxidants is evident by the presence of measurable quantities of 18:3.

Thiobarbituric acid (TBA) values, which measures peroxide decomposition products and final reaction products of lipid oxidation, is expressed as milligrams of malonaldehyde per 1000 g of wet sample (Figure 1). The unirradiated samples packaged under high and low vacuum without antioxidants had TBA values between 3 and 4. Even though this is within the range of odor detectability it is considerably lower than that which is considered a problem (Watts, 1961). It is interesting to note that 30 and 60 kGy levels of irradiation retarded the progress of lipid oxidation when measured by the TBA test. Unfortunately, end products of oxidation can cause off-flavors at very low levels and specific oxidative changes rather than total changes may have a more important role on flavor. TBA values were very low, below the detection threshold (Watts, 1961), when antioxidants were added regardless of level of irradiation.

Tarladgis et al (1960) noted that there is no necessary relationship between the TBA test and total carbonyls present in meat. Total carbonyls, which are directly responsible for much of the flavor of chicken, increased in those samples without antioxidants (Figure 2). The quantities of unsaturated carbonyls were small in comparison to the saturated carbonyls. Antioxidants essentially prevented the formation of unsaturated carbonyls and high vacuum packaging allowed less unsaturated carbonyl formation than did low vacuum packaging. Irradiation levels increased unsaturated carbonyl formation when samples were packaged under low vacuum. No explanation is offered for the relatively high level of saturated carbonyls in the sample with antioxidant that was not irradiated. Irradiation processing increased the saturated carbonyl formation in samples packaged under low and high vacuum. Antioxidants prevented the increase in formation of carbonyls due to irradiation.

The results of other analyses are in Table 2. These results were all within the expected ranges.

## CONCLUSIONS

IRRADIATION, vacuum packaging and antioxidants have an effect on the oxidative stability of chicken rolls. Irradiation at 30 kGy caused a slight decrease in the content of linoleic and linolenic acids and 60 kGy caused a larger decrease when samples were packaged under low vacuum. The effect of irradiation on polyunsaturated fatty acids was reduced or prevented when samples were packaged under high vacuum or when antioxidants were added to samples packaged under low vacuum. Irradiation retarded the progress of lipid oxidation as measured by the TBA test. TBA numbers were very low for samples with antioxidants regardless of level of irradiation. Antioxidants essentially prevented the formation of unsaturated carbonyls. Irradiation increased the saturated carbonyl concentration in samples packaged under low and high vacuum. Antioxidants prevented this increase in carbonyls due to irradiation.

Table 2. Mean results of other analyses

| IRRADIATION DOSE (kGy) | % fat | % protein | % ash | % moisture | %NaCl | % phosphates |
|---|---|---|---|---|---|---|
| | | | LOW VACUUM WITH ANTIOXIDANTS | | | |
| 0 | 8.66 | 22.59 | 1.85 | 69.80 | 1.29 | 1.13 |
| 30 | 9.02 | 21.41 | 1.92 | 67.25 | 1.29 | 1.29 |
| 60 | 7.89 | 22.20 | 1.85 | 66.84 | 1.29 | 1.11 |
| | | | LOW VACUUM | | | |
| 0 | 6.71 | 22.71 | 1.92 | 62.80 | 1.28 | 1.19 |
| 30 | 7.81 | 24.08 | 1.92 | 65.31 | 1.28 | 1.08 |
| 60 | 10.18 | 22.26 | 2.03 | 64.64 | 1.29 | 0.88 |
| | | | HIGH VACUUM | | | |
| 0 | 6.41 | 22.02 | 1.91 | 64.88 | 1.29 | 0.92 |
| 30 | 12.44 | 22.68 | 1.77 | 64.44 | 1.28 | 0.08 |
| 60 | 11.59 | 22.86 | 1.89 | 65.75 | 1.28 | 1.06 |
| Mean | 8.97 | 22.53 | 1.89 | 65.97 | 1.29 | 1.08 |
| S.D. | 2.08 | 0.72 | 0.07 | 1.96 | 0.01 | 0.04 |

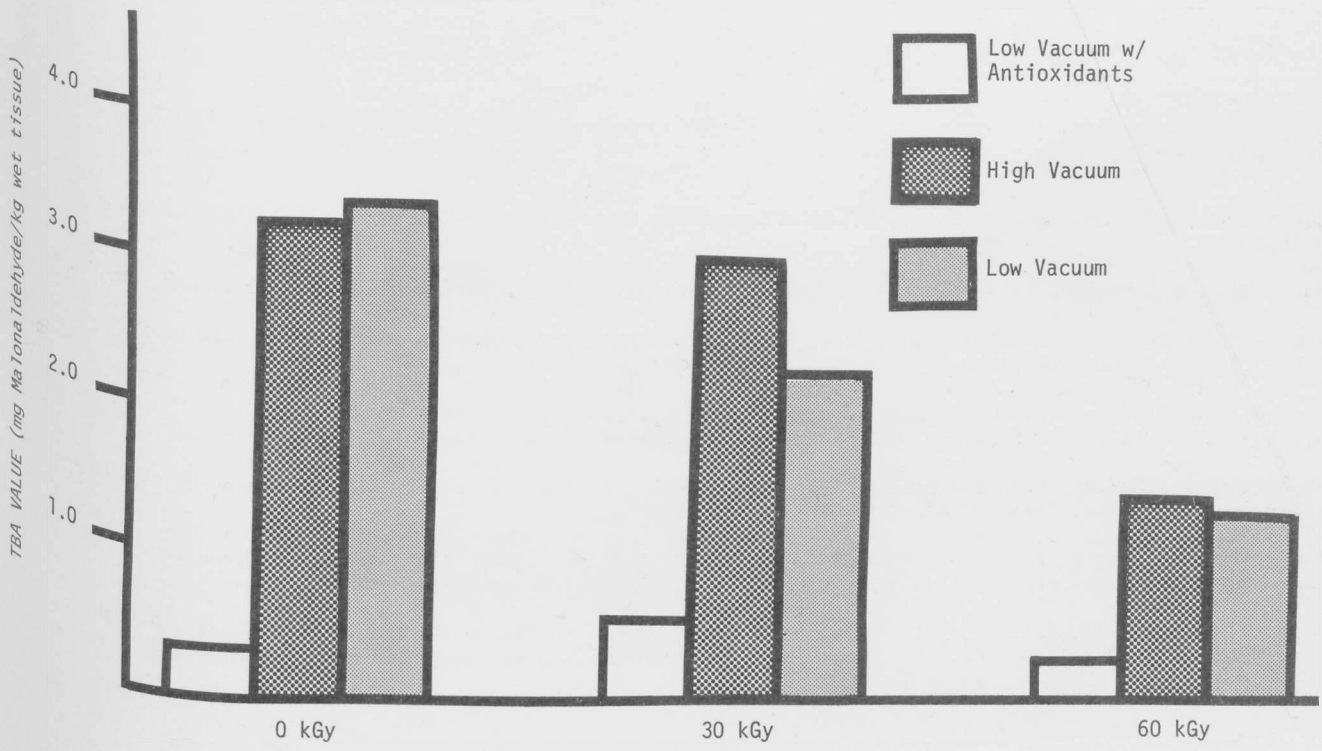


Fig.1 - Thiobarbituric acid (TBA) values for chicken roll samples at irradiation level and packaging conditions

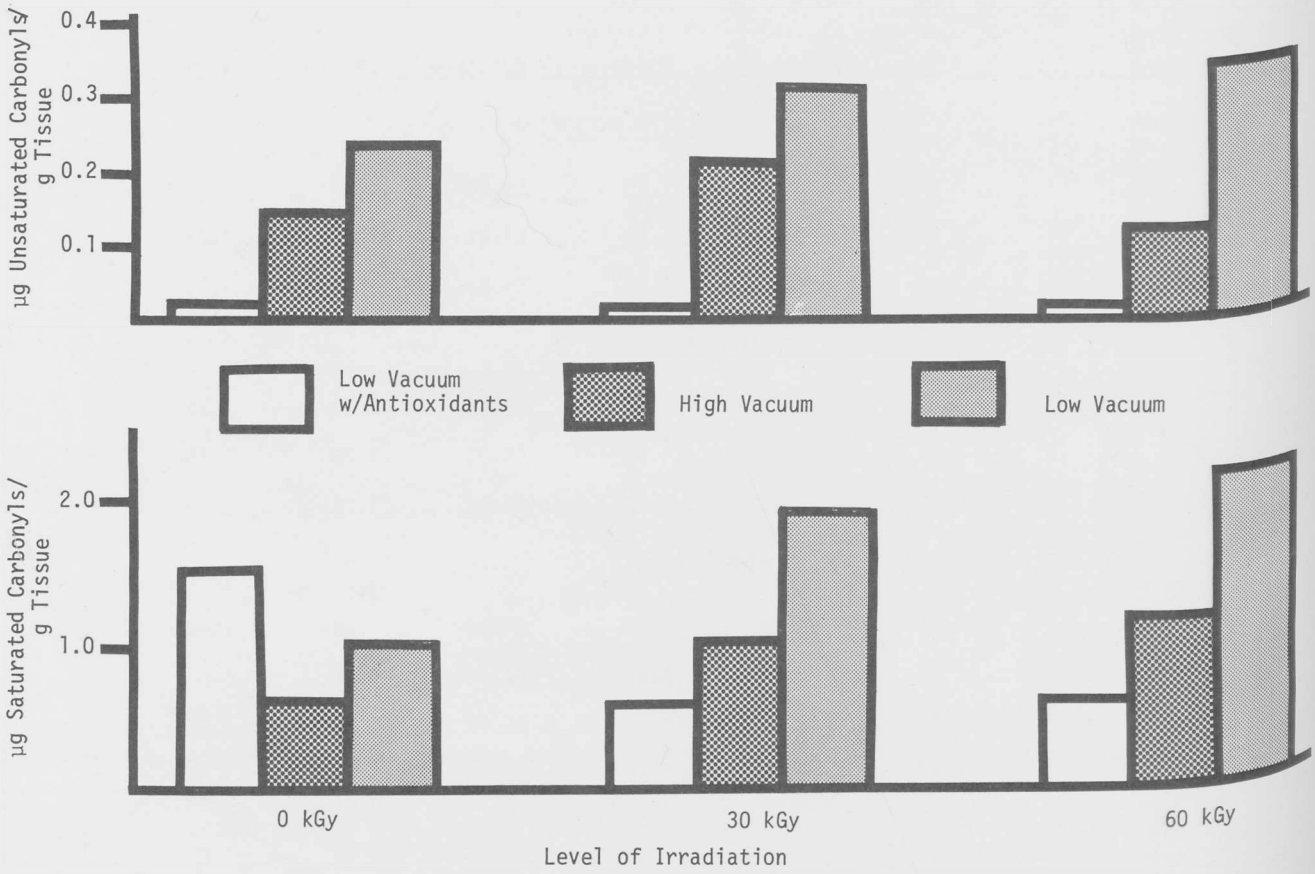


Fig.2 - Total saturated and unsaturated carbonyls for chicken roll samples at irradiation levels and packaging conditions

REFERENCES

Bauernfeind, J.C. and Pinkert, C.M. 1970 Food Processing with added ascorbic acid. Adv. in Food Res. 18:219.

Fiske,C.H. and Subbarow, Y. 1925. The colorimetric determination of phosphorous. J. Biol. Chem. 66:375.

Henick, A.S., Benca, M.F. and Mitchell, J.H., Jr. 1954. Estimating carbonyl compounds in rancid fats and foods. J. Am. Oil Chem. Soc. 31:88.

Lillard, D.A. 1978. Chemical changes involved in the oxidation of lipids in foods. p.68. In "Lipids as a Source of Flavor", Ed. Supran, M.K. ACS Symposium Series 75. Am. Chem. Soc., Washington, D.C.

Schwartz, D.P., Haller, H.S. and Keeney, M. 1963. Direct quantitative isolation of monocarbonyl compounds from fats and oils. Anal. Chem. 35:2191.

Tarladgis, B.G., Watts, B.M., Younathan, M.T. and Dugan, L., Jr. 1960. A distillation method for the quantitative determination of malonaldehyde in rancid foods. J. Am. Oil Chem. Soc. 37:44.

Watts, B.M. 1961. The role of lipid oxidation in lean tissues in flavor deterioration of meat and fish. p. 83. In "Proceedings Flavor Chemistry Symposium-1961". Campbell Soup Company, Camden, N.J.

[1] Scientific Contribution No. 827, Storrs Agricultural Experiment Station, The University of Connecticut, Storrs, Connecticut 06268