

RADURIZATION AND RADICIDATION OF MEAT IN SOUTH AFRICA

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INTRODUCTION

Fresh meats, especially when minced, have a very limited shelf life at refrigeration temperatures. Ionizing radiation as a means of preservation and hygienization of meat and meat products has been investigated for more than 30 years in many countries (Wierbicki *et al*, 1975). The basic approach has been to isolate typical spoilage bacteria and to inoculate these into fresh meat. After radurization these samples were stored at refrigeration temperatures to investigate the keeping quality (Wolin *et al*, 1957; Maxcy and Tiwari, 1972).

In our study we investigated the effects of different radiation doses on several bacterial groups as they occur naturally in fresh meat, as well as the interaction of the surviving bacteria during storage. Simultaneously, we applied several chemical-physical methods to obtain additional information on the meat quality, which, together with the microbiological analyses, reflect the advantages accrued with irradiation.

MATERIALS AND METHODS

The following culture media were employed to enumerate specific bacterial groups: Blood agar (Difco) - total aerobic bacteria; Standard I nutrient agar (Merck) - total anaerobic bacteria, psychrotrophes; *Lactobacillus*-selective agar (Rogosa)(Merck) - lactic acid bacteria; Violet Red Bile agar (Merck) - enterobacteria; *Pseudomonas*-selective agar (Kielwein, 1969) - pseudomonads; Streptomycin sulphate, Thallous acetate, Actidione medium (Gardner, 1966) - *Microbacterium thermosphaatum*; Citrate Azide Tween Carbonate agar (Merck) - enterococci; Baird-Parker medium (Oxoid) - staphylococci. The presence of *Salmonella* was determined qualitatively according to a modification (Holzapfel and Hall, 1976) of the method of Georgala and Boothroyd (1970).

Meat samples to be analysed were homogenised in a Stomacher Model 400 (Sharpe and Jackson, 1972) by mixing 20 g minced meat with 180 ml physiological saline for 2 min. From this homogenate, samples were taken for bacterial investigations as well as chemical-physical analyses. The extract release volume was determined according to Jay (1964). The free fatty acids extracted with chloroform were determined by titration with 0,01 N NaOH. Titratable alkalinity was determined by the method of Shelef and Jay (1970). Free amino acids were determined by a modification (Holzapfel, 1979) of the formaldehyde method (Ling, 1956). Meat samples were vacuum-packed in polyethylene-polyester-laminated pouches. Irradiations were carried out in a Gammabeam 650 facility at a dose rate of 3,64 kGy/h at 25 °C.

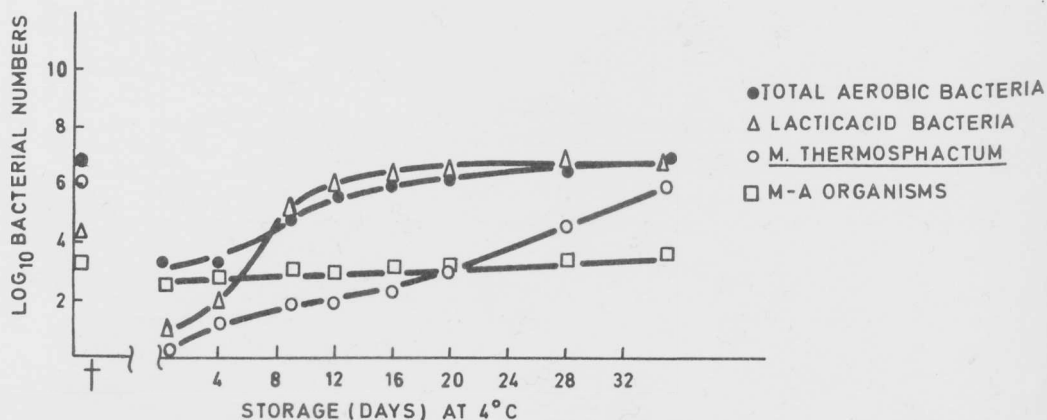
RESULTS AND DISCUSSION

Bacteriological analyses

Ground beef

The effects of a 3 kGy dose on several bacterial groups in ground beef are illustrated in Fig. 1.

Fig. 1. Effects of ionizing radiation on different bacterial groups in vacuum-packed ground beef



**Moraxella-Acinetobacter* (M-A) organisms were determined by a statistical procedure from total aerobic plates and identified according to Maxcy and Tiwari (1972).

[†]pre-irradiation numbers.

The pseudomonads, mainly responsible for spoilage of control samples, were completely destroyed by a 3 kGy dose and could not be detected at all for the duration of the storage period. The same applied to the enterobacteria and enterococci. Numbers of *M. thermosphactum* present in control samples in relatively large numbers, showed a great reduction at a 3 kGy dose. These bacteria multiplied during storage at 4 °C and contributed significantly to the total bacterial load at the onset of spoilage. The lactic acid bacteria followed the same pattern. However, a smaller reduction in numbers due to radurization was observed (99,9 %). Relatively high numbers were reached at the end of the storage period. The M-A organisms showed comparatively high resistance to the lethal effects of radiation and therefore could be detected in meat samples after irradiation. It was found, however, that these organisms did not increase significantly in numbers during storage, and were eventually overgrown by the gram-positive bacteria, even though the latter exhibited less resistance to the same radiation dose.

Staphylococcus colonies yielding a positive coagulase reaction were demonstrated in most control samples at levels of less than 1 000 per gram. However, doses as low as 1 kGy eliminated these organisms and no typical Staphylococcus colonies could be isolated on the appropriate medium from any irradiated samples.

A survey of the incidence of Salmonella in minced beef showed that 16,6 % of the samples obtained from 30 retail outlets were contaminated with this potential pathogen. After isolation, identification and serotyping, the radiation resistance in culture medium of all the isolates was determined and found to be relatively low, with D_{10} values between 0,37 to 0,63 kGy. This implies that even for the most resistant isolate (strain 10/S1b) a 3 kGy dose would destroy 58 000 bacteria per gram, if present in meat in such large numbers.

If a total aerobic count of 10 million bacteria per gram is considered to be the upper limit of acceptability, then many samples of ground beef obtained at the retail outlets investigated could be regarded as unfit for human consumption. The lowest total count for a ground beef sample during this investigation was 6 million bacteria per gram, whilst the highest value exceeded 500 million per gram. These findings are in agreement with those of other researchers (Rogers and McCleskey, 1957; Duitschaever *et al*, 1973) and are indicative of poor quality. This is a consequence of carelessness in the preparation of the product, or else of too long a storage period at too high a temperature (Rogers and McCleskey, 1957). However, we found that ground beef sold as 'top-side mince' was of a much higher quality, with numbers of total aerobic bacteria averaging 100 000 per gram.

The drastic reduction of large numbers of spoilage bacteria by radurization points to the considerable advantage attained with this treatment. Application of the same microbiological criteria to 3 kGy irradiated samples would therefore suggest that an unacceptable level would only be reached after 6 to 7 weeks at 4 °C. It must be emphasised, though, that only meat of high quality should be used for radurization. Irradiation should not be regarded as an excuse for bad hygiene or careless handling. Once deterioration has started it cannot be reversed by radurization even though large numbers of bacteria are destroyed.

Vacuum-packed beef cuts

The bacteriology of vacuum-packed, prime beef cuts, irradiated to a 2 kGy dose, was also investigated. Initial counts of all bacterial groups were considerable lower (Table 1) and therefore a lower dose (2 kGy) was found to give a significant extension of the shelf life.

Table 1. Effects of a 2 kGy radiation dose on bacterial groups of vacuum-packed beef cuts

Micro-organisms*		Weeks storage [†] at 4 °C			
		0	2	4	8
Total aerobes	control	4,34	6,38	7,58	8,15
	2 kGy	<1	4,77	5,98	6,11
Total anaerobes	control	2,04	6,04	7,46	7,94
	2 kGy	<1	3,88	----	6,18
Lactic acid bacteria	control	<1	3,93	3,28	5,38
	2 kGy	<1	3,70	----	5,76
Enterobacteria	control	<1	4,79	7	6,43
	2 kGy	<1	<1	<1	<1
Pseudomonads	control	1,34	6,20	6,88	7,2
	2 kGy	<1	<1	<1	<1

*All counts expressed in $\log_{10}$ figures.

[†] All groups monitored at weekly intervals.

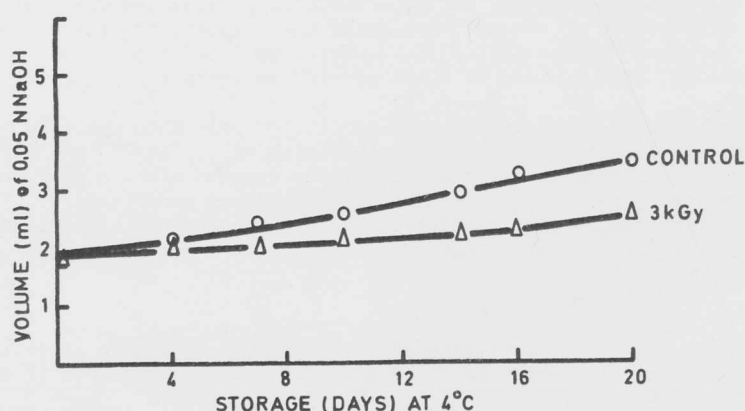
The study with vacuum-packed beef cuts was initiated at the request of a major meat supplier. General practice at present is to store such prime cuts at 0 °C, thereby rendering an average shelf life of approximately 6 weeks. If one regards the upper limit of acceptability for beef cuts also, as 10 million aerobic bacteria per gram, then control samples would have had a shelf life of less than 4 weeks compared to more than 8 weeks as effected by a 2 kGy dose. This is a considerable advantage with regard to energy savings as well as reduced losses and it could be an attractive proposition for commercial application. Edible animal offal is a traditional favourite of especially the Black population in Africa. It is relatively cheap and a rich source of protein in their diet. The radurization of these products has been studied by Van den Heever (1977). During his investigation, great difficulty was encountered with the reproducibility of results, but he could double the keeping time with the application of a 6 kGy dose. The same author also studied combined heat and irradiation treatments with favourable results. Radurized offal was perfectly acceptable when judged organoleptically. Further work on the microbiology of radurized offal needs to be done.

Chemical-physical analyses

It was envisaged that the chemical-physical analyses would reflect the quality of radurized and control meat samples. When applied as described in the literature, a general tendency in agreement with the bacteriological data could be found, but the results were unsatisfactory in many ways. Most methods gave very erratic results and even pH values *per se* were not useful as a short-term indicator of meat quality. This could be attributed to several factors relating to the metabolic activities of different micro-organisms in the meat.

Five methods were employed, and of these, the results of the modified formol titration method were the most reliable and meaningful (Fig. 2).

Fig. 2. The effect of a 3 kGy dose on the formol titration values of ground beef



When the meat became bacteriologically spoiled, titration values usually exceeded 2,5 ml 0,05 N NaOH.

Organoleptic evaluations

Organoleptic evaluations were carried out on ground beef as well as beef cuts vacuum-packed and irradiated at doses of 3 kGy and 2 kGy respectively. Ground beef samples were cooked without salt or spices. A panel of 12 members evaluated control and irradiated samples in the triangle - as well as the score ranking test. The panel could detect samples irradiated at doses higher than 2 kGy but did not find them objectionable even after six weeks of storage at 4 °C.

The evaluations on beef cuts were carried out at the National Research Institute of Animal and Dairy Sciences at Irene. Sirloin cuts were roasted at 160 °C until the internal temperature reached 75 °C. The following parameters were applied: cooking loss, water-holding capacity, cutting resistance, softness, juiciness, taste and odour, and residue. The results are shown in Table 2.

Table 2. Organoleptic evaluations of beef cuts

	Week 2		Week 4		Week 8	
	Control [†]	2 kGy	Control	2 kGy	Control	2 kGy
Cooking loss %	21,9	20,1	23	25,8	26,3	27,1
Water not bound %	37,3	39,6	45,6	52,4	43,8	40,5
Cutting resistance (Newton)	84,5	81,2	66,1	76,2	85,5	78,7
softness	3	3	3,5	3,17	4	4,3
juiciness	3	2,17	2,67	2,33	3	2,8
taste and odour	3	2,5	3,5	3	3,5	2,2
residue	3,5	3,5	4,3	4,17	4	4,5

*rating done as: excellent = 5 to very poor = 1.

[†]Controls in this experiment were stored at 0 °C to attain a shelf life of at least 8 weeks whilst irradiated samples were stored at 4 °C.

The irradiated samples scored as well or slightly better than the controls in all criteria except taste and odour. This could be the result of the fact that the temperature during irradiation was about 25 °C. Irradiation at temperatures of 0 to 4 °C is now being investigated as a means of improving the taste and odour quality.

CONCLUSIONS

Our results confirm the preservation potential of ionizing radiation for meat. A considerably lengthened shelf life can be attained whilst pathogenic micro-organisms are destroyed. This potential applies only to vacuum-packed meat which is as yet an uncommon way of selling at retail level. With plastic pouches becoming increasing popular for many food commodities, the application for radurized meats could become feasible.

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