DEVELOPMENT OF LUMINESCENCE TESTS TO IDENTIFY IRRADIATED FOODS

Progress Report 1: Project N384

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"But,Sir, though I be very backward to admit strange things for truths, yet I am not very forward to reject them as impossibilities, and therefore would not discourage any from making further inquiry whether or no there be in Rerum Natura, any such thing as a true Carbuncle, or Stone that without rubbing will shine in the Dark"

Robert Boyle,1663, in a letter to Sir Robert Moray concerning observations of a shining diamond.

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FIGURES AND DIAGRAMS

1.1 Introduction.

This is the first report of progress on project N384, aimed at developing luminescence tests to identify and quantify radiation treatments to diverse foodstuffs. Short feasibility studies were undertaken at SURRC in 1986 and 1987 and reported at a UK meeting on prospective methods for identifying irradiated foods (Sanderson and Izatt,1987, Parsons,1987).

Full time work began in December 1987, initial efforts being concentrated on establishing a significant corpus of irradiated samples , and on thermoluminescence (TL) measurements of them. Section 2 outlines the overall TL response of 161 samples of herbs, spices and seasonings irradiated using the 200 TBq cobalt-60 facility at SURRC. The stability requirements are discussed in section 3, which introduces a comprehensive validation procedure which should cover the needs of most tests. Section 4 is directed to the origins of the TL signals in food samples,results so far confirming our working hypothesis that the signals are associated with minor inorganic impurities in the samples. Initial progress in developing instrumentation to study phototransferred and photostimulated luminescence is outlined in section 5. Our expectation is that these new techniques will have a very significant role to play at later stages of the work. Section 6 summarises the results so far and indicates the immediate priorities for future work. Finally comprehensive details of sample credentials and measurements are appended.

1.2 Background and aims of the project

The research is motivated by the need for reliable laboratory tests to identify irradiated foods - a need expressed by United Nations and World Health Organisation bodies (FAO/WHO,1983), by the UK advisory committee on Irradiated and Novel Foods (ACINF,1986), and by considerable public demand in the UK (eg Webb & Lang,1987,Goodburn,1987a,b, Swallow,1988).

Although it is still illegal to sell irradiated foods in the UK there is a significant, and growing, overseas capacity summarised in table 1.1 below. The possibility of inadvertent or malign imports of irradiated foods to the UK, and the likely revision of the UK position add to immediacy the work.

The range of radiation doses recommended for commercial food processing in the UK and overseas is summarised in Table 1.2 below, and spans a range from 0.03 kGy to 50 kGy. 10 kGy is the maximum dose recommended for non-medical use.

Both FAO/WHO codices and the ACINF report advance the concept of "good irradiation practice" ,ie the use of recommended doses for the purposes outlined above and the proscription of re-irradiation of foods which have exceeded their shelf life. Furthermore it is accepted that labelling will be needed to protect consumer choice.

In the absence of appropriate laboratory tests these will depend on control of irradiation plant, and documentary validation. Both of these approaches have shortcomings, especially in respect of imported food.

Table 1.1 Current uses of Food Irradiation (FAO/IAEA,1987)

Country	Since	Use and annual tonnage
Belgium	1981	Spices(300), Frozen Foods (2000) Dried Vegetables (700)
Denmark	1986	Spices
Finland	1986	Spices
France	1981	Spices (500-600)
	1986	Spices and Poultry (300)
E. Germany	1983	Onions,Garlic (600)
	1986	Onions (4000), Enzyme sol. (300)
Netherlands	1978	Spices (100) and various foods
Norway	1982	Spices (500)
Israel	1986	Spices (120)
South Africa	1981	Fruits,meats,onions,potatoes Spices, dried vegetables
USA	1984	Spices (1500)
USSR	1983	Grains (400,000)
Japan	1973	Potatoes (20,000)

Table 1.2 Recommended Food Processing Doses (ACINF,1986)

Purpose	Dose /kGy
Inhibition of Sprouting	0.05-0.15
Delaying ripening of fruits	0.2 -0.5
Insect disinfestation	0.2-1.0
Elimination of parasites	0.2 -1.0
Reduction of microbial load	0.03-5.0
Elimination of non-sporing pathogens	3.0-10.0
Bacterial sterilisation	up to 50

Qualitative laboratory tests are needed to support labelling regulations and current import restrictions. Here it will be sufficient to either show that (a)" irradiated" food has been so treated or (b) that "unirradiated" food has not. These two conditions are not necessarily synonymous.

Beyond this the verification of good irradiation practice will need tests which are capable of quantitative dose estimation and also of establishing the duration and nature of post irradiation treatment including possible re-irradiation.

The project aims are to investigate the potential of three luminescence techniques to meet these broad objectives. These are thermoluminescence, photo-transferred luminescence and photostimulated luminescence. They share the common feature of being targetted at measurement of radiation induced populations of trapped charge carriers in irradiated

dielectric components in foods. This is done by stimulating the charge out of the traps by supplying non-ionising energy to the system and then observing luminescence arising from the subsequent relaxation process. The stimulation techniques however differ. TL makes use of the enhanced thermal energy of the sample lattice or molecular structure to release trapped charge under conditions of controlled heating. In Phototransferred luminescence (PTTL) an optical exposure is used to depopulate trapped charge while holding the sample at a low temperature to enable re-trapping at another site. The signal is then recorded during a subsequent TL measurement at lower temperatures than otherwise needed. Finally photo-stimulated luminescence (PSL) is phosphorescence arising from relaxation during or immediately after optical illumination. It is hoped that these latter two techniques will have a better signal to background ratio than TL for food samples.

In addition to our own feasibility measurements there are reports of other work on luminescence of foods. Lyoluminescence (ie light emitted during sample dissolution) has been proposed as a possible dosimeter for sacharides and carbohydrates (Ettinger et al,1977,1978). A similar technique using luminol solutions as lyoluminscence amplifiers has also been applied to qualitative assessments of spice samples by the Institute of Strahlenhygiene in Neuherberg, Germany(Bogl & Heide, 1984a,1984b,1985,Heide & Bogl,1985b). In the course of such work it was noticed that chemiluminescence intensities were enhanced by warming the samples, and this led to the discovery that the signals were even brighter if the sample was not put into the luminol solution! The ISH group have subsequently used both TL and Chemiluminescence measurements in complementary form (Heide & Bogl,1984b,1985a,1986,1987), and are currently organising a blind interlaboratory study (which we have participated in) as a prelude to achieving recognised legal status (in Germany) for the tests.

While recognising the important contribution of this work there are significant outstanding problems which must be resolved before it can be finally accepted. The chemiluminescence results show serious problems of long term stability which have not yet been studied over a full range of storage temperatures and times. Furthermore it has been assumed that the TL signals (which are extremely variable) recorded from spices arise from major components, which is not only surprising but also unsubstantiated. This assumption has also been adopted by Moriarty et al (1988) who have recently reported a preliminary study of 7 spices samples, also using unseparated whole samples.

Our working hypothesis at the outset of this project was that the TL signals from spices and vegetable samples are associated with adhering mineral detritus rather than with an intrinsic component. An initial priority has therefore been given to assessing this and to establishing whether or not it precludes the use of whole-sample measurements for qualitative purposes.

1.3 The significance of spices.

It is evident that spices are of foremost interest in food irradiation studies, a fact reflected in the focus of the ISH work discussed in the previous section. The need for irradiation arises because of the notoriously high infestation and microbial loads which they are subject to as a combination of tropical origins, storage conditions, and long shelf lifes. They also have a high specific value which can stand the costs of radiation processing, and there are drawbacks to alternative disinfestation procedures (ethylene oxide treatment, or solvent extraction of oleoresins).

Nevertheless the current estimated european irradiation capacity for spices amounts to some 1500 tons per year, which is only one to two per cent of the annual european spice consumption. The 1979 spice imports to the EEC and the UK are tabulated below and indicate both the minor extent of current irradiation capacity, and perhaps the growth potential for irradiation if the present obstacles are removed. Growth in pepper consumption was estimated at 4% per year in 1979 (UNCTAD,1982a,b).

Table 1.3 Spices imports to the EEC and UK in 1979 (UNCTAD,1982a)

	EEC		UK	
Type of Spice	Quantity	Value	Quantity	Value
Pepper	31,191	73.4	5,014	11.4
Ginger	6,158	8.0	3,802	4.57
Cardamom	450	5.0	135	1.3
Cloves	1,622	11.7	218	1.37
Cinnamon/Cassia	3,905	4.9	662	0.7
Capsicum,Chilli,& Paprika	22,774	35.2	2,392	4.6
Nutmeg/Mace	5,421	11.5	617	1.3
Pimento(allspice)	853	1.4	92	0.2
Turmeric	3,612	3.8	2,411	2.4
Spice seeds	16,542	17.9	3,591	3.7

Quantities in tons, Values in million US $.

The case for measuring herbs and seasoning mixes arises from similar considerations.

2. Thermoluminescence of herbs, spices and seasonings

2.1 The samples and irradiation procedures

For the first stages of the investigation 161 diverse samples of herbs spices and seasonings were obtained from retail and wholesale outlets and used for TL sensitivity and stability tests. An index of sample types and suppliers in given in appendix B, and fuller details including country of origin and dates of purchase are given in appendix C. In addition to this we have received over 50 German samples from Dr. Lydia Heide as part of the second ISH RingVersuch. These are also listed in Appendix C but not discussed further in this report.

Each sample was logged in to the laboratory record and 8 aliquots prepared, four of which which were simultaneously irradiated to a nominal 10 kGy gamma dose in the SURRC cobalt-60 facility. Coarse grained or leaved samples were either ground or chopped finely using a pestle and mortar or a herb knife before packaging. Care was taken at all stages to work on clean surfaces and to avoid cross contamination. Each batch of samples was accompanied by several Harwell 4034 red perspex dosimeters (Whittaker,1970, Whittaker et al 1985) used to determine the dose variation of each batch. The calibration of our red dosimetry system has been reviewed recently as part of a high dose dosimetry project (Ward,1988), and we can confirm that the dosimeters can be read to 1% precision, and can be traced to NPL ,NBS and AECL standards via a recent recalibration exercise with Harwell (Glover et al,1985). In practice the dose variation across a finite package of samples was much greater than this precision level. Appendix E gives full details of dosimetry readings for the batches of samples. The dose rate was roughly 2.5 kGy per hour.

After irradiation the four subsamples and associated unirradiated blanks were sealed in black plastic bags and stored at either -20°C ,5°C, 30°C or 55°C centigrade in freezer,fridge, incubator or oven ready for TL measurements.

2.2 TL sensitivity measurements.

The irradiated samples stored at 30°C and their associated blanks were all used for initial TL sensitivity measurements 3-4 days after irradiation to 10 kGy. It is intended to repeat each of these measurements after several months. Individual run details and notes are given in Appendix D; the procedure is described here.

The samples were dispensed onto weighed 1 cm diameter 0.25mm thick stainless steel discs which had been previously ultrasonically cleaned in acetone and coated with a thin layer of Electrolube silicone grease as a contact lubricant. Excess material was shaken off and the sample weights recorded. Typical sample weights on disc ranged from 1 to 15 mg. All sample handling was conducted under subdued red light as we wish to isolate the perturbing effects of bleaching of TL by white light for study under controlled conditions.

The discs were then taken to the TL readout laboratory and glow curves recorded from ambient temperatures to 500°C at a heating rate of 6°C s^{-1}. The TL reader used was a single sample research reader with computer controlled temperature program, single photon counting light detection (EMI 9883QB photomultiplier) with a bandpass restricted to 350 to 450 nm by Chance HA3 and Corning 7/59 filters. Oxygen free nitrogen was flowed through the oven to suppress spurious (ie non radiation induced) luminescence. We were pleasantly surprised to have few problems with spurious signals given the nature of the samples; the exception to this was on a single occasion when the oven was badly contaminated with vapours and partciles from previous samples (see Basil, below). Each glow curve was recorded in 250 channels (2 degrees per channel) and followed by an automatic re-heat cycle to determine dark counts and black body background. The net TL curves were calculated on line and archived before being subject to an automatic data reduction procedure including generation of scaled plots, peak temperature and intensity identification and calculation of weight normalised thermoluminescence in 10 degree bands from 200 to 500 degrees.

Every irradiated sample was accompanied by a full blank comprising an identical unirradiated blank processed in parallel at every stage.

2.3 Results of whole sample measurements.

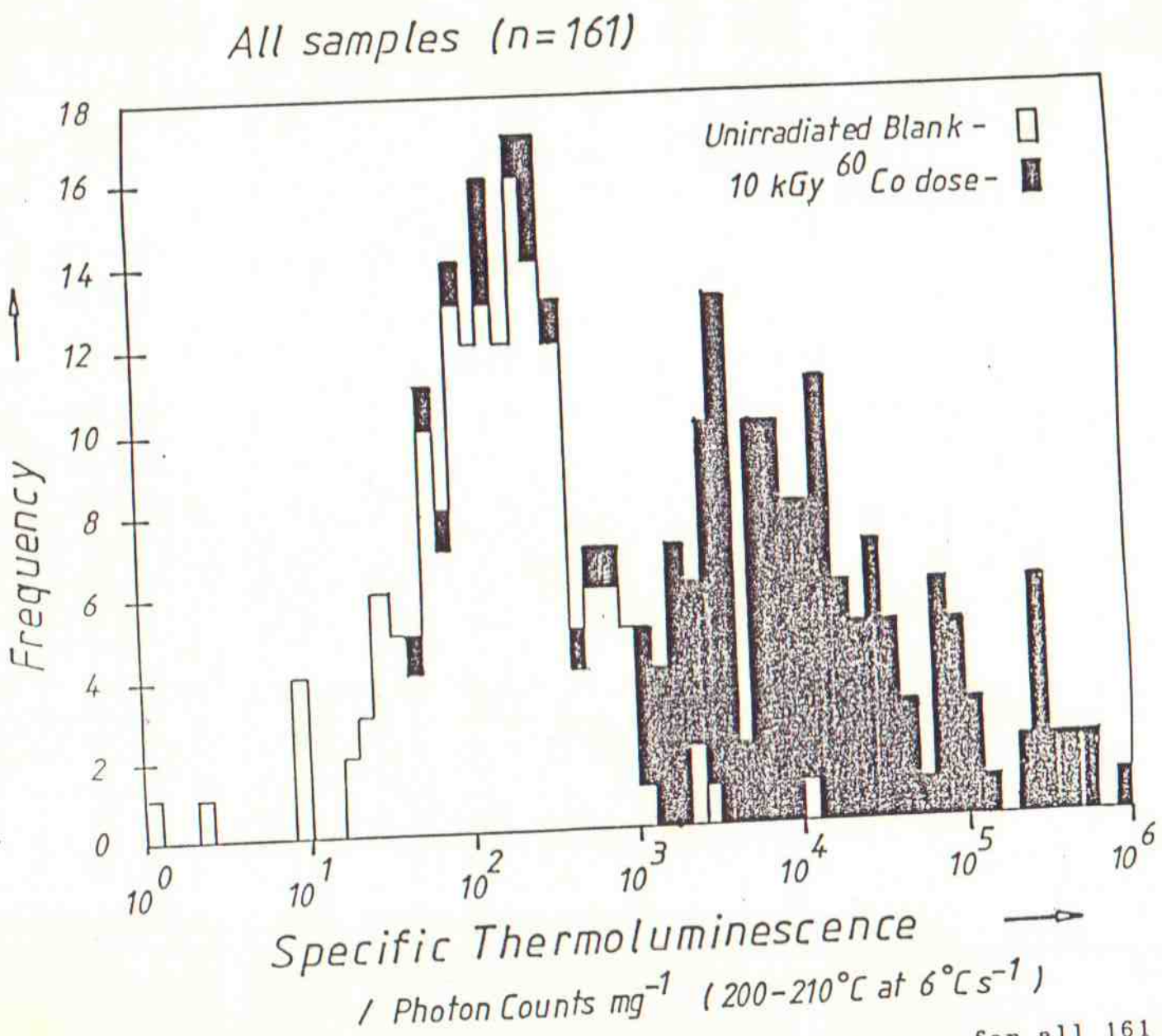
The initial sensitivity measurements confirmed our expectations that whole samples display a range of promising characteristics. By far the majority of irradiated samples showed positive signals compared with their blanks. The overall histogram of TL sensitivity at 200-210°C summarises the discriminating power of simple whole-sample results. TL sensitivities range over more than 5 orders of magnitude - providing ample justification of the decision to begin the project with an intensive sample survey. Levels from unirradiated samples also show variation of 3 orders of magnitude. It is notable that although the majority of samples can be correctly identified as irradiated or unirradiated on the basis of these simple measurements there are significant exceptions. Four samples show high blanks and roughly 20 samples out of 161 show very low TL sensitivities compared with blanks. Another interesting feature of the overall histogram is that blanks and irradiated samples show roughly log-normal distributions. This implies fractional sensitivity variation from sample to sample which is extremely significant in the light of the possibility that the signals originate from a minor and varying component.

The situation improves somewhat if groups of whole seeds which consistently show negligible TL are excluded and the sample is subdivided into categories of herbs, spices and seasonings. This is shown in figure 2.2. Greater than 90% separation can now be achieved for herbs and spices, and seasoning mixes containing salt can be unambiguously resolved.

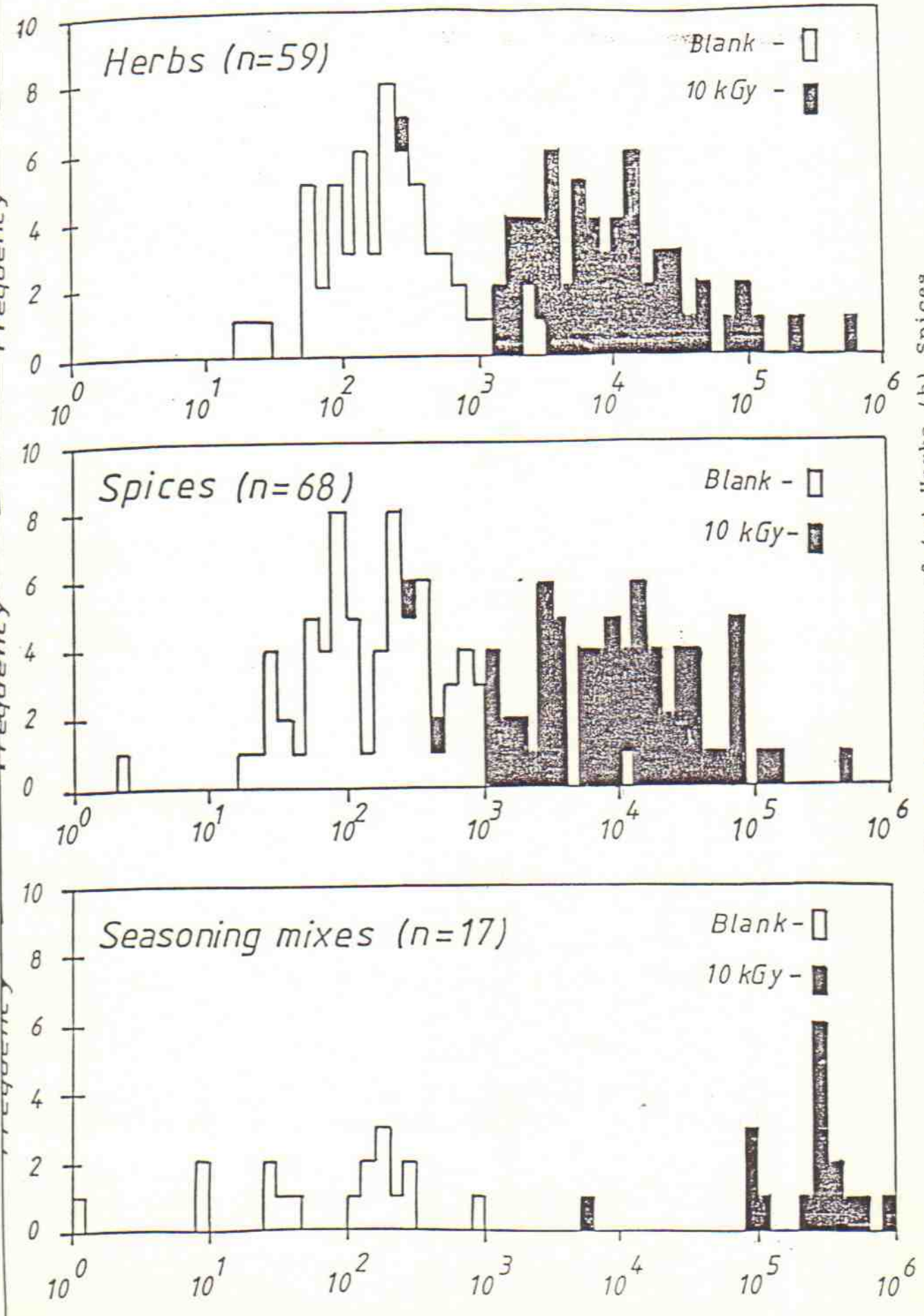
There are also signs that high sensitivity samples also have high blanks and therefore discrimination is improved when the samples are sorted into individual groups. This is shown for herbs in figure 2.3. Rosemary has shown high blanks from two different sources, and may need further investigation. Figure 2.4 to 2.11 show examples of glow curves from basil, marjormam, mint, oregano, sage, thyme and miscellaneous samples, all of which display a remarkable similarity of form (see section 4). The basil sample SP135, incidently illustrates the spurious TL phenomenon clearly where if the nitrogen flow is restricted ,or the oven contaminated there is a high and irreproducibale signal above 450°C. Fortunately this does not interfere with the temperature region of interest to this study, and in any case our experience is that it can be avoided by careful laboratory techniques.

The discrimination of spices from their respective blanks is also improved by sorting them into categories relating to their morphological forms as shown in figure 2.12. Spices of course comprise an enormous variety of plant materials, we take the taxonomic definitions from Purseglove et al (1981). It is especially notable that whole seeds have the problematic low-sensitivity samples- which we believe to be a significant reflection of the inorganic origin of the signal. Capsicums, Rhizomes and Barks by contrast have the highest whole-sample sensitivities. Glow curves from paprika,cayenne & chilli,ginger, ground onion and garlic, and black and white pepper are shown in figures 2.13-2.17, again showing a remarkable consistency of form.

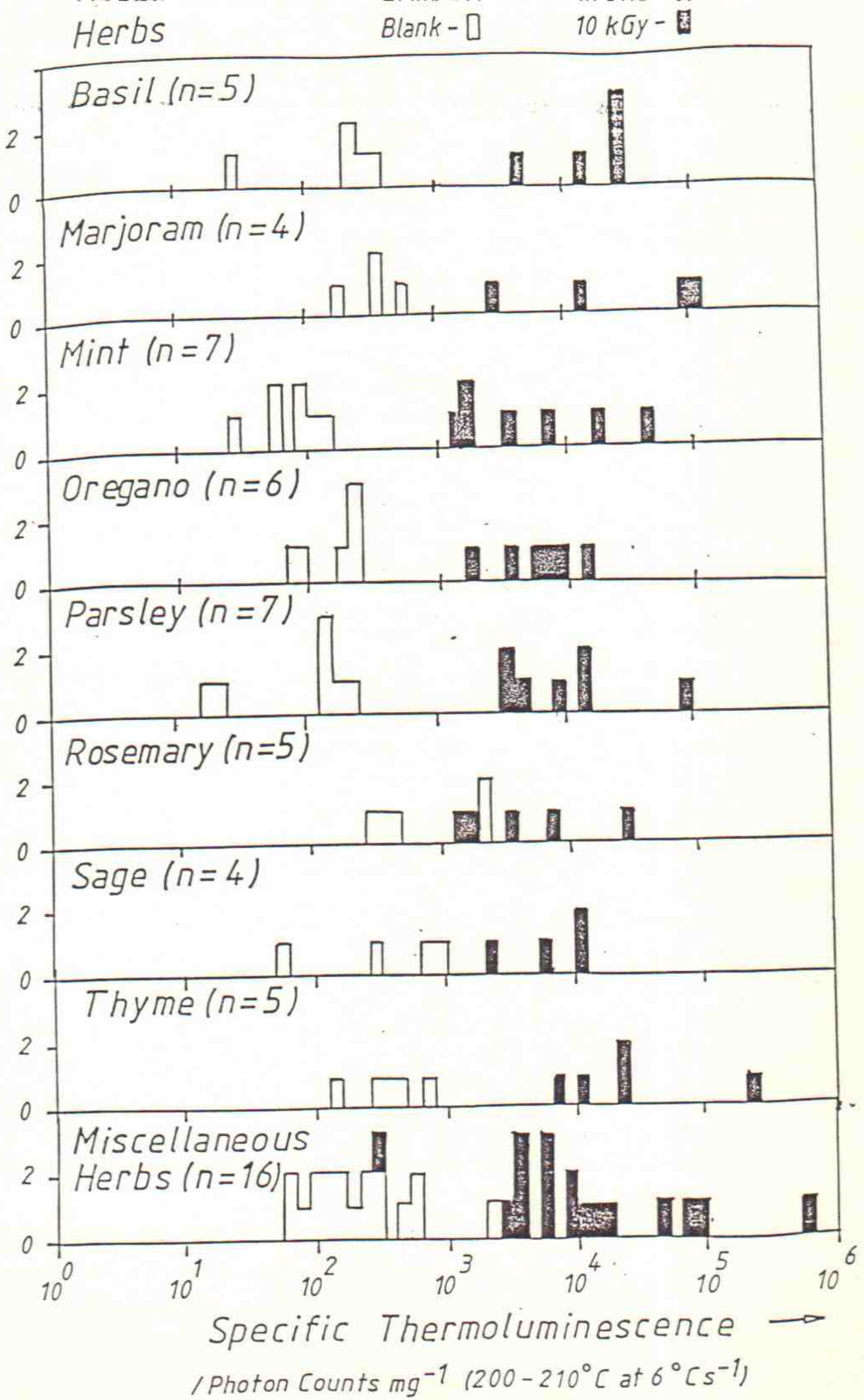
The glow curves from seasonings containing salt and other special samples are discussed in section 4.



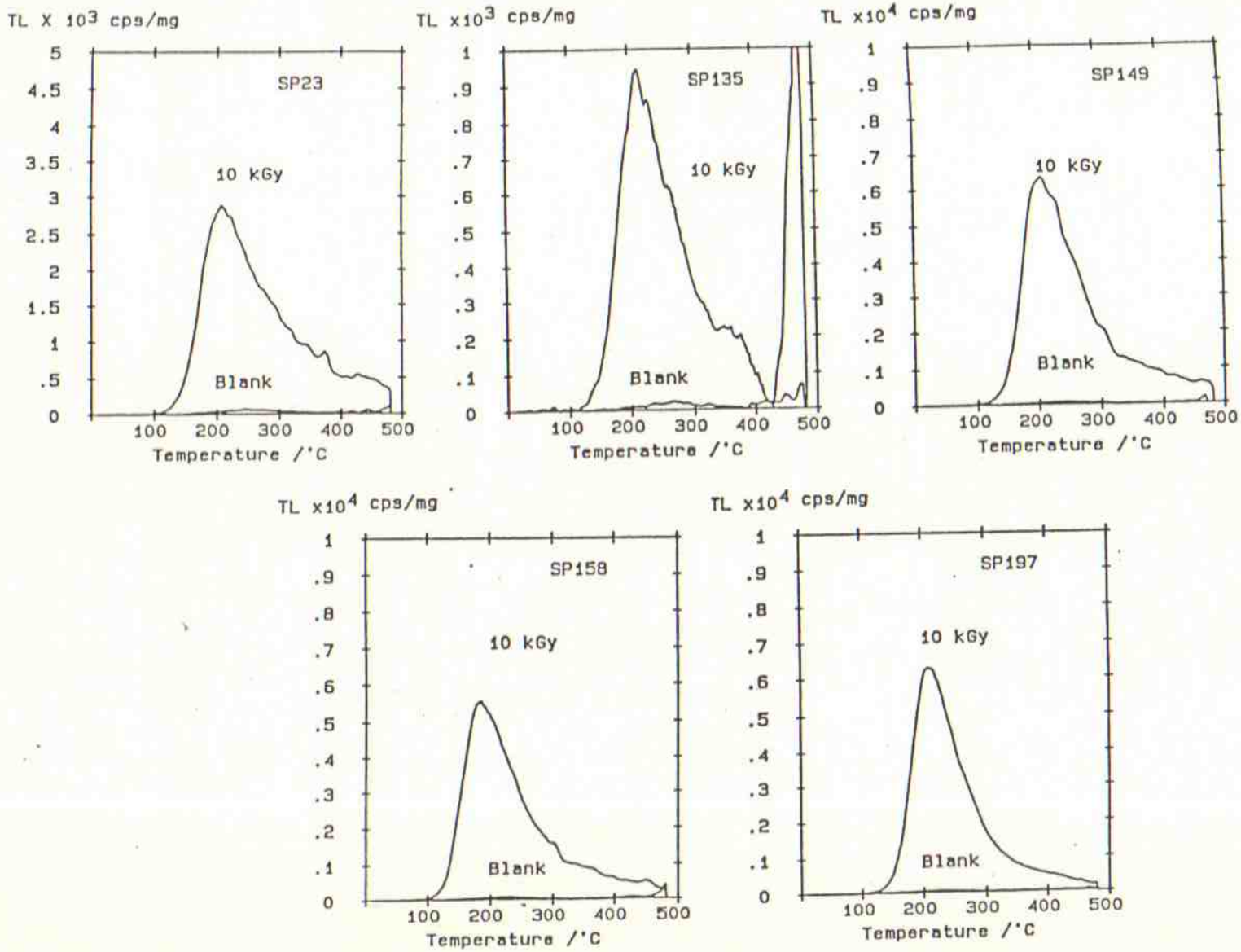
2.1 Histogram of Specific Thermoluminescence for all 161 samples and blanks.



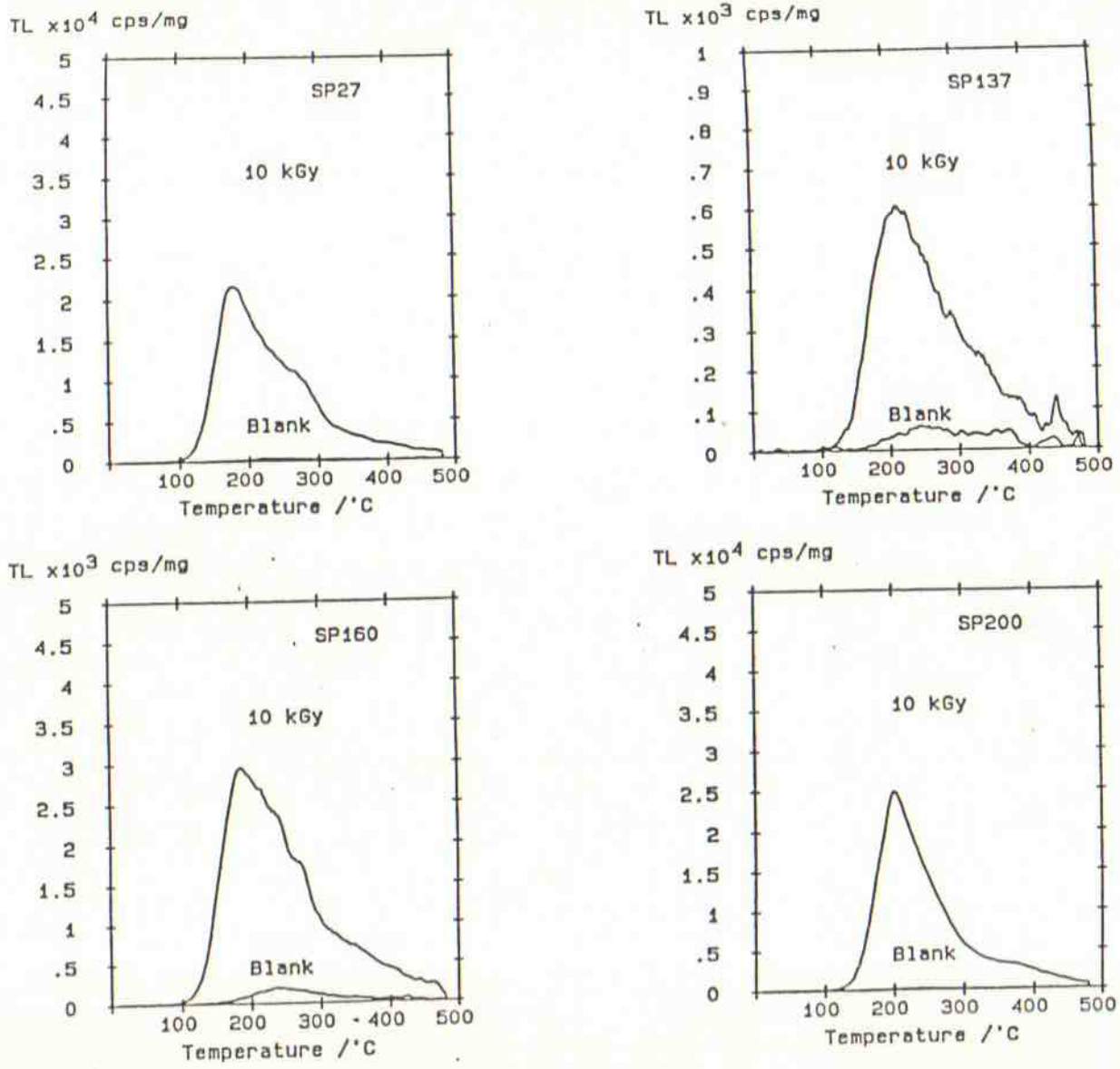
2.2 Specific Thermoluminescence of (a) Herbs (b) Spices (excluding seeds which consistently gave no TL) and (c) Seasoning mixes containing salt.



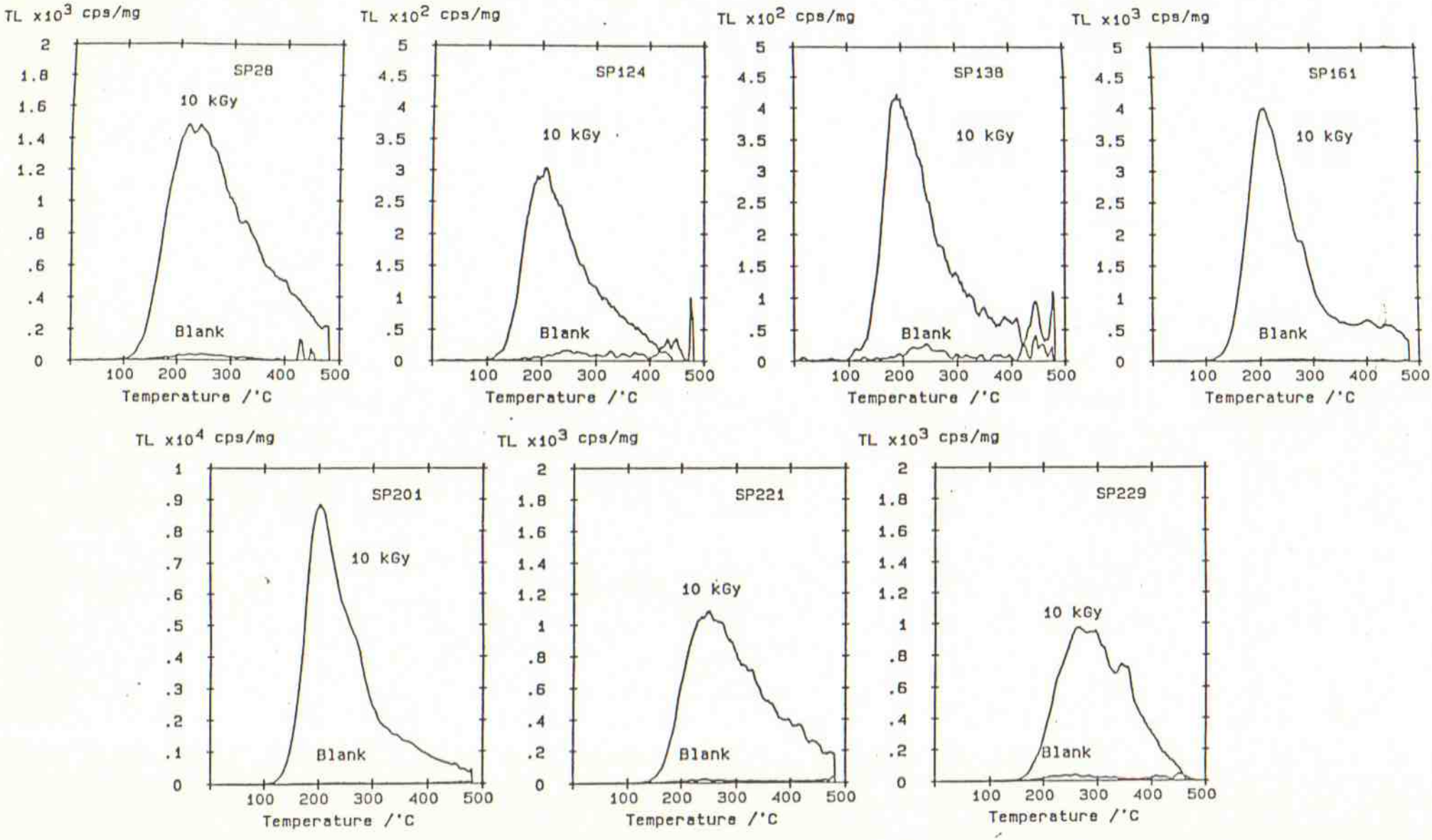
2.3 Specific Thermoluminescence of different herbs.



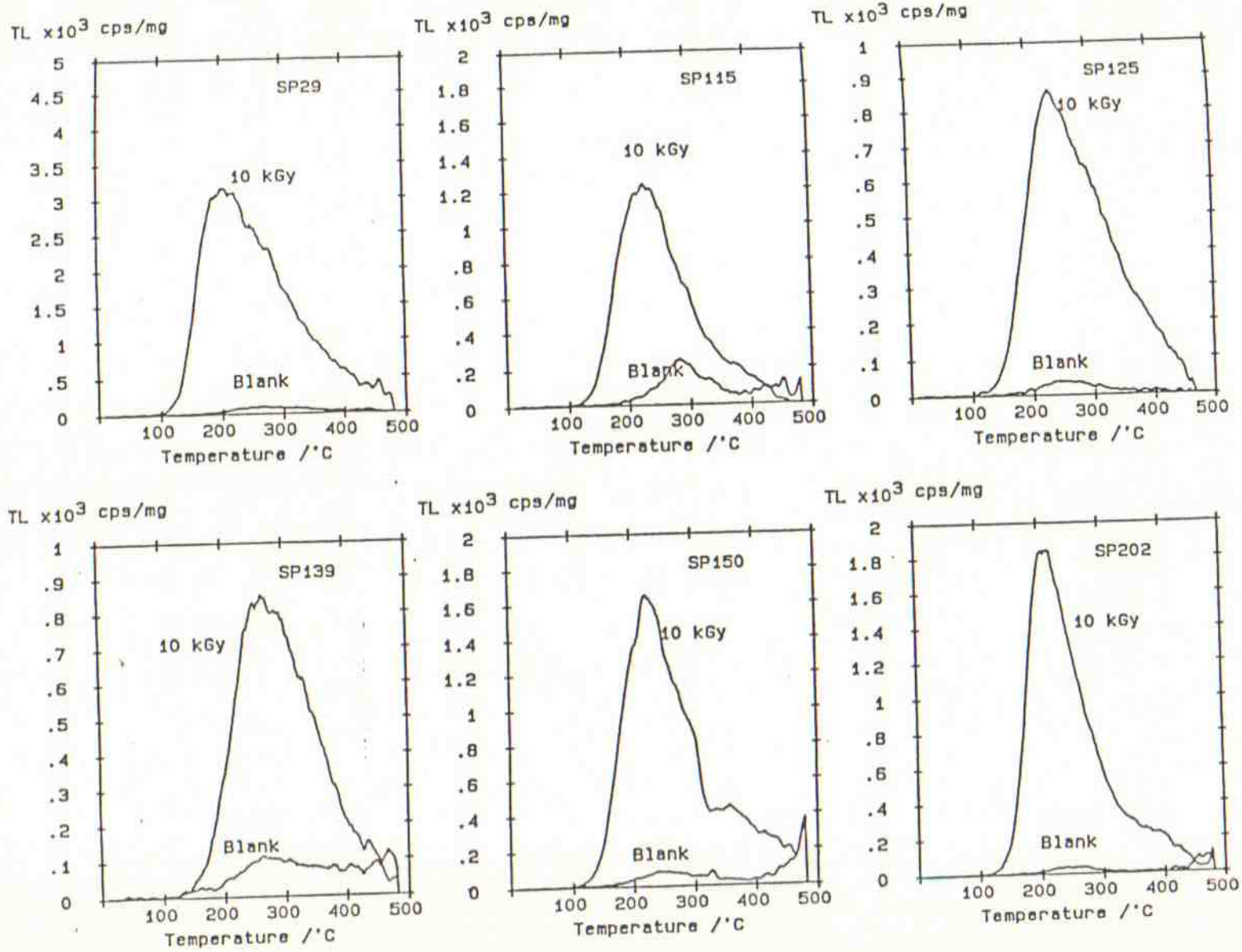
2.4 Glow curves from Basil



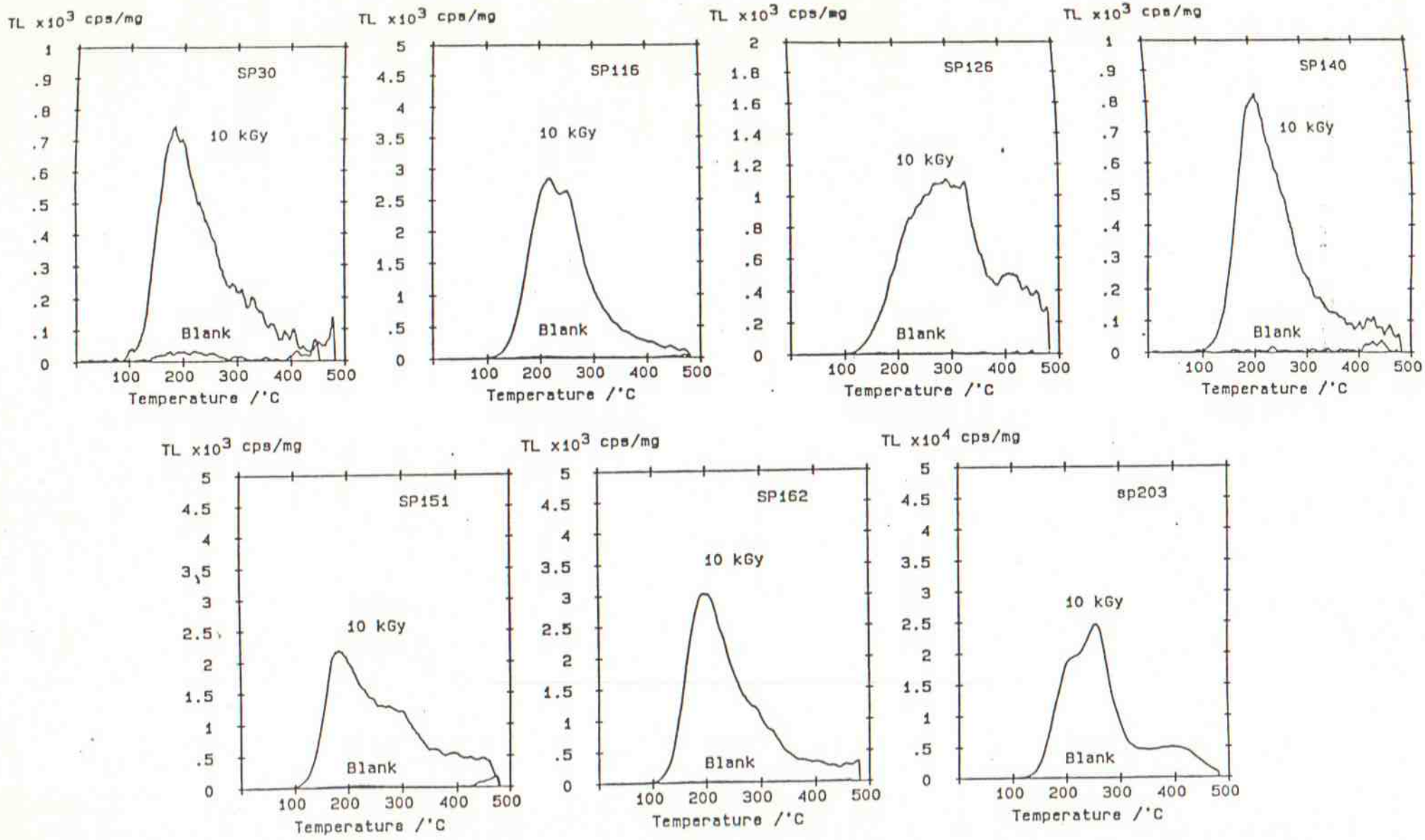
2.5 Glow curves from Marjoram



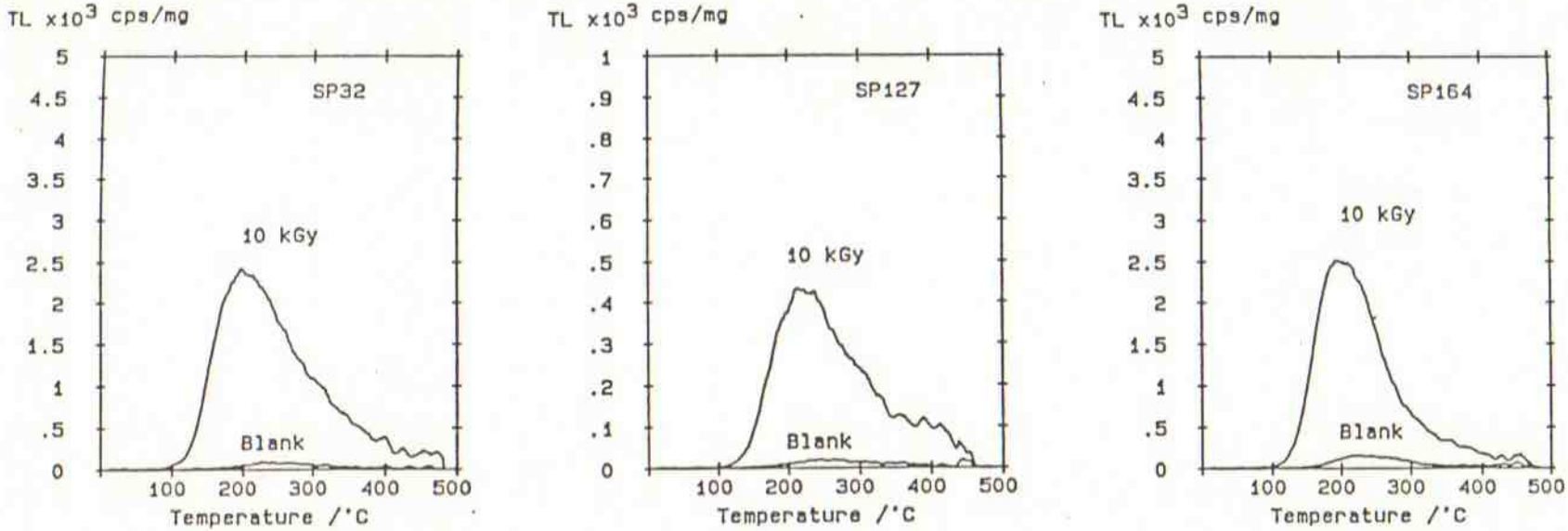
2.6 Glow curves from Mint



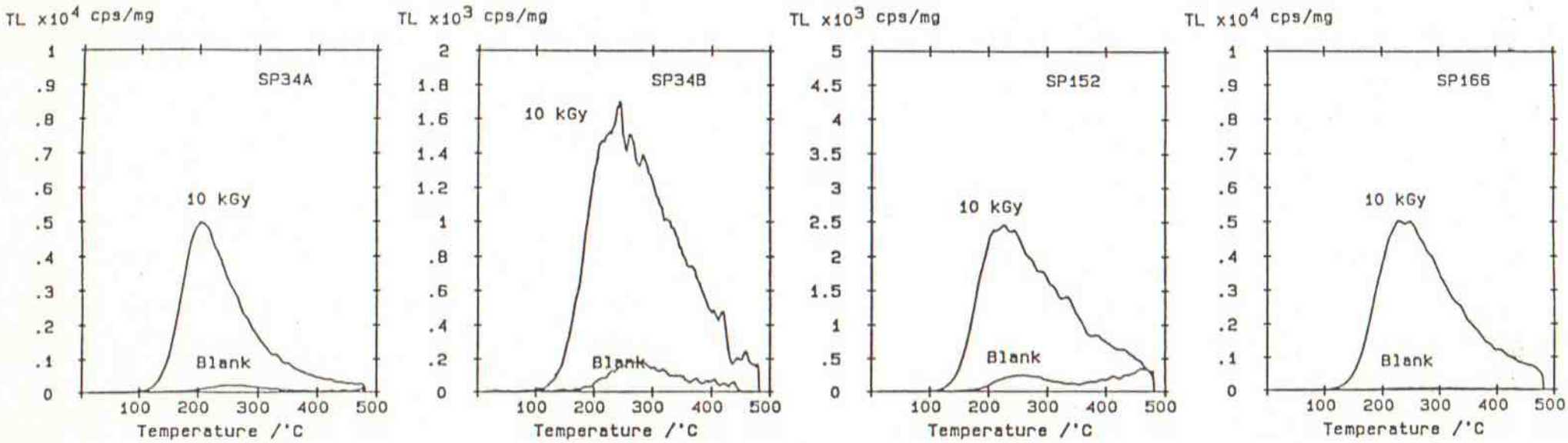
2.7 Glow curves from Oregano



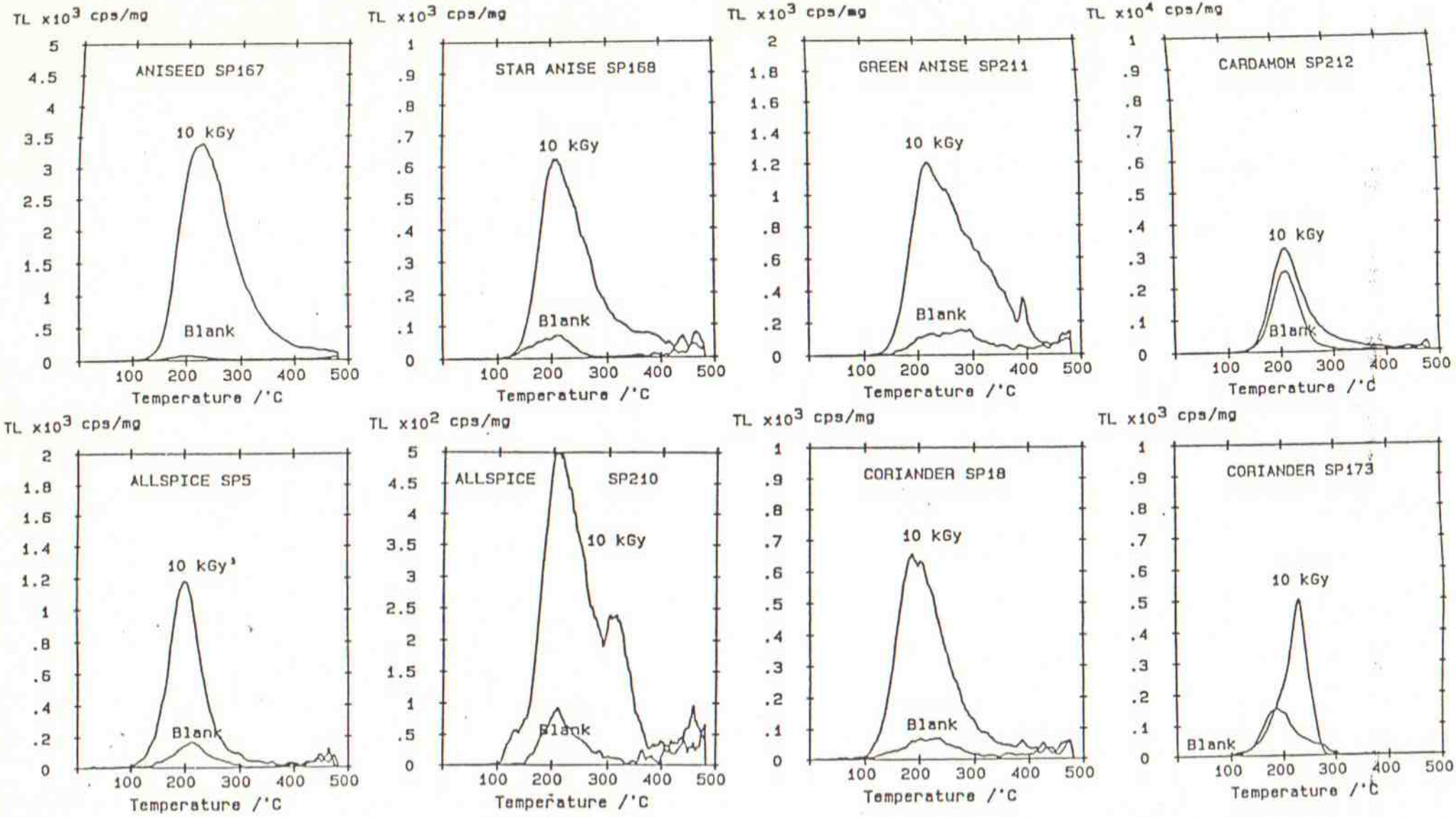
2.8 Glow curves from Parsley



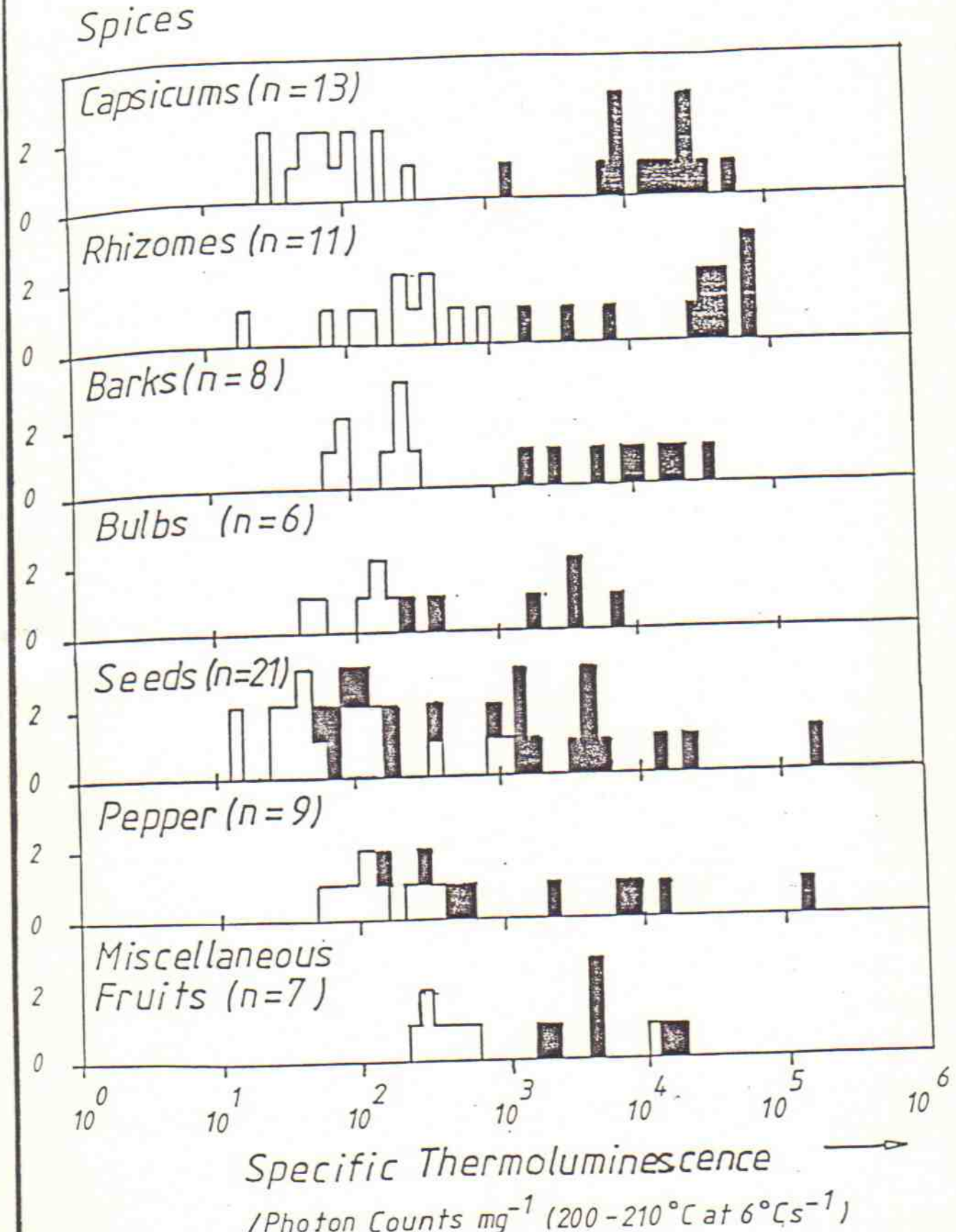
2.9 Glow curves from Sage



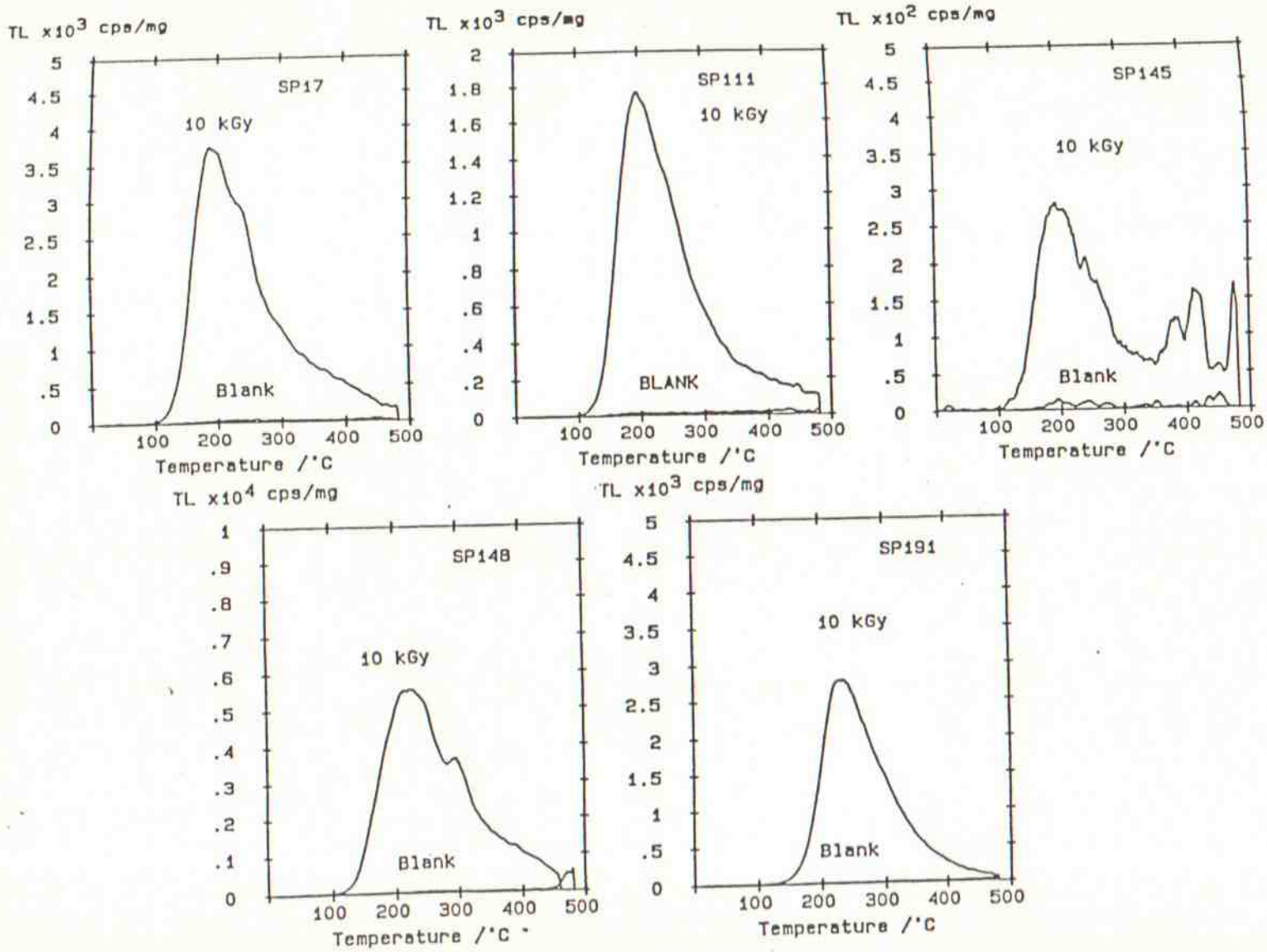
2.10 Glow curves from Thyme



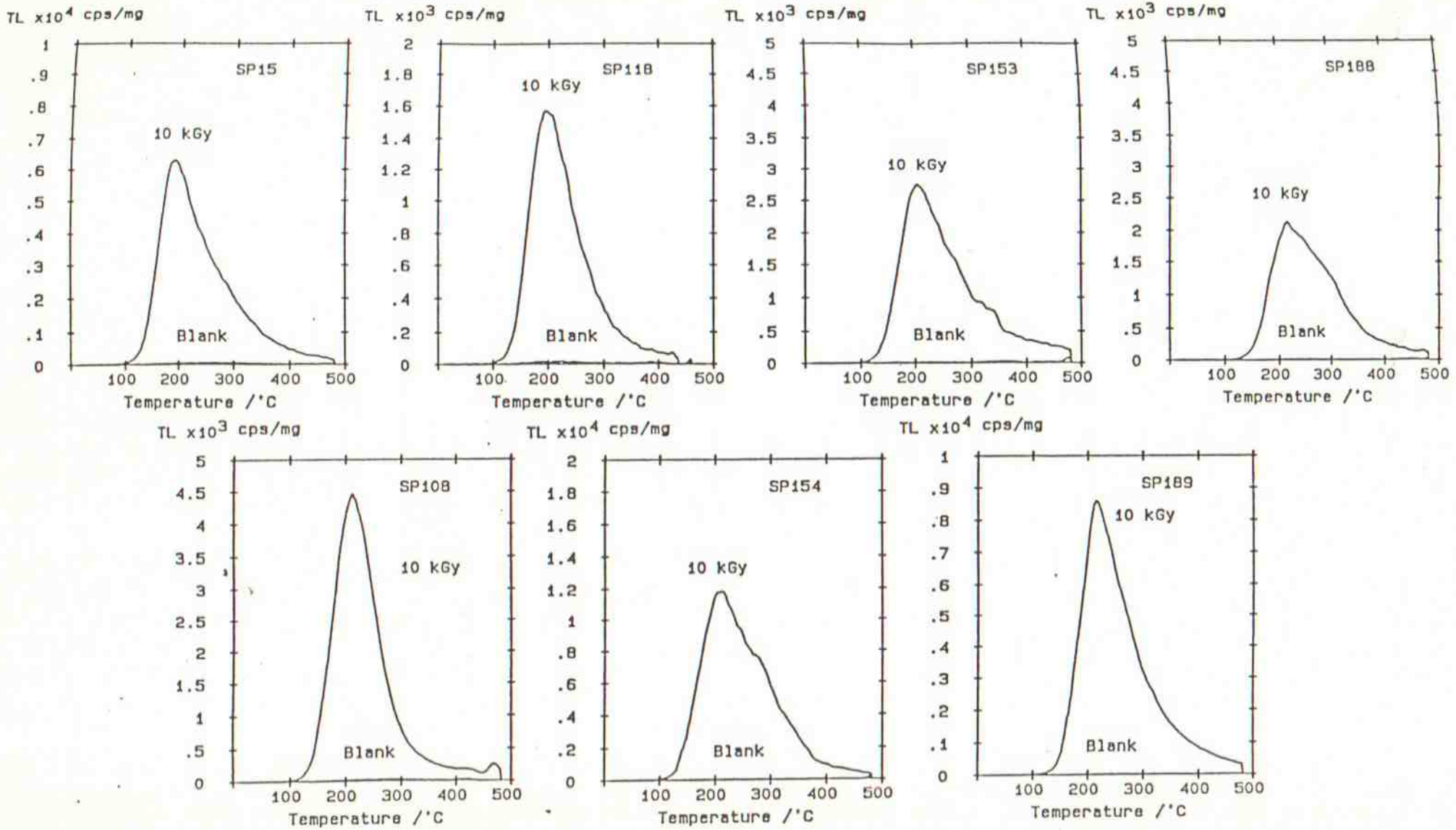
2.11 Glow curves from miscellaneous herbs



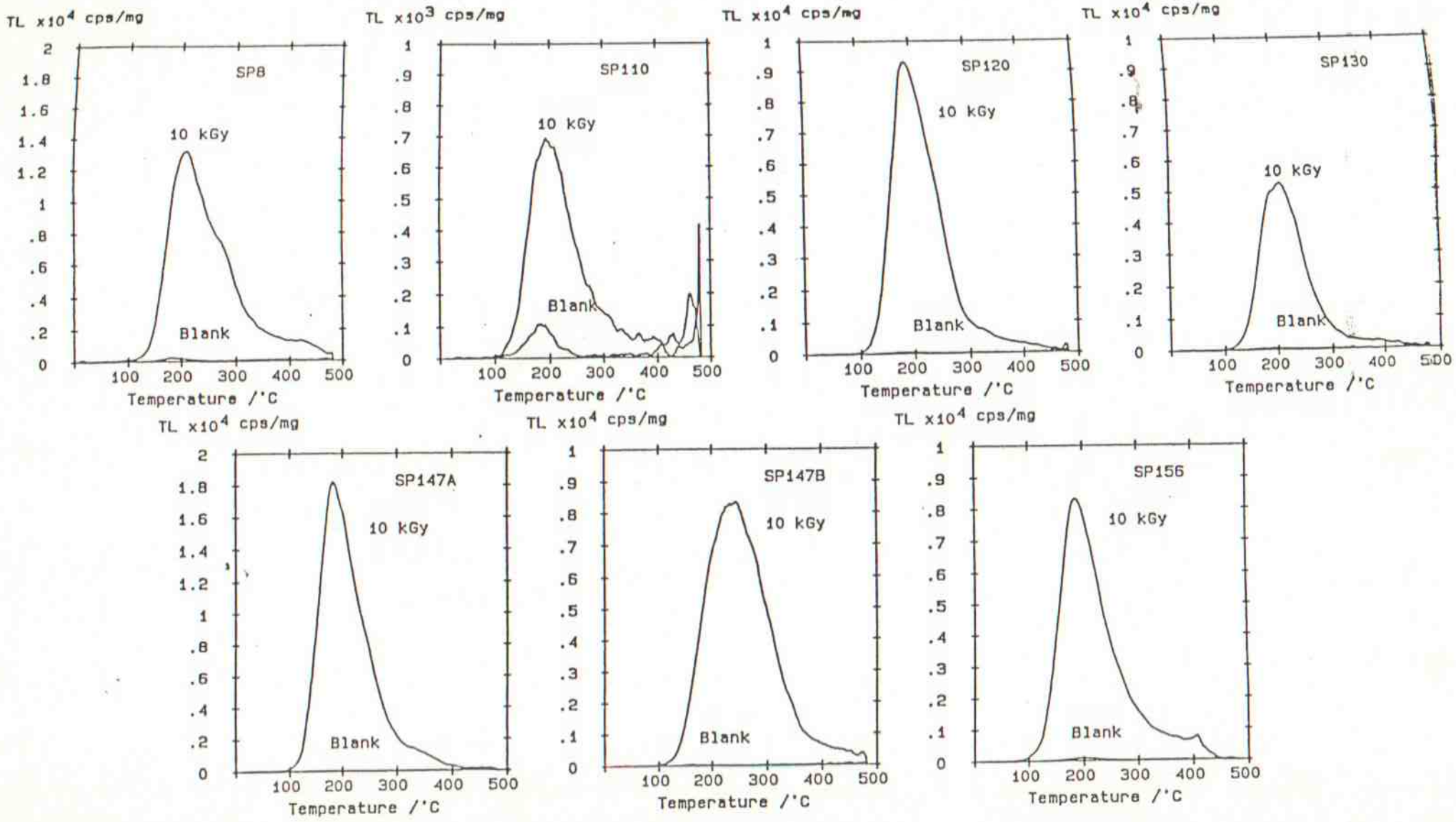
2.12 Specific Thermoluminescence of different types of spice.



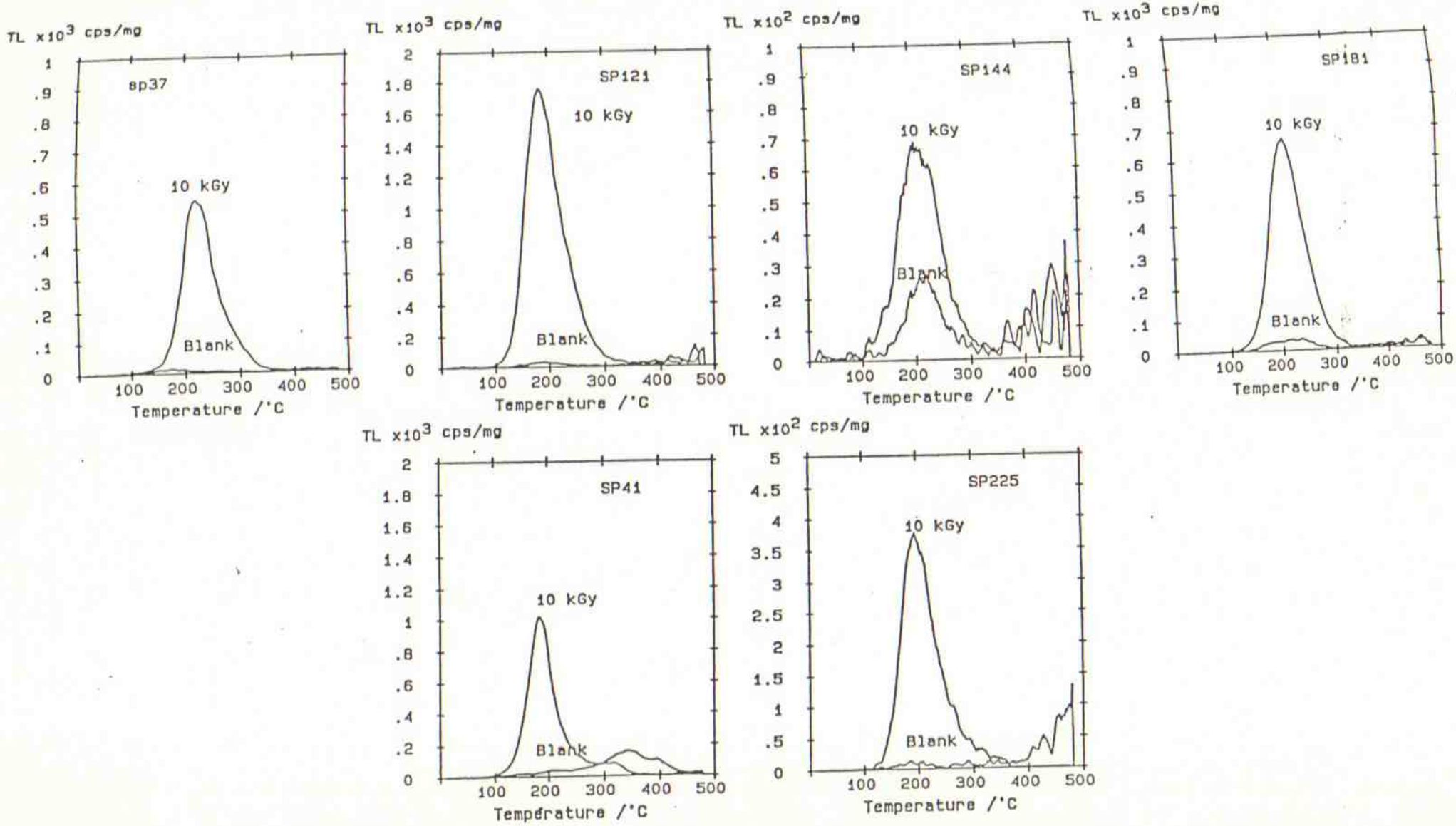
2.13 Glow curves from Paprika



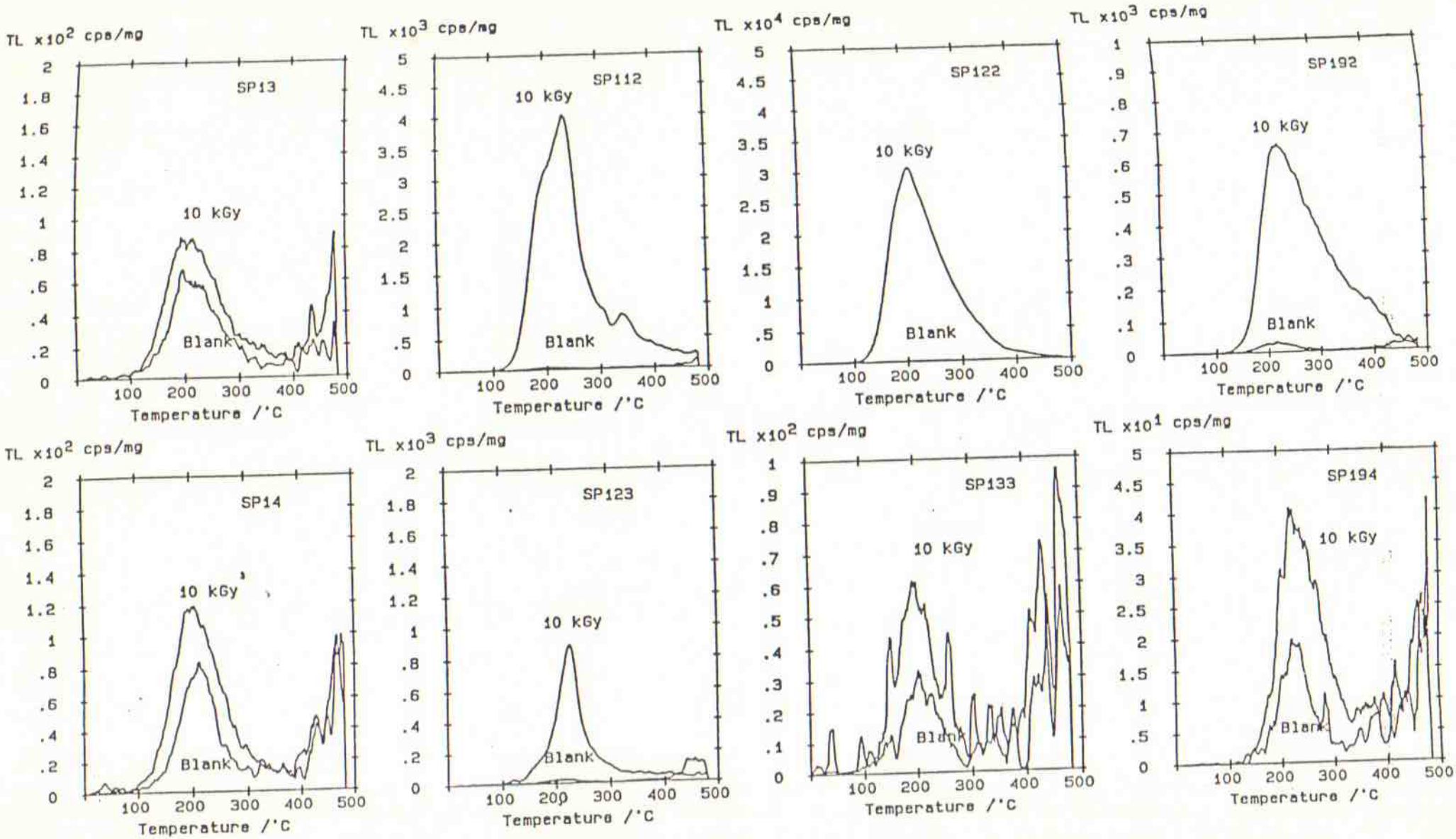
2.14 Glow curves from Cayenne (top row) and Chilli (Bottom row)



2.15 Glow curves from Ginger



2.16 Glow curves from dried Garlic (top row) and Onion (bottom row)



2.17 Glow curves from Black Pepper (top row) and White Pepper (bottom row)

3. The stability of thermoluminescence signals.

3.1 Theoretical background.

Given the promising discriminating potential of TL of freshly irradiated samples, the stability of the signals becomes an important consideration. The stability requirements and empirical validation procedures are outlined in the succeeding section. Here very brief attention is given to the theoretical expectations for retention of trapped charge in insulating dielectrics.

The simplest models for TL and associated phosphorescence were first put forward by Randall & Wilkins (1945) in which single glow peaks are related to a first order description of the release of charge from monenergetic traps of depth E, and frequency factor s.

The probability per unit time of thermal release of charge carriers at temperature T is given by

3.1.1 $P = s \exp(-E.kT)$ where k is Boltzmanns constant

For a population of n charge carriers and a fixed luminescence recombination probability (first order kinetics), the trapped population as a function of time then becomes

3.2.2 $dn/dt = s.n.\exp(-E.kT)$

which can be solved for isothermal storage to give a simple exponential decay characterised by a thermal lifetime of

3.2.3 $tau = s^{-1} \exp (E/ kT_s)$

where T_s is the storage temperature.

Extension of this model to higher kinetic orders (kinetic order b) to account for retrapping and competitive recombination processes generates functions of the form (Braunlich,1979, Chen & Kirsh,1981, McKeever,1985)

3.2.4 $n= N((b-1) + n_o^{(b-1)}.t/tau)^{-b/(b-1)}$ where $N=n_o^b/tau$

which are approximately power laws whose rates are governed by tau, and are generally slower than exponential form. In practice most natural samples contain distributions of traps of different energies which lead to the broad glow curve peaks observed in TL measurements, and add to the complexity of isothermal decay characteristics, which not only depend on storage temperature nut also on glow curve temperature. Two different lifetime spectra, one operating on the glow curve ordinate; the other a function of storage temperature are predicted by the simplest considerations of thermal release of charge carriers from traps.

A secondary relaxation mechanism may also need to be considered in connection with TL stability studies of natural

materials; that of recombination of charge carriers by tunnelling (Visocekas et al,1976). The features of loss of signal by tunnelling are a hyperbolic time dependence and a much less significant dependence on storage temperature than conventional thermal fading. Tunnelling depends on charge carrier proximity, and has been shown not to dominate the low dose behaviour of feldspar minerals (Sanderson,1988). Nevertheless the high doses used in food irradiation studies make this a possibility at least for short times following irradiation.

3.2 Experimental Approach.

It will be evident from the preceding section that it is not possible to make any detailed predictions of the stabilisation characteristics of an unknown material. Even with known trap parameters (from kinetic analysis) there is a need to supplement models with empirical results. Although we are interested in modelling the TL processes from new materials, the priority at this stage of our work is to provide empirical validation of the stability needed to support reliable identification tests.

Irradiated food may be stored for months or even years before consumption, and the storage temperatures could quite credibly vary from deep freezes to tropical temperatures. Stability tests at ambient temperatures for periods of only a few months do not therefore provide a sufficient validation for tests.

The procedure which we have adopted in this project and which we reccommend to other groups investigating tests (especially ESR) is to store separate aliquots of each sample at temperatures which span the range of interest and to measure them at logarithmically spaced time intervals. This has the built in advantage that hyperbolic or parabolic decays can be readily characterised by simple data analysis, and that the interval between measurements increases at longer times with obvious operational benefits to the laboratory programme. In our case we have set up four sample stores at -20,5,30, and 55°C, into which samples are placed immediately after irradiation. Our first readings are routinely taken from each 30°C sample 3.5 day after irradiation, and used to decide whether or not to pursue a full study of the subsequent temperature and time dependence of the signal.

Samples selected for full study are then measured after 7 days, 14 days, 28,56,112 etc - intervals which are easily planned. The rest of the samples are left in their respective stores since aged irradiated samples are a valuable commodity for later stages of the research programme.

3.3 Preliminary results.

So far 12 samples and their respective blanks have been selected for full fading analysis. We expect to add others to this regime periodically throughout the research programme, however given that this entails a total of 48 irradiated samples and 48 blanks which have so far been measured 4 times

each, a balance must be struck between the amount of effort expended in fading analysis and in measuring new materials.

These are of course long term experiments which will be analysed more fully at a later stage. Preliminary results from four samples are however included here to indicate the sort of information which is being recovered.

Figures 3.1 to 3.4 show the time and storage tempoerature dependence of signals and blanks from Chicken Seasoning, Parsley, Ginger and Cinnamon.

The signal in chicken seasoning (see 4.4) is attributable to salt, and the data already show that the four storage temperatures are following different fading trajectories. The signal to background ratio of this sample is of the order of 10,000; therefore providing the fading process does not accelerate we are confident that the irradiated sample will be identifiable for years. If the storage condition were known we would expect to be able to develop quantitative dose-estimation procedures for sample like this. The parsley samples by contrast are currently on a trend which will cross the blank level approximately two years after irradiation if it continues to fade at the present rate. Ginger (SP8) shows a markedly higher rate of loss of signal at 55°C, and is already entering the ambiguous zone after only 56 days. At lower storage temperatures the signals are holding up well. Similarly there are no immediate causes for concern regarding the stability of cinnamon.

There is a marked constrast between the reproducibility of signals from herbs and spices and those from chicken seasoning; which again supports the view that minor adhering debris produces the signals.

These preliminary results refer to the glow ordinate range from 200-210°C - which has been chosen for preliminary analysis on the basis of our expectation that it would show sufficient stability to identify irradiated foods, but be short lived compared with geological timescales. A fuller analysis of the glow-temperature dependence of stability, and signal to background ratio is intended at later stages.

3.4 Optical bleaching.

It is well established that some parts of the TL signal are susceptible to optical bleaching by various components in daylight. We have deliberately excluded the uncontrolled exposure of samples to daylight so that reproducibility of results would not be adversely affected by variations in sample handling.

A preliminary examination of the sensitivity of a cinnamon sample to daylight was made at the start of the project, and the results (shown in figure 3.5 and described in the run sheet in appendix D) from a 4 hour exposure to mixed tungsten lamp and daylight show the need for more detailed assessment of the practical effects of illumination on TL stability.

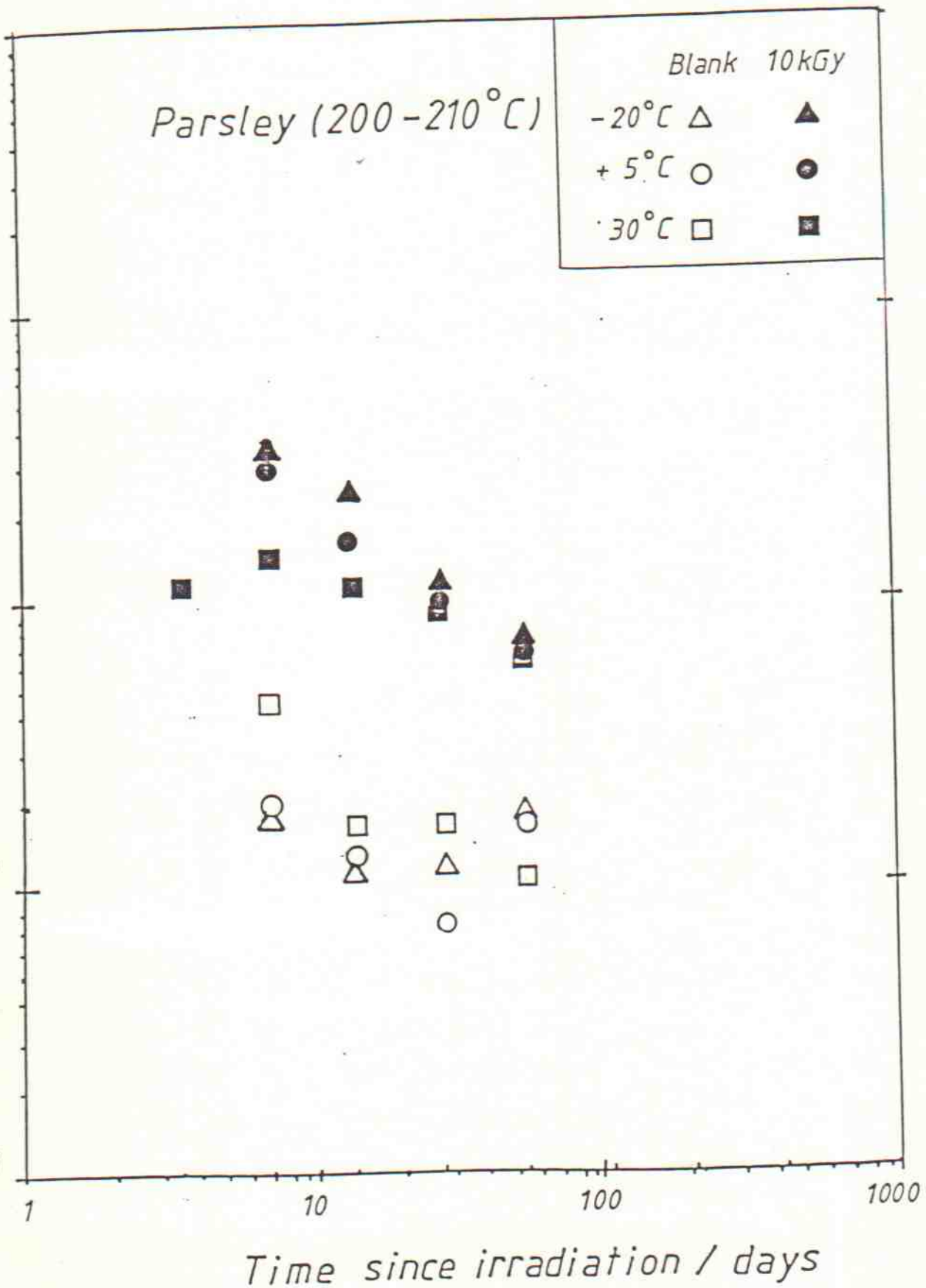
3.5 Discussion

The stability of signals is of vital significance to the status of any proposed test to identify or quantify radiation treatment of foods. In the case of TL results, probably also ESR, the importance of extending tests to cover a full range of storage times and conditions has been underestimated in the past. Nevertheless our theoretical expectation that storage temperatures would be significant has been amply verified by preliminary results, and this stresses the need for rigorous validation of the method. The importance of optical illumination will also need to be investigated.

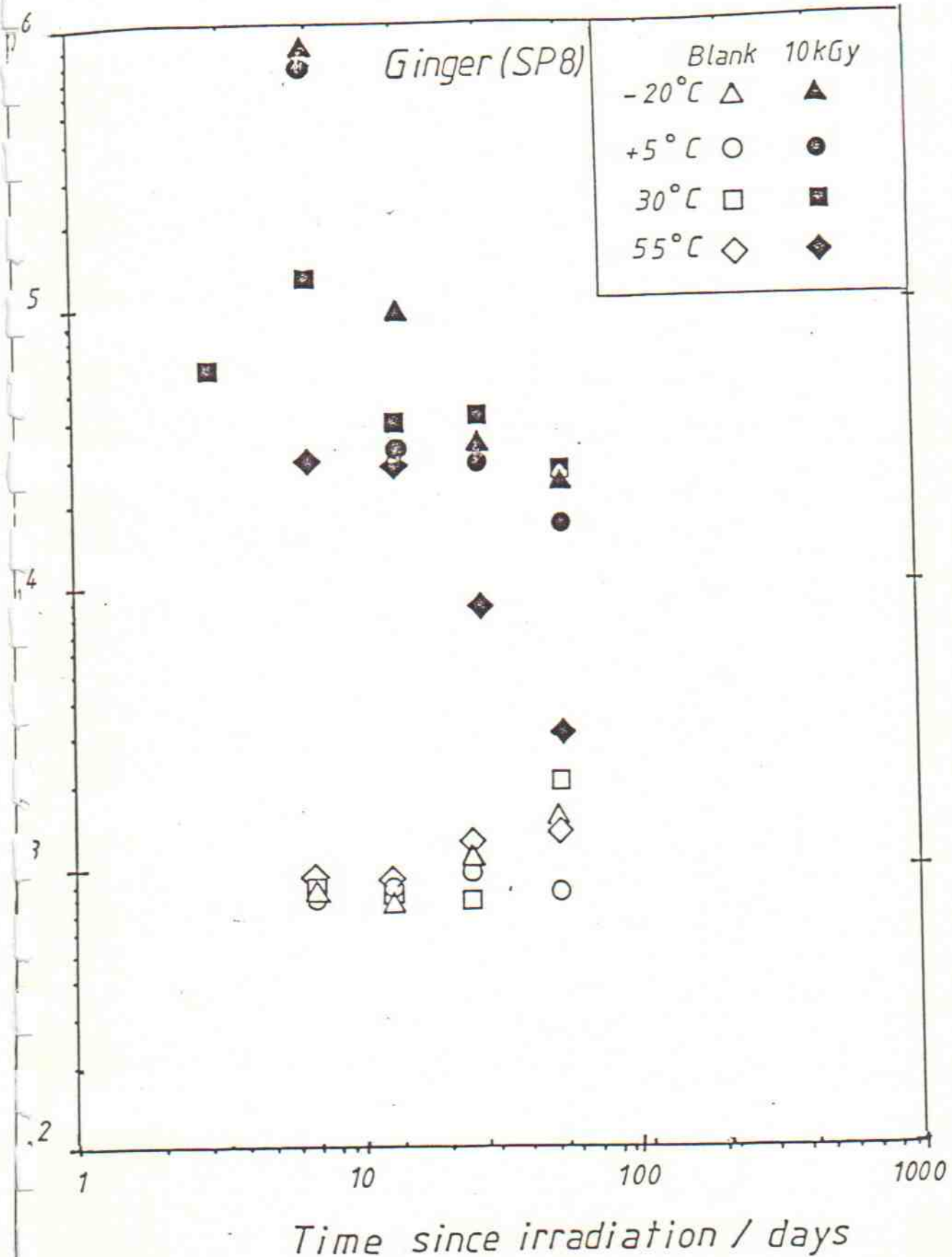
Preliminary results show that stability of TL signals is likely to be adequate for many samples.

3.1 Fading results from Chicken Seasoning

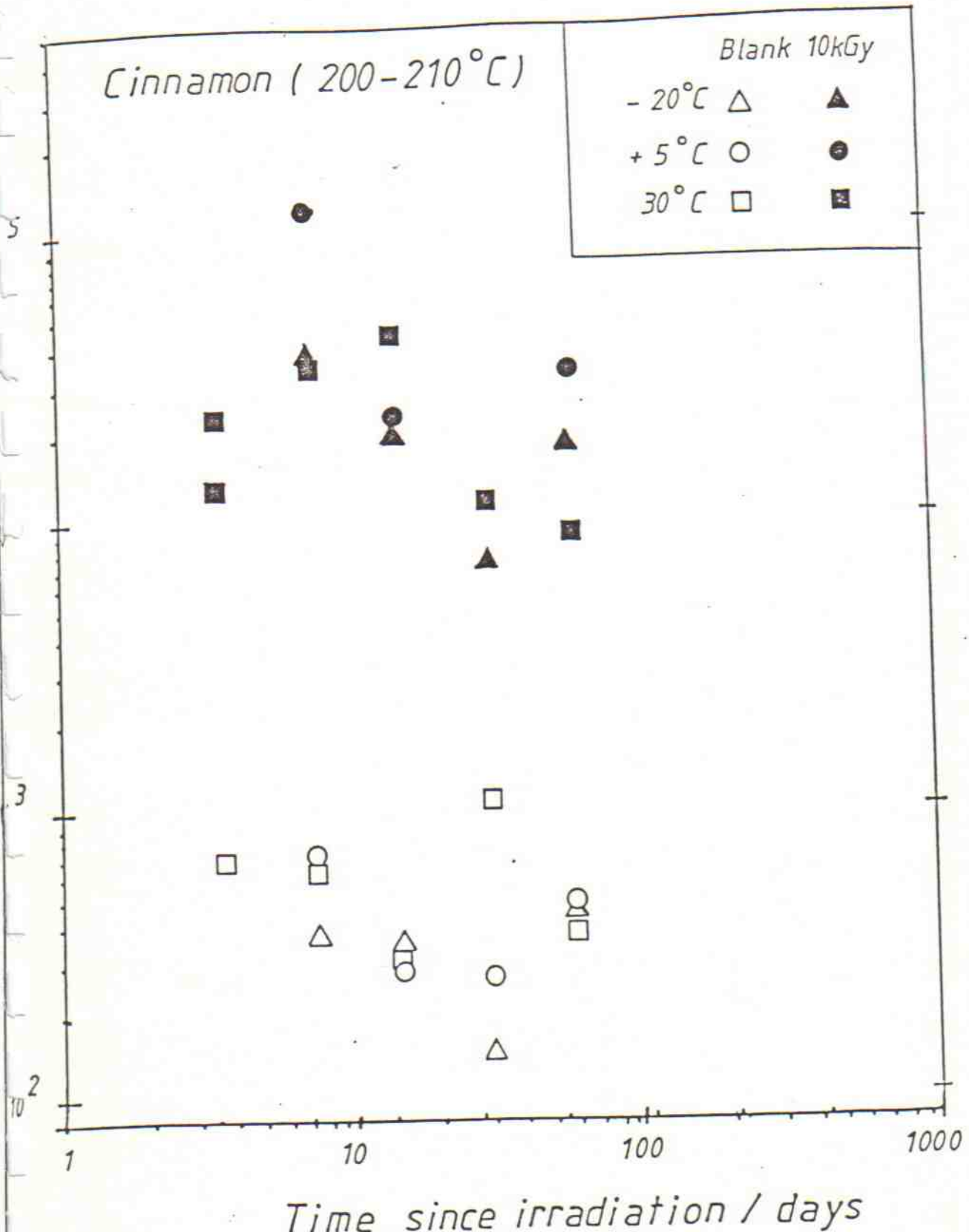
3.2 Fading results from Parsley

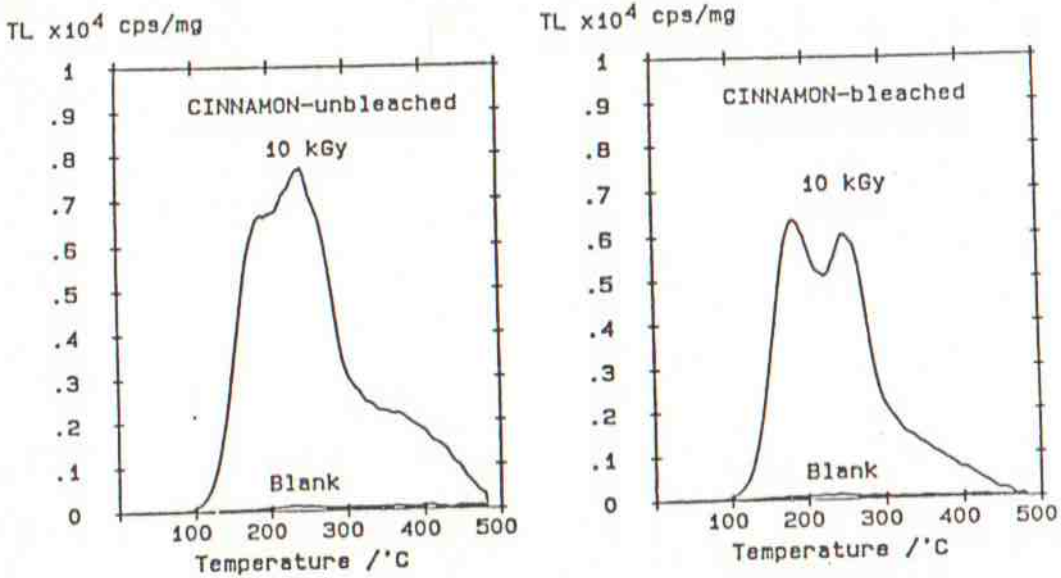


3.3 Fading results from Ginger (SP8)



3.4 Fading results from Cinnamon





3.5 Preliminary assessment of the effects of optical bleaching on TL from Cinnamon

4. The origin of thermoluminescence signals in foods

4.1 Expectations.

The suggestion that the organic phases in spices and herbs should give rise to blue band thermoluminescence at high temperatures would be received with scepticism by solid state physicists amd TL specialists if it were explicitly articulated, as this runs contrary to many received ideas about the nature of matter. Yet this is apparently an implicit assumption of the ISH group and also of Moriarty et al (1988).

Experience of TL from natural minerals, gleaned from many years of exploring TL dating, has shown that quartzes, clay minerals and feldspars have high temperature specific TL sensitivities ranging from 10^3 to 10^6 cps mg^{-1} Gy^{-1} over 10 degree bands using readers of comparable sensitivity to that used here. Even allowing for possible saturation effects in the 1 - 10 kGy dose region, microgram quantities of such inorganic materials could easily account for all the signals observed from herbs and spices. In addition other inorganic materials, including salts, and hydroxyapatites have known TL properties which are of interest to food studies.

Our expectation is therefore that the signals arise from inorganic phases in or on the samples, an explanation in keeping with the very variable characteristics of herbs and spices shown by the sensitivity histograms and fading results, and with the low signals from seeds and nutmeg.

Further explicit investigation of other facets of this hypothesis follows.

4.2 Early results from density separations.

Microscopic examination of herbs and spice samples at an early stage of the project verified the presence of extraneous inorganic matter on their surfaces, and an experiment to verify the association between such fractions and the TL signal was undertaken.

Small quantities of parsley, tarragon, cinnamon and paprika were agitated in an ultrasonic bath in solutions of sodium polytungstate prepared to a density of 1.6 g cm^{-3} and then centrifuged to separate organic and mineral fractions. The low density layer, which floated, was decanted off and the sub-milligram residues of higher density material were then washed, resuspended in acetone, and allowed to settle onto stainless steel discs. After drying in a laboratory oven overnight, irradiated samples and blanks (both subject to parallel extraction as usual) were glowed out along with dried organic residues and whole samples.

The results are shown in figures 4.1 and 4.2 demonstrating enrichment factors of 10-10,000 in the inorganic phases. It is also notable that signal to blank ratios were higher in these phases than in the whole samples.

This experiment shows clearly that most of the signals from these samples indeed originate from the inorganic phase. The residual signals are very possibly due to trapped inorganic material which was not fully removed from the low density samples.

4.3 Tests with oleoresins

A further test for TL in organic phases was undertaken by examining pure oleoresin extracts from Nutmeg, Pepper, and Sage, very kindly supplied by Spicemanns, a Glasgow spice processing company.

Irradiated samples and blanks were dried onto discs and glowed out giving the curves shown in figure 4.3. The results are totally insignificant compared with the intensities measured from whole samples, and are well beneath the whole sample blank levels.

The combination of these tests and those in the previous section do not suggest that organic processes are involved.

4.4 Samples containing salt.

The most sensitivive samples examined in this study by far were those comprising seasoning mixes containing salt or salt based oleoresins. They all have a characteristic glow shape shown in figure 4.4, which can also be measured from table salt. The origin of the signal in this case can be established beyond doubt.

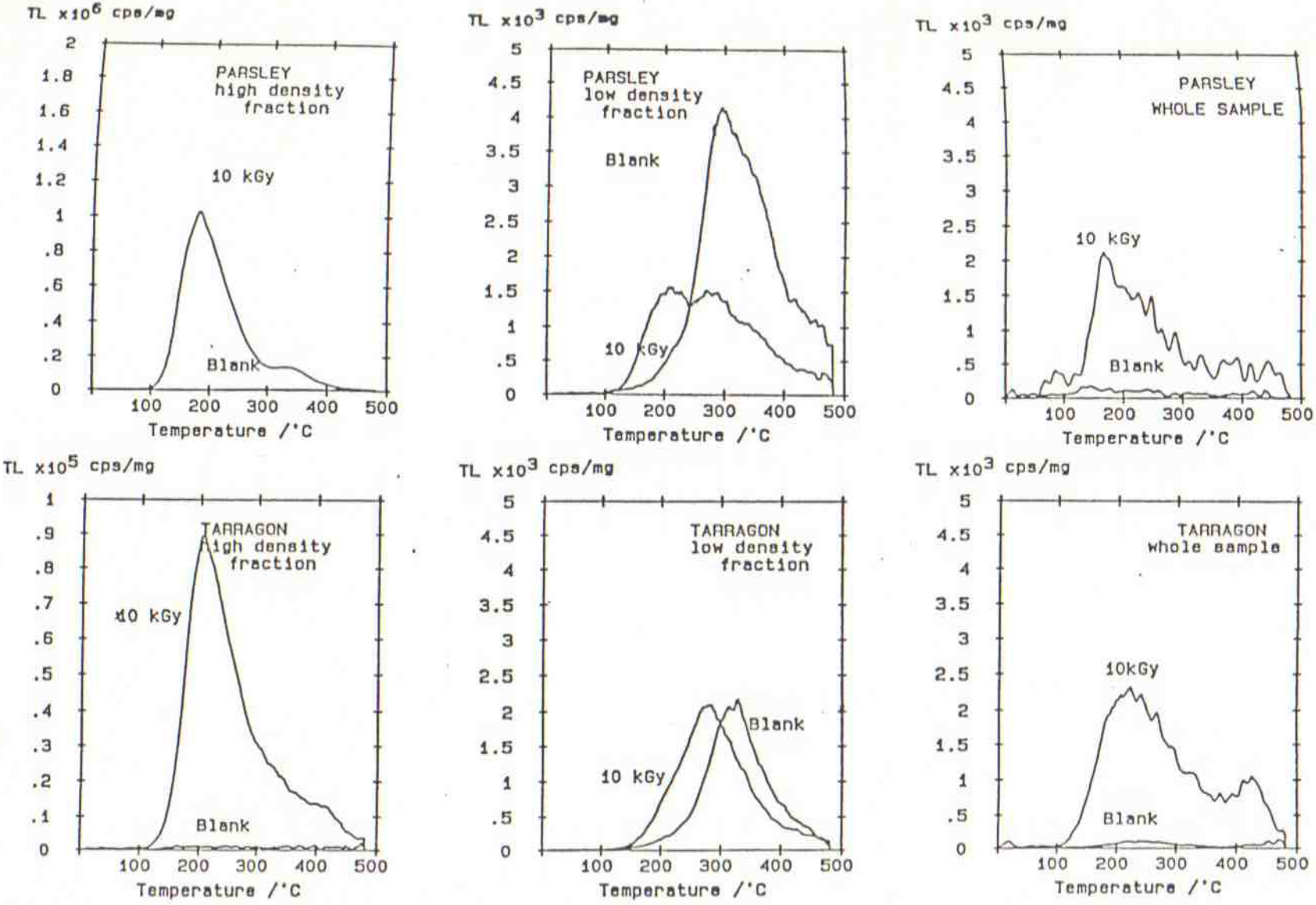
4.5 Bones

Hydroxyapatite has well established TL characteristics, and bones and other bio-inorganic materials are of obvious interest. Examples of cooked chicken and lamb bones have been examined and show promising characteristics (figure 4.5). Again we have no doubt of the origins of the signals; however further work will be needed to avoid high blank levels, either by PTTL, PSL or by developing extraction techniques to isolate the inorganic phase.

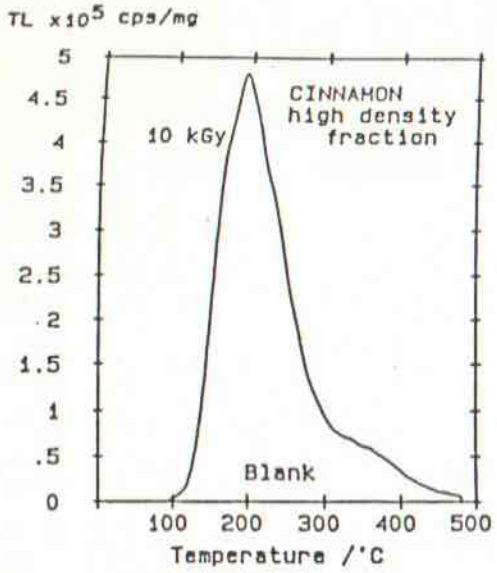
Hydroxyapatite is also sensitive to ESR, however the benefits of luminescence methods here are that mg quantities might be sufficient, which would be useful for processed meats or cooked foods containing small bone fragments

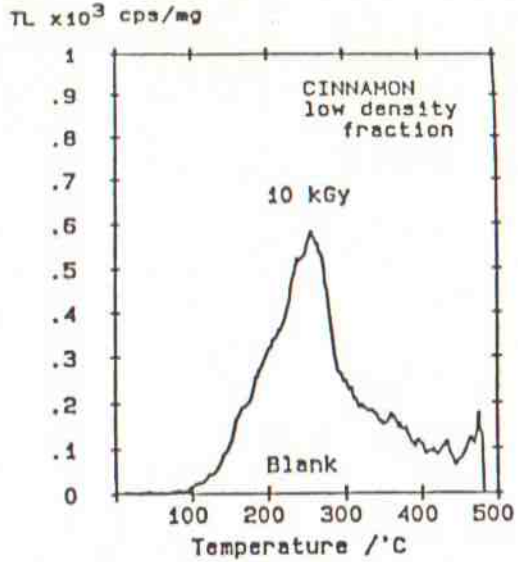
4.6 Potatoes.

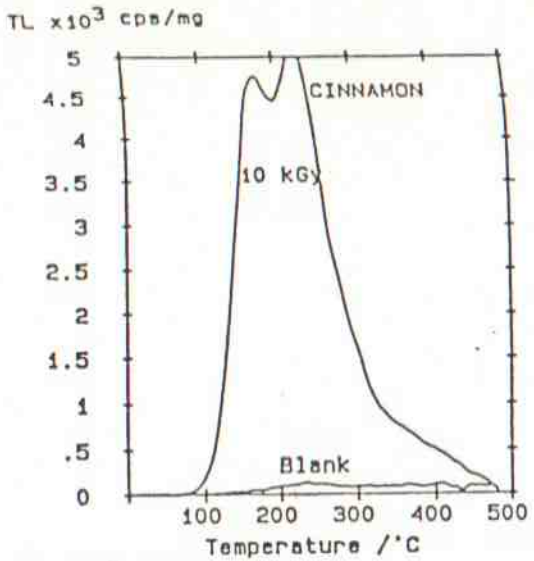
Figure 4.7 shows our original results from mineral grains shaken of the outside of a potato sample which had been irradiated to 0.2 kGy. The similarity of glow shape between this sample and all herbs and spices provides further support, if needed, for the association of TL with extraneous matter, and shows the way for dealing with fruits and vegetables in future work.

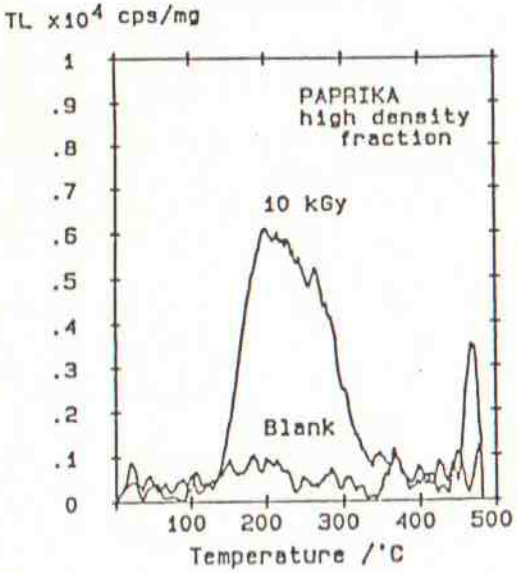


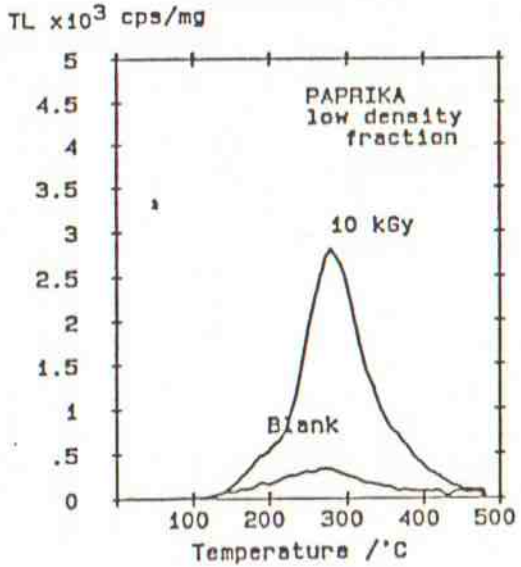
4.1 Comparison between whole sample and density separates : Parsley and Tarragon

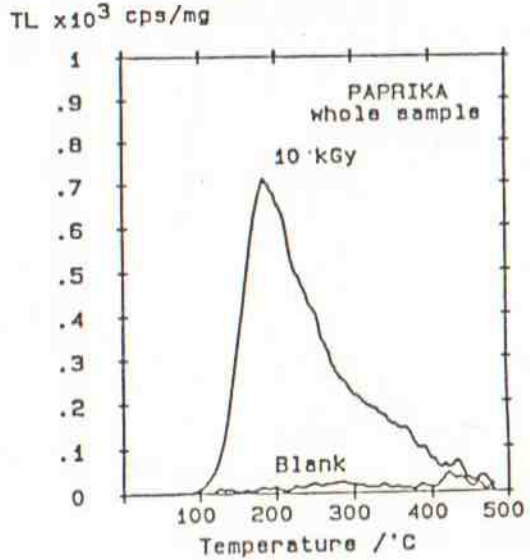




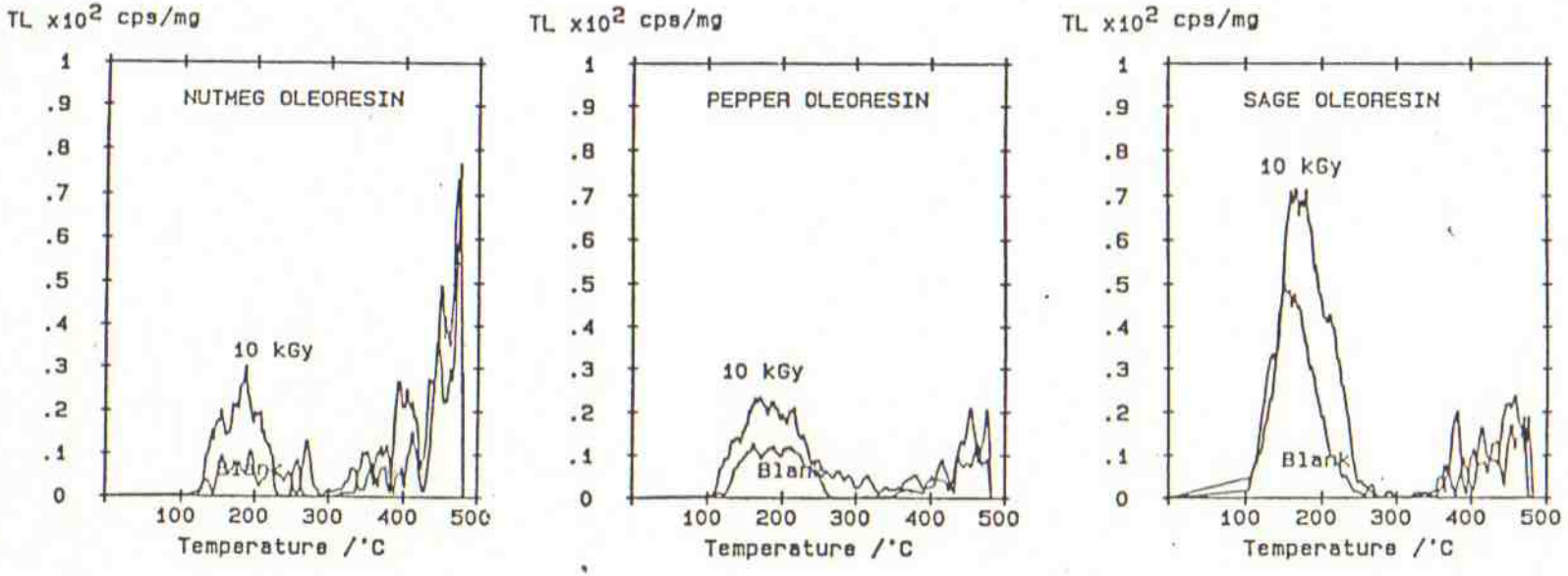




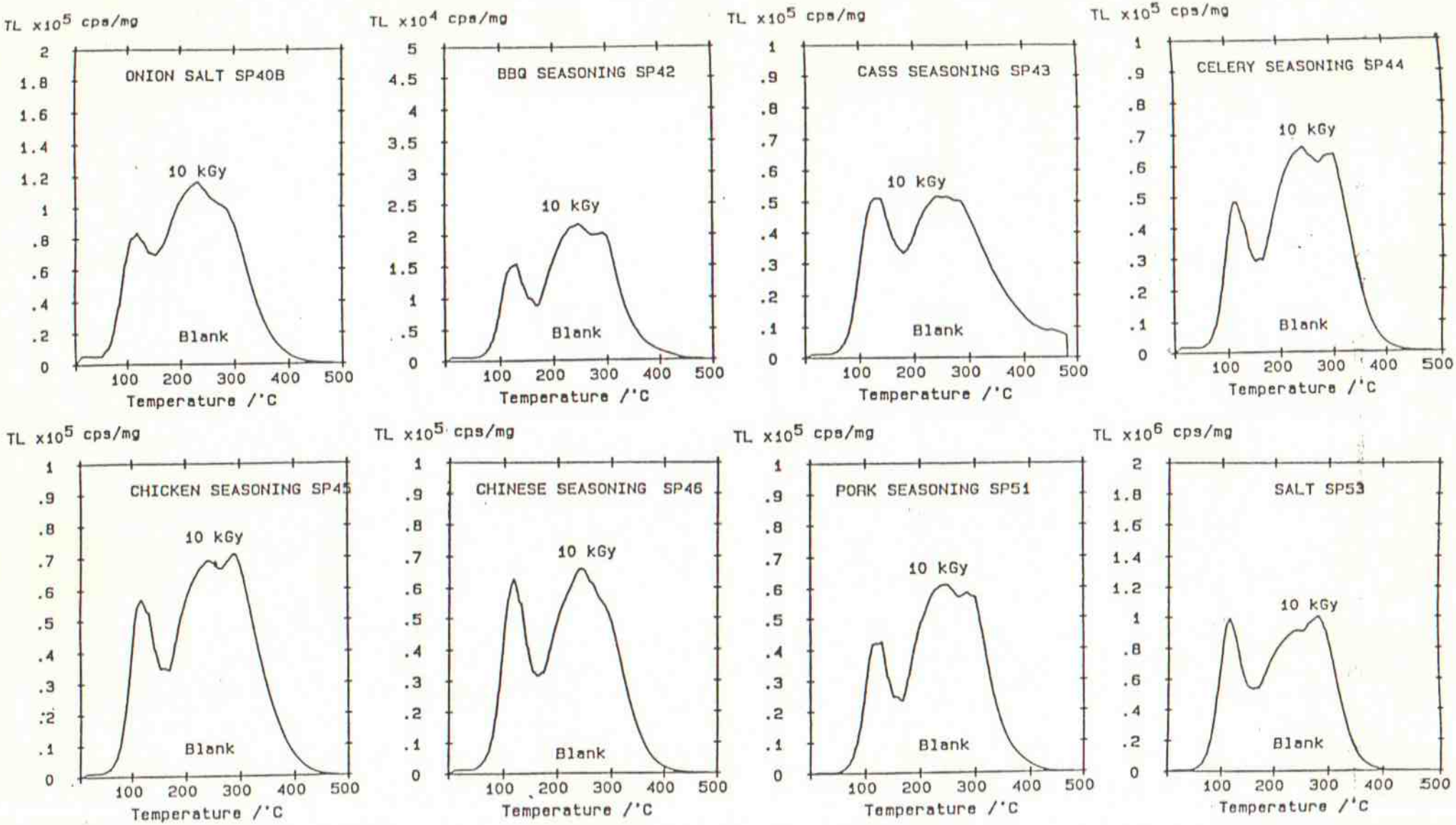




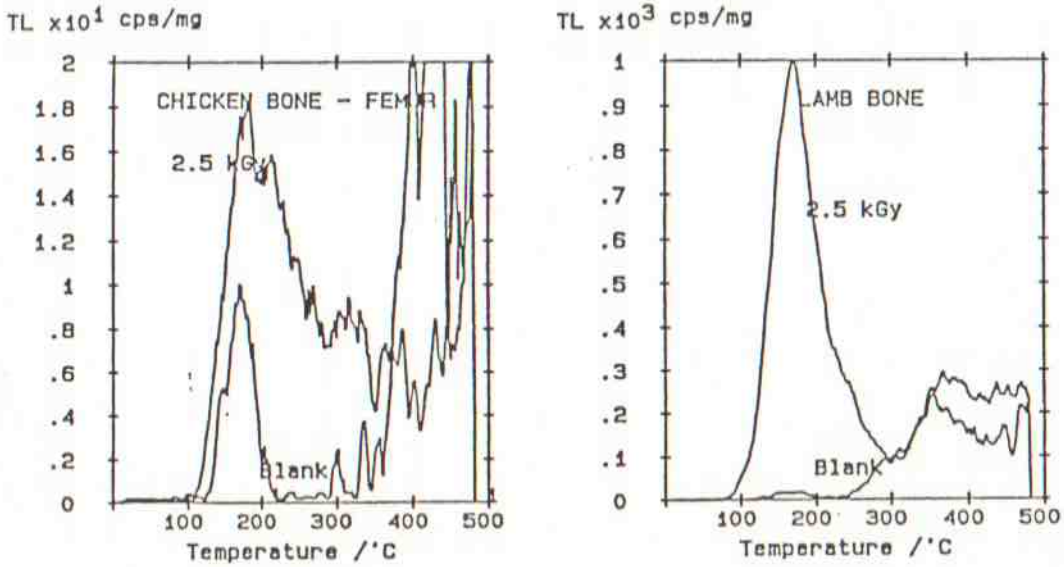
4.2 Comparison between whole sample and density separates :
Cinnamon and Paprika



4.3 Thermoluminescence of Oleoresins



4.4 Thermoluminescence glow curves from samples containing salt

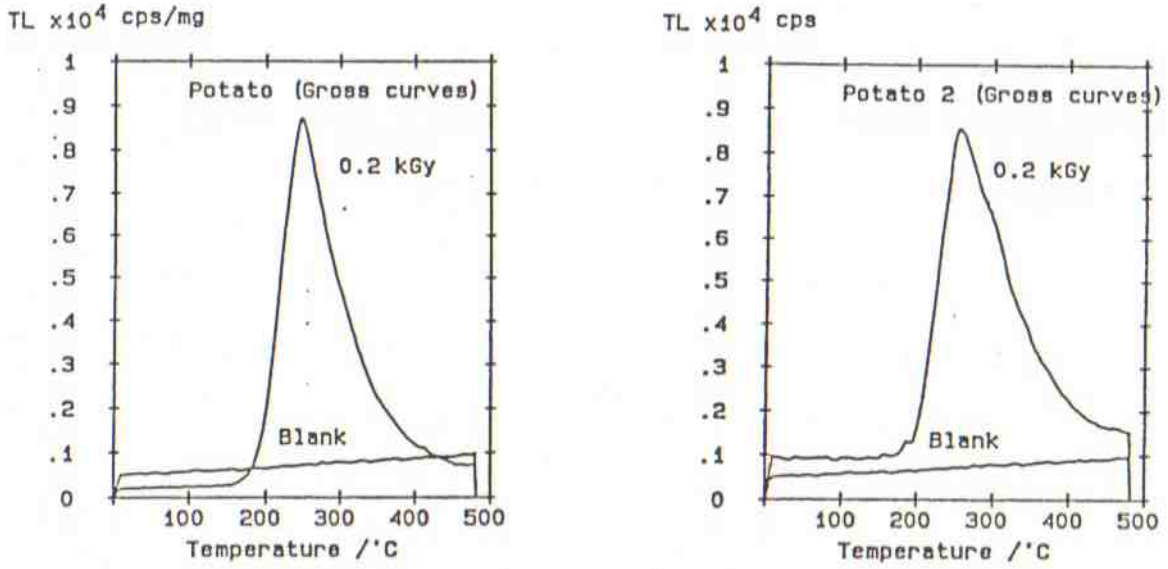


4.5 Thermoluminescence of Chicken and Lamb bones

Two extracts from the same potato stored at 50 degrees centigrade

for 20 and 30 days respectively before readout

Measured October 1986



4.6 Thermoluminescence of minerals removed from a potato.

5. Phototransferred and Photostimulated Luminescence

5.1 Progress report on instrumental development

The thrust of the first four months of work on this project has been very clearly directed towards TL measurements and establishing an assemblage of aged irradiated samples.

Parallel effort has however been expended on beginning to develop an instrument for combined PTTL/PSL measurements. A modular illuminator and spectrometer rack has been specified comprising a 300 W Cermax Xe lamp with optics to produce a 12 mm diameter beam which can be passed through an f3.4 grating monochromator, or through a filter holder to select continuous illumination. These components have been manufactured to our specification by Applied Photophysics Ltd, and incorporated a facility for placing a fast electro-optic shutter in the beam for time slicing excititaion pulses. Space for a versatile sample chamber, which we will be designing in house, and beam transport optics have been designed into this system. Delivery of these components and the electro-optic shutter and driver (from Electro-Optic Developments Ltd) is expected in the first week of April.

A fast photon counting photomultiplier and pre-amplifier (Thorn EMI) has already been delivered, and an inexpensive multichannel scaling facility has been constructed using a fast AT compatible computer and an Ortec MCS card. It may be necessary to supplement the MCS system by further components to allow sub-microsecond time domain measurements at a later stage, however this will require a significantly more expensive MCS system. A temperature controller for the sample chamber is currently under construction in house using our established design.

The current development priorities are to evaluate and commision the spectrometry system on arrival, and then to add a sample chamber with cryogenic and vacuum components during the next project phase, at which stage we hope to be in a position to undertake feasibility studies of PTTL and PSL. PSL measurements will be assessed firstly using time sliced Xe lamp excitation and then the equipment will be taken to Glasgow University for feasibility evaluation of laser stimulation.

This part of the project is currently on schedule for production of a working system within the first year.

6. Conclusions

The potential of TL measurements of whole samples of herbs spices and seasonings for identifying irradiation has been explored in detail. There are very strong radiation induced signals from most samples, which in some cases could already lead to unambiguous identification. Samples with specific TL greater than 5000 cps/mg at 200°C, for example can be confidently identified as irradiated.

Nevertheless reciprocal judgements concerning the absence of irradiation in samples with lower readings are adversely affected by the very variable characteristics revealed by a substantial data set from 161 samples. With complementary information on sample type and TL sensitivity measurements these ambiguities can probably be resolved. They would also be resolved by an enhanced signal to blank ratio.

Detailed specifications of stability criteria tests which will be needed to confirm the validity of qualitative tests have been outlined, and may be of interest to other groups involved in complmentary research. Results so far indicate that stability must be assessed at all conceivable storage temperatures, but that promising TL results have been obtained in most cases. The effects of optical bleaching need further investigation.

The confirmation that the signals originate from inorganic debris has significant implications for the status of luminescence tests. Furthermore it suggests a very promising line of immediate research in applying extraction techniques to enrich the sensitive phase. This may well improve the signal to blank ratios to the level at which unambiguous qualitative tests become routine, and quantitative test possible for some samples.

Our next priorities are therefore to develop routine separation procedures for TL measurements, to supplement the range of samples and continue fading tests, and to investigate the effects of storage in daylight on retention of TL signals.

In parallel with this we shall be developing the new stimulation techniques which we hope will be useful for quantitative dose estimation.

Appendices.

The format of the laboratory sample archive is presented in Appendix A, followed by selected sections from it which provide supplementary details of the samples and measurements discussed in the report.

Appendix A

DEFINITIONS

BATCH: An irradiation event.

RUN: An extraction.

DISC: Part of an extraction.

SAMPLE: The type of sample.

The laboratory archive consists of indexes and sheets.

The indexes, in order of appearance are :
(i) Master index - an overall list of contents
(ii) Batch index - cross tabulating irradiation batches, samples, runs
(iii) Run index - giving references to the runs, dates and pages
(iv) Sample index - giving a list of samples
(v) Procedure index - list of procedures

The sheets consist of
(i) Batch sheets containing details of the irradiation batches including dates, sample contents, dosimetry details etc..
(ii) Run sheets giving details of experimental work and results from sequences of measurements
(iii) Sample list - description of sample, provenance, purchasing details etc
(iv) Procedure sheets giving details of experimental procedures, extractions etc.

Appendix B

AMPLE INDEX

Last update:11.2.88

eference	Sample Type	Source	Date	Page
SP1	Ground Cinnamon	Spicemanns	28.4.87	S.5
SP2	Ground Paprika	Spicemanns	28.4.87	S.5
SP3	Rubbed Parsley	Spicemanns	28.4.87	S.5
SP4	Rubbed Tarragon	Spicemanns	28.4.87	S.5
SP5	Ground Allspice	Schwartz	20.1.88	S.5
SP6	Ground Cinnamon	Schwartz	20.1.88	S.5
SP7	Ground Cloves	Schwartz	20.1.88	S.5
SP8	Ground Ginger	Schwartz	20.1.88	S.5
SP9	Ground Mace	Schwartz	20.1.88	S.5
SP10	Ground Nutmeg	Schwartz	20.1.88	S.6
SP11	Apple Pie Spice	Schwartz	20.1.88	S.6
SP12	Mixed spice	Schwartz	20.1.88	S.6
SP13	Ground Black Pepper	Schwartz	20.1.88	S.5
SP14	Ground White Pepper	Schwartz	20.1.88	S.6
SP15	Cayenne Pepper	Schwartz	20.1.88	S.6
SP16	Hot Chili Powder	Schwartz	20.1.88	S.6
SP17	Paprika	Schwartz	20.1.88	S.7
SP18	Ground Coriander	Schwartz	20.1.88	S.7
SP19	Ground Cumin	Schwartz	20.1.88	S.7
SP20	Turmeric	Schwartz	20.1.88	S.7
SP21	Curry Powder	Schwartz	20.1.88	S.7
SP22	Garam Masala	Schwartz	20.1.88	S.7
SP23	Basil	Schwartz	20.1.88	S.7
SP24	Ground Bay Leaves	Schwartz	20.1.88	S.8
SP25	Chives	Schwartz	20.1.88	S.8
SP26	Dill Weed	Schwartz	20.1.88	S.8
SP27	Marjoram	Schwartz	20.1.88	S.8
SP28	Mint	Schwartz	20.1.88	S.8
SP29	Oregano	Schwartz	20.1.88	S.8
SP30	Parsley	Schwartz	20.1.88	S.8
SP31	Rosemary	Schwartz	20.1.88	S.9
SP32	Rubbed Sage	Schwartz	20.1.88	S.9
SP33	Tarragon	Schwartz	20.1.88	S.9
SP34(A+B)	Thyme	Schwartz	20.1.88	S.9
SP35	Herbes de Provence	Schwartz	20.1.88	S.9
SP36	Mixed Herbs	Schwartz	20.1.88	S.9
SP37	Garlic Granules	Schwartz	20.1.88	S.9
SP38	Garlic Pepper	Schwartz	20.1.88	S.10
SP39	Garlic Salt	Schwartz	20.1.88	S.10
SP40(A+B)	Onion Salt	Schwartz	20.1.88	S.10
SP41	Onion Granules	Schwartz	20.1.88	S.10
SP42	Barbecue Seasoning	Schwartz	20.1.88	S.10
SP43	Casserole Seasoning	Schwartz	20.1.88	S.10
SP44	Celery Seasoning	Schwartz	20.1.88	S.11
SP45	Chicken Seasoning	Schwartz	20.1.88	S.11
SP46	Chinese Seasoning	Schwartz	20.1.88	S.11
SP47	Fish Seasoning	Schwartz	20.1.88	S.11
SP48	Grill Seasoning	Schwartz	20.1.88	S.11
SP49	Italian Seasoning	Schwartz	20.1.88	S.11
SP50	Pizza Seasoning	Schwartz	20.1.88	S.12
SP51	Pork Seasoning	Schwartz	20.1.88	S.12
SP52	Steak Seasoning	Gateway	25.1.88	S.12
SP53	Salt			

SAMPLE INDEX Last update:11.2.88

Reference	Sample Type	Source	Date	Page
SP54	TL 1	L.Heide	14.12.87	S.12
SP55	TL 2	L.Heide	14.12.87	S.12
SP56	TL 3	L.Heide	14.12.87	S.12
SP57	TL 4	L.Heide	14.12.87	S.12
SP58	Pfifferlinge 1	L.Heide	14.12.87	S.13
SP59	Pfifferlinge 2	L.Heide	14.12.87	S.13
SP60	Pfifferlinge 3	L.Heide	14.12.87	S.13
SP61	Pfifferlinge 4	L.Heide	14.12.87	S.13
SP62	Pfifferlinge 5	L.Heide	14.12.87	S.13
SP63	Bohnenkraut 1	L.Heide	14.12.87	S.13
SP64	Bohnenkraut 2	L.Heide	14.12.87	S.13
SP65	Bohnenkraut 3	L.Heide	14.12.87	S.13
SP66	Bohnenkraut 4	L.Heide	14.12.87	S.13
SP67	Bohnenkraut 5	L.Heide	14.12.87	S.14
SP68	Curcuma 1	L.Heide	14.12.87	S.14
SP69	Curcuma 2	L.Heide	14.12.87	S.14
SP70	Curcuma 3	L.Heide	14.12.87	S.14
SP71	Curcuma 4	L.Heide	14.12.87	S.14
SP72	Curcuma 5	L.Heide	14.12.87	S.14
SP73	Ingwer 1	L.Heide	14.12.87	S.14
SP74	Ingwer 2	L.Heide	14.12.87	S.14
SP75	Ingwer 3	L.Heide	14.12.87	S.14
SP76	Ingwer 4	L.Heide	14.12.87	S.15
SP77	Ingwer 5	L.Heide	14.12.87	S.15
SP78	Majoran 1	L.Heide	14.12.87	S.15
SP79	Majoran 2	L.Heide	14.12.87	S.15
SP80	Majoran 3	L.Heide	14.12.87	S.15
SP81	Majoran 4	L.Heide	14.12.87	S.15
SP82	Majoran 5	L.Heide	14.12.87	S.15
SP83	Paprika 1	L.Heide	14.12.87	S.15
SP84	Paprika 2	L.Heide	14.12.87	S.15
SP85	Paprika 3	L.Heide	14.12.87	S.16
SP86	Paprika 4	L.Heide	14.12.87	S.16
SP87	Paprika 5	L.Heide	14.12.87	S.16
SP88	Pfeffer,schwarz 1	L.Heide	14.12.87	S.16
SP89	Pfeffer,schwarz 2	L.Heide	14.12.87	S.16
SP90	Pfeffer,schwarz 3	L.Heide	14.12.87	S.16
SP91	Pfeffer,schwarz 4	L.Heide	14.12.87	S.16
SP92	Pfeffer,schwarz 5	L.Heide	14.12.87	S.16
SP93	Salbei 1	L.Heide	14.12.87	S.16
SP94	Salbei 2	L.Heide	14.12.87	S.17
SP95	Salbei 3	L.Heide	14.12.87	S.17
SP96	Salbei 4	L.Heide	14.12.87	S.17
SP97	Salbei 5	L.Heide	14.12.87	S.17
SP98	Sellerie saat 1	L.Heide	14.12.87	S.17
SP99	Sellerie saat 2	L.Heide	14.12.87	S.17
SP100	Sellerie saat 3	L.Heide	14.12.87	S.17
SP101	Sellerie saat 4	L.Heide	14.12.87	S.17
SP102	Sellerie saat 5	L.Heide	14.12.87	S.18

SAMPLE INDEX Last update:11.2.88

Reference	Sample Type	Source	Date	Page
SP103	Thymian 1	L.Heide	14.12.87	S.18
SP104	Thymian 2	L.Heide	14.12.87	S.18
SP105	Thymian 3	L.Heide	14.12.87	S.18
SP106	Thymian 4	L.Heide	14.12.87	S.18
SP107	Thymian 5	L.Heide	14.12.87	S.18
SP108	Chilli Powder	Boots	3.2.88	S.18
SP109	Cinnamon	Boots	3.2.88	S.18
SP110	Ground Ginger	Boots	3.2.88	S.18
SP111	Paprika	Boots	3.2.88	S.19
SP112	Black Pepper	Boots	3.2.88	S.19
SP113	Turmeric	Boots	3.2.88	S.19
SP114	Caraway seeds	Boots	3.2.88	S.19
SP115	Oregano	Boots	3.2.88	S.19
SP116	Parsley	Boots	3.2.88	S.19
SP117	Rosemary	Boots	3.2.88	S.19
SP118	Chilli(Cayenne)	Millstone	3.2.88	S.20
SP119	Ground Cinnamon	Millstone	3.2.88	S.20
SP120	Ground Ginger	Millstone	3.2.88	S.20
SP121	Garlic Powder	Millstone	3.2.88	S.20
SP122	Ground Black Pepper	Millstone	3.2.88	S.20
SP123	Ground White Pepper	Millstone	3.2.88	S.20
SP124	Dried Mint	Millstone	3.2.88	S.21
SP125	Dried Oregano	Millstone	3.2.88	S.21
SP126	Dried Parsley	Millstone	3.2.88	S.21
SP127	Dried Sage	Fine Fare	3.2.88	S.21
SP128	Cayenne Pepper	Safeway	3.2.88	S.21
SP129	Ground Cinnamon	Safeway	3.2.88	S.21
SP130	Ground Ginger	Safeway	3.2.88	S.22
SP131	Ground Nutmeg	Safeway	3.2.88	S.22
SP132	Ground Black Pepper	Safeway	3.2.88	S.22
SP133	Ground White Pepper	Safeway	3.2.88	S.22
SP134	Paprika	Safeway	3.2.88	S.22
SP135	Dried Basil	Safeway	3.2.88	S.22
SP136	Dried Chives	Safeway	3.2.88	S.22
SP137	Dried Marjoram	Safeway	3.2.88	S.23
SP138	Dried Mint	Safeway	3.2.88	S.23
SP139	Dried Oregano	Safeway	3.2.88	S.23
SP140	Dried Parsley	Safeway	3.2.88	S.23
SP141	Dried Rosemary	Safeway	3.2.88	S.23
SP142	Dried Sage	Safeway	3.2.88	S.23
SP143	Dried Thyme	Safeway	3.2.88	S.23
SP144	Ground Garlic	Lion	3.2.88	S.24
SP145	Paprika	Rajah	3.2.88	S.24
SP146	Ground Cinnamon	Lion	3.2.88	S.24
SP147(A+B)	Ground Ginger	Lion	3.2.88	S.24
SP148	Paprika	Lion	3.2.88	S.24
SP149	Basil	Lion	3.2.88	S.24
SP150	Oregano	Lion	3.2.88	S.25
SP151	Parsley	Lion	3.2.88	S.25
SP152	Thyme	Lion	3.2.88	S.25

SAMPLE INDEX

Last update: 18.2.88

Reference	Sample Type	Source	Date	Page
SP153	Cayenne	Bart	3.2.88	S.25
SP154	Chilli	Bart	3.2.88	S.25
SP155	Cinnamon	Bart	3.2.88	S.25
SP156	Ginger	Bart	3.2.88	S.25
SP157	Turmeric	Bart	3.2.88	S.26
SP158	Basil	Bart	3.2.88	S.26
SP159	Chives	Bart	3.2.88	S.26
SP160	Marjoram	Bart	3.2.88	S.26
SP161	Mint	Bart	3.2.88	S.26
SP162	Parsley	Bart	3.2.88	S.26
SP163	Rosemary	Bart	3.2.88	S.26
SP164	Sage	Bart	3.2.88	S.27
SP165	French Tarragon	Bart	3.2.88	S.27
SP166	Thyme	Bart	3.2.88	S.27
SP167	Ground Aniseed	Spicemanns	16.2.88	S.27
SP168	Ground Star Anise	Spicemanns	16.2.88	S.27
SP169	Ground Caraway	Spicemanns	16.2.88	S.27
SP170	Ground Cardamom	Spicemanns	16.2.88	S.27
SP171	Ground Cassia	Spicemanns	16.2.88	S.27
SP172	Ground Cinnamon	Spicemanns	16.2.88	S.27
SP173	Ground Coriander	Spicemanns	16.2.88	S.28
SP174	Ground Cloves	Spicemanns	16.2.88	S.28
SP175	Ground Cloves	Spicemanns	16.2.88	S.28
SP176	Ground Clove Stems	Spicemanns	16.2.88	S.28
SP177	Ground Cumin	Spicemanns	16.2.88	S.28
SP178	Ground Dill	Spicemanns	16.2.88	S.28
SP179	Ground Fennel	Spicemanns	16.2.88	S.28
SP180	Ground Fenugreek	Spicemanns	16.2.88	S.28
SP181	Garlic Powder	Spicemanns	16.2.88	S.28
SP182	Ground Ginger	Spicemanns	16.2.88	S.28
SP183	Ground Ginger	Spicemanns	16.2.88	S.28
SP184	Mace	Spicemanns	16.2.88	S.29
SP185	Ground Mixed Spice	Spicemanns	16.2.88	S.29
SP186	Ground Mustard	Spicemanns	16.2.88	S.29
SP187	Ground Nutmeg	Spicemanns	16.2.88	S.29
SP188	Ground Cayenne	Spicemanns	16.2.88	S.29
SP189	Chilli Powder	Spicemanns	16.2.88	S.29
SP190	Ground Paprika	Spicemanns	16.2.88	S.29
SP191	Ground Paprika	Spicemanns	16.2.88	S.29
SP192	Ground Black Pepper	Spicemanns	16.2.88	S.29
SP193	Ground Black Pepper	Spicemanns	16.2.88	S.29
SP194	Ground White Pepper	Spicemanns	16.2.88	S.29
SP195	Ground White Pepper	Spicemanns	16.2.88	S.30
SP196	Ground Turmeric	Spicemanns	16.2.88	S.30
SP197	Ground Basil	Spicemanns	16.2.88	S.30
SP198	Ground Bay	Spicemanns	16.2.88	S.30
SP199	Ground Celery	Spicemanns	16.2.88	S.30
SP200	Ground Marjoram	Spicemanns	16.2.88	S.30
SP201	Ground Mint	Spicemanns	16.2.88	S.30

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Last update:14.3.88

erence	Sample Type	Source	Date	Page
SP202	Ground Oregano	Spicemanns	16.2.88	S.30
SP203	Ground Parsley	Spicemanns	16.2.88	S.30
SP204	Ground Rosemary	Spicemanns	16.2.88	S.30
SP205	Ground Sage	Spicemanns	16.2.88	S.30
SP206	Ground Thyme	Spicemanns	16.2.88	S.31
SP207	Nutmeg extract S.B.	Spicemanns	16.2.88	S.31
SP208	Pepper extract S.B.	Spicemanns	16.2.88	S.31
SP209	Sage extract S.B.	Spicemanns	16.2.88	S.31
SP210	Ground Allspice	Grass Roots	29.2.88	S.31
SP211	Green Anise	Grass Roots	29.2.88	S.31
SP212	Ground Cardamom	Grass Roots	29.2.88	S.31
SP213	Caraway Seeds	Grass Roots	29.2.88	S.31
SP214	Celery Seeds	Grass Roots	29.2.88	S.32
SP215	Chervil	Grass Roots	29.2.88	S.32
SP216	Fennel Seeds	Grass Roots	29.2.88	S.32
SP217	Fennel Herb	Grass Roots	29.2.88	S.32
SP218	Ground Fennel	Grass Roots	29.2.88	S.32
SP219	Fenugreek Seeds	Grass Roots	29.2.88	S.32
SP220	Methi Leaves	Grass Roots	29.2.88	S.32
SP221	Mint	Grass Roots	29.2.88	S.32
SP222	Yellow Mustard Seed	Grass Roots	29.2.88	S.33
SP223	Black Mustard Seed	Grass Roots	29.2.88	S.33
SP224	Ground Mustard	Grass Roots	29.2.88	S.33
SP225	Onion Powder	Grass Roots	29.2.88	S.33
SP226	Poppy Seeds	Grass Roots	29.2.88	S.33
SP227	Sesame Seeds	Grass Roots	29.2.88	S.33
SP228	Saffron	Grass Roots	29.2.88	S.33
SP229	Spearmint	Grass Roots	29.2.88	S.33
SP230	Nutmeg oleoresin	Spicemanns	9.3.88	S.33
SP231	Pepper oleoresin	Spicemanns	9.3.88	S.33
SP232	Sage oleoresin	Spicemanns	9.3.88	S.34
SP233	Chicken bones	CS	14.3.88	S.34
SP234	Lamb bones	DCWS	14.3.88	S.34

Appendix C

SAMPLE LIST

eference SP1	Ground Cinnamon (100g) from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to JAI 28.4.87. Batch RM 0063. Country of origin:Seychelles.
Reference SP2	Ground Paprika (100g) from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to JAI 28.4.87. Batch RM 0202. Country of origin:Spain.
eference SP3	Rubbed Parsley (100g) from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to JAI 28.4.87. Batch RM 0205. Country of origin:England.
Reference SP4	Rubbed Tarragon (100g) from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to JAI 28.4.87. Batch RM 0268. Country of origin:France.
eference SP5	Ground Allspice (29g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride, 20.1.88 Batch no. 3367. Product of Jamaica. Price 68p.
Reference SP6	Ground Cinnamon (32g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride, 20.1.88 Batch no. 2737. Product of more than one country. Price 59p.
Reference SP7	Ground Cloves (35g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride, 20.1.88 Batch no. 0257. Product of Madagascar. Price £1.24.
Reference SP8	Ground Ginger (26g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride, 20.1.88 Batch no. 3367. Product of India. Price 54p.
Reference SP9	Ground Mace (29g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride, 20.1.88 Batch no. 3367. Product of Sri Lanka. Price 79p.

SAMPLE LIST

ference SP10	Ground Nutmeg (32g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 3037. Product of West Indies. Price 66p.
ference SP11	Apple Pie Spice (32g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 3216. Ingredients: cassia, cinnamon, nutmeg. Country of origin unknown. Price 74p.
ference SP12	Mixed Spice (26g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 3367. Ingredients: coriander seed, cinnamon, caraway seed, cassia, nutmeg, ginger, cloves. Country of origin unknown. Price 59p.
ference SP13	Ground Black Pepper (32g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 2727. Product of Malaysia. Price 84p.
ference SP14	Ground White Pepper (32g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 0867. Product of Malaysia. Price 84p.
ference SP15	Cayenne Pepper (32g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 1967. Product of Pakistan. Price 84p.
ference SP16	Hot Chili Powder (36g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 2507. Ingredients: chili pepper, chili seed, cumin seed, salt, garlic, oregano. Country of origin unknown. Price 74p.

SAMPLE LIST

rence SP17	Paprika (34g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 3227.Product of Spain. Price 69p.
ference SP18	Ground Coriander (23g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 2477.Product of Morocco. Price 69p.
ference SP19	Ground Cumin (26g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 3297.Product of India. Price 74p.
ference SP20	Turmeric (29g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 3017.Product of India. Price 66p.
rence SP21	Curry Powder (35g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 2807. Ingredients: coriander seed salt, turmeric, allspice, ginger, fenugreek seed, garlic powder, black pepper, cumin seed, cayenne pepper, bay leaves. Country of origin unknown. Price 66p.
rence SP22	Garam Masala (30g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 1977. Ingredients: coriander seed black pepper, cumin seed, allspice, cardamom, turmeric, nutmeg, ginger, cloves, bay leaves, cinnamon, chili powder. Country of origin unknown. Price 74p.
rence SP23	Basil packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 1177.Product of Egypt. Price 54p.
erence SP24	Ground Bay Leaves (25g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 1037.Product of Turkey. Price 54p.

SAMPLE LIST

eference SP25	Chives packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 3247. Product of Denmark. Price 74p.
Reference SP26	Dill Weed packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 3217. Product of West Germany. Price 69p.
Reference SP27	Marjoram packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 2397. Product of Egypt. Price 66p.
eference SP28	Mint packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 0347. Product of Egypt. Price 54p.
eference SP29	Oregano packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 2757. Product of Turkey. Price 66p.
eference SP30	Parsley packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 3427. Product of U.S.A. Price 54p.
Reference SP31	Rosemary packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 2537. Product of Spain. Price 54p.

SAMPLE LIST

ference SP32	Rubbed Sage packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 2597. Product of Turkey. Price 66p.
ference SP33	Tarragon packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 2677. Product of France. Price 79p.
ference SP34(A+B)	Thyme packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 1187. Product of Spain. Price 54p.
ference SP35	Herbes de Provence packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 2116. Ingredients: bay leaves, parsley, sage, thyme, rosemary. Country of origin unknown. Price 64p.
ference SP36	Mixed Herbs packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 2307. Ingredients: marjoram, basil,oregano, thyme. Country of origin unknown. Price 54p.
ference SP37	Garlic Granules (41g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 1917. Product of more than one country. Price 79p.
ference SP38	Garlic Pepper (46g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 2017. Ingredients: dried garlic, white pepper, salt, flavour enhancer 621 (MSG), celery seed. Country of origin unknown. Price 79p.

SAMPLE LIST

Reference SP39	Garlic Salt (73g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 2167.Ingredients: salt,garlic powder. Country of origin unknown. Price 69p.
Reference SP40(A+B)	Onion Salt (65g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 3147.Ingredients: salt, onion powder. Country of origin unknown. Price 66p.
Reference SP41	Onion Granules (32g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 2517. Product of more than one country. Price 64p.
Reference SP42	Barbecue Seasoning (42g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 2096.Ingredients: salt, onion powder,mustard flour, chili powder, flavouring. Country of origin unknown. Price 74p. (This jar had a faulty cap when purchased.)
Reference SP43	Casserole Seasoning (45g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 2517.Ingredients: salt, dried onion, flavour enhancer 621 (MSG), pepper, marjoram, garlic powder, oregano, basil, thyme, nutmeg. Country of origin unknown. Price 74p.
Reference SP44	Celery Seasoning (49g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 1556.Ingredients: salt, celery seed, starch, dried pimentos, flavour enhancer 621 (MSG), dried onion, paprika, poppy seeds, sugar, dried garlic, pepper, parsley. Country of origin unknown. Price 59p.

SAMPLE LIST

eference SP45	Chicken Seasoning (53g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 2467. Ingredients: salt, paprika, onion powder, celery seed, red pepper. Country of origin unknown. Price 74p.
eference SP46	Chinese Seasoning (58g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 1467. Ingredients: salt, flavour enhancer 621 (MSG), star anise, onion powder, sugar, black pepper,fennel seed, cinnamon, cloves, ginger, garlic powder, flavouring. Country of origin unknown. Price 74p.
eference SP47	Fish Seasoning (57g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 3166. Ingredients: salt, flavour enhancer 621 (MSG), white pepper, onion powder, celery seed, paprika. Country of origin unknown. Price 68p.
eference SP48	Grill Seasoning (55g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 0207. Ingredients: salt, flavour enhancer 621 (MSG), onion powder, coriander seed, black pepper, sesame seed, paprika, garlic powder, red pepper. Country of origin unknown. Price 74p.
eference SP49	Italian Seasoning packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 2647. Ingredients: oregano, thyme parsley, basil, sage, pepper, bay leaves. Country of origin unknown. Price 69p.
eference SP50	Pizza Seasoning (28g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 0557. Ingredients: sesame seed, salt, basil, rosemary, oregano, thyme sugar, pepper, onion powder, garlic powder. Country of origin unknown. Price 74p.

SAMPLE LIST

eference SP51	Pork Seasoning (48g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 2117. Ingredients: salt,black pepper, flavour enhancer 621 (MSG), onion powder, ginger, sage, bergamot oil. Country of origin unknown. Price 74p.
eference SP52	Steak Seasoning (46g) packed by Schwartz Spices, Wenman Road, Thame, Oxon OX9 3SL. Purchased from Safeway, East Kilbride 20.1.88. Batch no. 1467. Ingredients: salt,black pepper, celery seed, flavour enhancer 621 (MSG), onion powder, sugar, ginger, flavouring. Country of origin unknown. Price 74p.
eference SP53	Salt (Na Cl) Gateway Cooking Salt Ingredients: salt, anticaking agent:sodium hexacyanoferrate II
Reference SP54	TL1 from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG. Identity unknown.
Reference SP55	TL2 from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG. Identity unknown.
Reference SP56	TL3 from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG. Identity unknown.
Reference SP57	TL4 from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG. Identity unknown.

SAMPLE LIST

eference SP58	Pfifferlinge 1, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
ference SP59	Pfifferlinge 2, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
ference SP60	Pfifferlinge 3, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
ference SP61	Pfifferlinge 4, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
eference SP62	Pfifferlinge 5, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP63	Bohnenkraut 1, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
eference SP64	Bohnenkraut 2, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
ference SP65	Bohnenkraut 3, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
ference SP66	Bohnenkraut 4, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.

SAMPLE LIST

ference SP67	Bohnenkraut 5, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
erence SP68	Curcuma 1, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
ference SP69	Curcuma 2, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
ference SP70	Curcuma 3, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
ference SP71	Curcuma 4, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
ference SP72	Curcuma 5, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
ference SP73	Ingwer 1, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
ference SP74	Ingwer 2, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP75	Ingwer 3, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.

SAMPLE LIST

:eference SP76	Ingwer 4, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP77	Ingwer 5, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP78	Majoran 1, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP79	Majoran 2, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP80	Majoran 3, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP81	Majoran 4, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP82	Majoran 5, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP83	Paprika 1, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP84	Paprika 2, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.

SAMPLE LIST

Reference SP85	Paprika 3, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP86	Paprika 4, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
ference SP87	Paprika 5, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
ference SP88	Pfeffer,schwartz 1, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
ference SP89	Pfeffer,schwartz 2, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP90	Pfeffer,schwartz 3, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP91	Pfeffer,schwartz 4, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP92	Pfeffer,schwartz 5, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
eference SP93	Salbei 1, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.

SAMPLE LIST

Reference SP93	Salbei 1, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP94	Salbei 2, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP95	Salbei 3, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP96	Salbei 4, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP97	Salbei 5, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP98	Sellerie saat 1, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP99	Sellerie saat 2, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP100	Sellerie saat 3, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP101	Sellerie saat 4, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.

SAMPLE LIST

erence SP102	Sellerie saat 5, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
erence SP103	Thymian 1, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
erence SP104	Thymian 2, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
eference SP105	Thymian 3, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP106	Thymian 4, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP107	Thymian 5, (14.12.87) from the laboratory of L.Heide, Institute for Radiation Hygiene of the Federal Health Office, Ingolstadter Landstrasse, D-8042, Neuerberg,FRG.
Reference SP108	Chilli Powder (32g), packed for The Boots Co., Nottingham, England. Product code 0209 3642 TS7HB 1E2. Produce of China. Purchased 3.2.88 from Boots, East Kilbride. Price 56p.
Reference SP109	Cinnamon (25g), packed for The Boots Co., Nottingham, England. Product code 0209 3154 TS7XV 1C. Produce of Madagascar. Purchased 3.2.88 from Boots, East Kilbride. Price 42p.
Reference SP110	Ground Ginger (28g), packed for The Boots Co., Nottingham, England. Product code 0209 2751 WK3CH 2B2. Produce of China. Purchased 3.2.88 from Boots, East Kilbride. Price 47p.

SAMPLE LIST

Reference SP111	Paprika (37g), packed for The Boots Co., Nottingham, England. Product code 0209 2379 WK2VC 1C2. Produce of Spain. Purchased 3.2.88 from Boots, East Kilbride. Price 52p.
Reference SP112	Black Pepper Powder (35g), packed for The Boots Co., Nottingham, England. Product code 0209 2980 TS4ZE 1C2. Produce of Sarawak. Purchased 3.2.88 from Boots, East Kilbride. Price 61p.
Reference SP113	Turmeric (32g), packed for The Boots Co., Nottingham, England. Product code 0209 2492 WK2ZE 1K. Produce of India. Purchased 3.2.88 from Boots, East Kilbride. Price 41p.
Reference SP114	Caraway Seeds (33g) packed for The Boots Co., Nottingham, England. Product code 0209 3383 WK3KV 1C2. Produce of UK. Purchased 3.2.88 from Boots, East Kilbride. Price 74p.
Reference SP115	Oregano, packed for The Boots Co., Nottingham, England. Product code 0209 3758 TS7TC 1L2. Produce of Turkey. Best before end September 88. Purchased 3.2.88 from Boots, East Kilbride. Price 56p.
Reference SP116	Parsley packed for The Boots Co., Nottingham, England. Product code 0209 2263 WK2KZ 1H. Produce of UK. Best before end May 87. Purchased 3.2.88 from Boots, East Kilbride. Price 47p.
Reference SP117	Rosemary packed for The Boots Co., Nottingham, England. Product code 0209 3871 TS8BH 2E. Produce of Spain. Best before end July 87. Purchased 3.2.88 from Boots, East Kilbride. Price 47p.

SAMPLE LIST

Reference SP118	Chilli Powder(Cayenne)(50g) Millstone Brand, packed by The British Pepper & Spice Co. Ltd., Rhosili Road, Brackmills, Northampton NN4 0LD. Product code 5 000385 001673. Produce of more than one country. Purchased 3.2.88 from Gateway, East Kilbride. Price 35p.
Reference SP119	Ground Cinnamon (25g) Millstone Brand, packed by The British Pepper & Spice Co. Ltd., Rhosili Road, Brackmills, Northampton NN4 0LD. Product code 5038 5096. Country of origin unknown. Purchased 3.2.88 from Gateway, East Kilbride. Price 19p.
Reference SP120	Ground Ginger (25g) Millstone Brand, packed by The British Pepper & Spice Co. Ltd., Rhosili Road, Brackmills, Northampton NN4 0LD. Product code 5038 5119. Country of origin unknown. Purchased 3.2.88 from Gateway, East Kilbride. Price 22p.
Reference SP121	Garlic Powder (70g) Millstone Brand, packed by The British Pepper & Spice Co. Ltd., Rhosili Road, Brackmills, Northampton NN4 0LD. Product code 5 000385 000515. Produce of USA. Purchased 3.2.88 from Gateway, East Kilbride. Price 39p.
Reference SP122	Ground Black Pepper (25g). Millstone Brand, packed by The British Pepper & Spice Co. Ltd., Rhosili Road, Brackmills, Northampton NN4 0LD. Product code 5038 5041. Country of origin unknown. Purchased 3.2.88 from Gateway, East Kilbride. Price 33p.
Reference SP123	Ground White Pepper (25g). Millstone Brand, packed by The British Pepper & Spice Co. Ltd., Rhosili Road, Brackmills, Northampton NN4 0LD. Product code 5038 5034. Country of origin unknown. Purchased 3.2.88 from Gateway, East Kilbride. Price 36p.

SAMPLE LIST

erence SP124	Dried Mint Millstone Brand, packed by The British Pepper & Spice Co. Ltd., Rhosili Road, Brackmills, Northampton NN4 0LD. Product code 5 000385 000379. Produce of Egypt. Purchased 3.2.88 from Gateway, East Kilbride. Price 26p.
erence SP125	Dried Oregano Millstone Brand, packed by The British Pepper & Spice Co. Ltd., Rhosili Road, Brackmills, Northampton NN4 0LD. Product code 5 000385 000386. Produce of Turkey. Purchased 3.2.88 from Gateway, East Kilbride. Price 26p.
Reference SP126	Dried Parsley Millstone Brand, packed by The British Pepper & Spice Co. Ltd., Rhosili Road, Brackmills, Northampton NN4 0LD. Product code 5 000385 000348. Produce of Great Britain. Purchased 3.2.88 from Gateway, East Kilbride. Price 26p.
Reference SP127	Dried Sage (25g) Packed for Fine Fare Ltd.,Welwyn Garden City, Herts. Product code 0000 4541 454. Batch no.6148. Produce of Italy. Purchased 3.2.88 from Gateway, East Kilbride. Price 27p.
erence SP128	Cayenne Pepper (25g). Packed for Safeway Food Stores Ltd., Aylesford, Kent. Product code 0500 2108. Batch no.7300. Country of origin unknown. Purchased 3.2.88 from Safeway, East Kilbride. Price 23p.
erence SP129	Ground Cinnamon (25g). Packed for Safeway Food Stores Ltd., Aylesford, Kent. Product code 0500 2160. Batch no.8012. Country of origin unknown. Purchased 3.2.88 from Safeway, East Kilbride. Price 23p.

SAMPLE LIST

Reference SP130	Ground Ginger (25g). Packed for Safeway Food Stores Ltd., Aylesford, Kent. Product code 0500 2139. Batch no.7348. Country of origin unknown. Purchased 3.2.88 from Safeway, East Kilbride. Price 26p.
Reference SP131	Ground Nutmeg (25g). Packed for Safeway Food Stores Ltd., Aylesford, Kent. Product code 0500 2146. Batch no.7320. Produce of West Indies. Purchased 3.2.88 from Safeway, East Kilbride. Price 34p.
Reference SP132	Ground Black Pepper (25g). Packed for Safeway Food Stores Ltd., Aylesford, Kent. Product code 0500 2085. Batch no.7349. Country of origin unknown. Purchased 3.2.88 from Safeway, East Kilbride. Price 33p.
Reference SP133	Ground White Pepper (25g). Packed for Safeway Food Stores Ltd., Aylesford, Kent. Product code 0500 2061. Batch no.7329. Country of origin unknown. Purchased 3.2.88 from Safeway, East Kilbride. Price 36p.
Reference SP134	Paprika (25g). Packed for Safeway Food Stores Ltd., Aylesford, Kent. Product code 0500 2115. Batch no.8005. Product of Hungary. Purchased 3.2.88 from Safeway, East Kilbride. Price 25p.
Reference SP135	Dried Basil Packed for Safeway Food Stores Ltd., Aylesford, Kent. Product code 0502 3066. Batch no.7323. Produce of Egypt. Purchased 3.2.88 from Safeway, East Kilbride. Price 35p.
Reference SP136	Dried Chives (9g) Packed for Safeway Food Stores Ltd., Aylesford, Kent. Product code 0500 2320. Batch no.7216. Product of West Germany. Purchased 3.2.88 from Safeway, East Kilbride. Price 49p.

SAMPLE LIST

Reference SP137	Dried Marjoram. Packed for Safeway Food Stores Ltd., Aylesford, Kent. Product code 0500 2344. Batch no.7280. Produce of Egypt. Purchased 3.2.88 from Safeway, East Kilbride. Price 37p.
eference SP138	Dried Mint. Packed for Safeway Food Stores Ltd., Aylesford, Kent. Product code 0500 2252. Batch no.6077. Produce of Egypt. Purchased 3.2.88 from Safeway, East Kilbride. Price 28p.
Reference SP139	Dried Oregano. Packed for Safeway Food Stores Ltd., Aylesford, Kent. Product code 0500 2313. Batch no.7324. Produce of Chile. Purchased 3.2.88 from Safeway, East Kilbride. Price 37p.
eference SP140	Dried Parsley. Packed for Safeway Food Stores Ltd., Aylesford, Kent. Product code 0500 2276. Batch no.7324. Produce of United Kingdom. Purchased 3.2.88 from Safeway, East Kilbride. Price 35p.
Reference SP141	Dried Rosemary. Packed for Safeway Food Stores Ltd., Aylesford, Kent. Product code 0502 3059. Batch no.7191. Produce of Spain. Purchased 3.2.88 from Safeway, East Kilbride. Price 35p.
Reference SP142	Dried Sage. Packed for Safeway Food Stores Ltd., Aylesford, Kent. Product code 0500 2283. Batch no.7324. Produce of Italy. Purchased 3.2.88 from Safeway, East Kilbride. Price 37p.
Reference SP136	Dried Thyme. Packed for Safeway Food Stores Ltd., Aylesford, Kent. Product code 0500 2290. Batch no.7282. Produce of Spain. Purchased 3.2.88 from Safeway, East Kilbride. Price 37p.

SAMPLE LIST

eference SP144	Pure Ground Garlic (45g). Packed by Lion Foods Ltd., Astmoor, Runcorn, Cheshire, England. Product code 5098 2134 Produce of USA. Purchased 3.2.88 from Safeway, East Kilbride. Price 65p.
ference SP145	Paprika (Sweet Red Pepper Powder) (100g). Rajah Brand, packed by B.E. International Foods Ltd., Radiant House, Pegamoid Road, London N18 2NG, England. Product code 5 010928 055117. Produce of Spain. Purchased 3.2.88 from Safeway, East Kilbride. Price 58p.
ference SP146	Ground Cinnamon (25g). Packed by Lion Foods Ltd., Astmoor, Runcorn, Cheshire, England. Product code 5096 6899. Country of origin unknown. Purchased 3.2.88 from Holland & Barret, East Kilbride. Price 26p.
ference SP147(A+B)	Ground Ginger (25g). Packed by Lion Foods Ltd., Astmoor, Runcorn, Cheshire, England. Product code 5096 6882. Country of origin unknown. Purchased 3.2.88 from Holland & Barret, East Kilbride. Price 26p.
eference SP148	Paprika (25g). Packed by Lion Foods Ltd., Astmoor, Runcorn, Cheshire, England. Product code 5096 6844. Produce of Spain. Purchased 3.2.88 from Holland & Barret, East Kilbride. Price 29p.
ference SP149	Basil. Packed by Lion Foods Ltd., Astmoor, Runcorn, Cheshire, England. Product code 5096 3256. Batch no.7238. Produce of Egypt. Purchased 3.2.88 from Holland & Barret, East Kilbride. Price 42p.

SAMPLE LIST

Reference SP150	Oregano. Packed by Lion Foods Ltd., Astmoor, Runcorn, Cheshire, England. Product code 5096 3218. Batch no.7292. Produce of Turkey. Purchased 3.2.88 from Holland & Barret, East Kilbride. Price 42p.
Reference SP151	Parsley. Packed by Lion Foods Ltd., Astmoor, Runcorn, Cheshire, England. Product code 5096 3201. Batch no.7282. Produce of United Kingdom. Purchased 3.2.88 from Holland & Barret, East Kilbride. Price 42p.
Reference SP152	Thyme. Packed by Lion Foods Ltd., Astmoor, Runcorn, Cheshire, England. Product code 5096 3164. Batch no.7281. Produce of Spain. Purchased 3.2.88 from Holland & Barret, East Kilbride. Price 42p.
Reference SP153	Cayenne (40g). Packed by Bart Spices, Bristol, England. Product code 5098 1168. Batch no.801. Produce of England. Purchased 3.2.88 from Holland & Barret, East Kilbride. Price 49p.
Reference SP154	Chilli (35g). Packed by Bart Spices, Bristol, England. Product code 5098 1137. Batch no.803. Produce of China. Purchased 3.2.88 from Holland & Barret, East Kilbride. Price 49p.
Reference SP155	Cinnamon (30g). Packed by Bart Spices, Bristol, England. Product code 5098 1106. Batch no.750. Produce of Seychelles. Purchased 3.2.88 from Holland & Barret, East Kilbride. Price 49p.
Reference SP156	Ginger (35g). Packed by Bart Spices, Bristol, England. Product code 5098 0994. Batch no.742. Produce of more than one country. Purchased 3.2.88 from Holland & Barret, East Kilbride. Price 59p.

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Reference SP157	Turmeric (40g). Packed by Bart Spices, Bristol, England. Product code 5098 0758. Batch no.802. Produce of India. Purchased 3.2.88 from Holland & Barret, East Kilbride. Price 49p.
Reference SP158	Basil (15g). Packed by Bart Spices, Bristol, England. Product code 5098 1236. Produce of Egypt. Purchased 3.2.88 from Holland & Barret, East Kilbride. Price 49p.
Reference SP159	Chives (5g). Packed by Bart Spices, Bristol, England. Product code 5098 1113. Batch no.750. Produce of Morocco. Purchased 3.2.88 from Holland & Barret, East Kilbride. Price 59p.
Reference SP160	Marjoram (10g). Packed by Bart Spices, Bristol, England. Product code 5098 0918. Batch no.749. Produce of Egypt. Purchased 3.2.88 from Holland & Barret, East Kilbride. Price 49p.
Reference SP161	Mint (15g). Packed by Bart Spices, Bristol, England. Product code 5098 0901. Batch no.781. Produce of Egypt. Purchased 3.2.88 from Holland & Barret, East Kilbride. Price 49p.
Reference SP162	Parsley (10g). Packed by Bart Spices, Bristol, England. Product code 5098 0840. Batch no.748. Produce of England. Purchased 3.2.88 from Holland & Barret, East Kilbride. Price 49p.
Reference SP163	Rosemary (25g). Packed by Bart Spices, Bristol, England. Product code 5098 0819. Batch no.747. Produce of France. Purchased 3.2.88 from Holland & Barret, East Kilbride. Price 49p.

SAMPLE LIST

Reference SP164	Sage (20g). Packed by Bart Spices, Bristol, England. Product code 5098 0802. Batch no.749. Produce of Italy. Purchased 3.2.88 from Holland & Barret, East Kilbride. Price 49p.
Reference SP165	French Tarragon (5g). Packed by Bart Spices, Bristol, England. Product code 5098 0772. Batch no.750. Produce of France. Purchased 3.2.88 from Holland & Barret, East Kilbride. Price 69p.
Reference SP166	Thyme (15g). Packed by Bart Spices, Bristol, England. Product code 5098 0765. Produce of Spain. Purchased 3.2.88 from Holland & Barret, East Kilbride. Price 49p.
Reference SP167	Ground Aniseed from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Turkey
Reference SP168	Ground Star Anise from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: China
Reference SP169	Ground Caraway from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Holland
Reference SP170	Ground Cardamom from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Papua New Guinea
Reference SP171	Ground Cassia from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Indonesia
Reference SP172	Ground Cinnamon from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Seychelles

SAMPLE LIST

Reference SP173	Ground Coriander from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Morocco
Reference SP174	Ground Cloves (darker) from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin unknown.
Reference SP175	Ground Cloves (lighter) from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin unknown.
Reference SP176	Ground Clove Stems from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Madagascar
Reference SP177	Ground Cumin from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Turkey.
Reference SP178	Ground Dill from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: India.
Reference SP179	Ground Fennel from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: China.
Reference SP180	Ground Fenugreek from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Turkey.
Reference SP181	Garlic Powder from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: USA.
Reference SP182	Ground African Ginger from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Nigeria.
Reference SP183	Ground Chinese Ginger from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: China.

SAMPLE LIST

Reference SP184	Ground Mace from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Grenada.
Reference SP185	Ground Mixed Spice from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Ingredients: cinnamon, coriander, dill, fennel, nutmeg, cloves, ginger, cassia, turmeric. Product of more than one country.
Reference SP186	Ground Mustard from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Canada.
Reference SP187	Ground Nutmeg from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: West Indies.
Reference SP188	Ground Cayenne from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Various.
Reference SP189	Chilli Powder from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: China.
Reference SP190	Ground Hungarian Paprika from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Hungary
Reference SP191	Ground Paprika from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Spain
Reference SP192	Ground Black Pepper from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Indonesia.
Reference SP193	Ground Black Pepper (840 micro) from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Indonesia.
Reference SP194	Ground White Pepper SP1 from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Sarawak/Indonesia.

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Reference SP195	Ground White Pepper SP2 from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Sarawak/Indonesia.
Reference SP196	Ground Turmeric from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: India.
Reference SP197	Ground Basil from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Egypt.
Reference SP198	Ground Bay from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Turkey.
Reference SP199	Ground Celery from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: India.
Reference SP200	Ground Marjoram from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Egypt.
Reference SP201	Ground Mint from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Morocco.
Reference SP202	Ground Oregano from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Isreal.
Reference SP203	Ground Parsley from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: England.
Reference SP204	Ground Rosemary from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Spain.
Reference SP205	Ground Sage from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Yugoslavia.

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Reference SP206	Ground Thyme from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Spain.
Reference SP207	Nutmeg extract-salt base from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: West Indies.
Reference SP208	Pepper extract-salt base from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Sri Lanka.
Reference SP209	Sage extract-salt base from Spicemanns, Kelvin Avenue, Glasgow G52 4LR. Supplied to DCWS/CS 16.2.88. Country of origin: Yugoslavia.
Reference SP210	Ground Allspice Purchased from Grass Roots, Great Western Road, Glasgow. Supplied by Green City, Glasgow. Tel. 041-556 4469. Country of origin unknown.
Reference SP211	Green Aniseed Purchased from Grass Roots, Great Western Road, Glasgow. Supplied by Green City, Glasgow. Tel. 041-556 4469. Country of origin unknown. Chopped prior to irradiation.
Reference SP212	Ground Cardamom Purchased from Grass Roots, Great Western Road, Glasgow. Supplied by Green City, Glasgow. Tel. 041-556 4469. Country of origin: India.
Reference SP213	Caraway Seeds Purchased from Grass Roots, Great Western Road, Glasgow. Supplied by Green City, Glasgow. Tel. 041-556 4469. Country of origin: Denmark. Chopped prior to irradiation.
Reference SP214	Whole Celery Seed Purchased from Grass Roots, Great Western Road, Glasgow. Supplied by Green City, Glasgow. Tel. 041-556 4469. Country of origin unknown.

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Reference SP215	Chervil Purchased from Grass Roots, Great Western Road, Glasgow. Supplied by Green City, Glasgow. Tel. 041-556 4469. Country of origin unknown.
Reference SP216	Fennel Seed Purchased from Grass Roots, Great Western Road, Glasgow. Supplied by Green City, Glasgow. Tel. 041-556 4469. Country of origin: India. Chopped prior to irradiation.
Reference SP217	Fennel Herb Purchased from Grass Roots, Great Western Road, Glasgow. Supplied by Green City, Glasgow. Tel. 041-556 4469. Country of origin: India? Chopped prior to irradiation.
Reference SP218	Ground Fennel Purchased from Grass Roots, Great Western Road, Glasgow. Supplied by Green City, Glasgow. Tel. 041-556 4469. Country of origin unknown.
Reference SP219	Fenugreek Seeds Purchased from Grass Roots, Great Western Road, Glasgow. Supplied by Green City, Glasgow. Tel. 041-556 4469. Country of origin unknown. Crushed using pestle & mortar prior to irradiation.
Reference SP220	Methi Leaves (fenugreek leaves) Purchased from Grass Roots, Great Western Road, Glasgow. Supplied by Green City, Glasgow. Tel. 041-556 4469. Country of origin unknown. Chopped prior to irradiation.
Reference SP221	Mint Purchased from Grass Roots, Great Western Road, Glasgow. Supplied by Green City, Glasgow. Tel. 041-556 4469. Country of origin unknown.
Reference SP222	Yellow Mustard Seeds Purchased from Grass Roots, Great Western Road, Glasgow. Supplied by Green City, Glasgow. Tel. 041-556 4469. Country of origin unknown. Crushed using pestle & mortar prior to irradiation.

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Reference SP223	Black Mustard Seeds Purchased from Grass Roots, Great Western Road, Glasgow. Supplied by Green City, Glasgow. Tel. 041-556 4469. Country of origin unknown. Crushed using pestle & mortar prior to irradiation.
Reference SP224	Ground Mustard Purchased from Grass Roots, Great Western Road, Glasgow. Supplied by Green City, Glasgow. Tel. 041-556 4469. Country of origin unknown.
Reference SP225	Onion Powder Purchased from Grass Roots, Great Western Road, Glasgow. Supplied by Green City, Glasgow. Tel. 041-556 4469. Country of origin unknown.
Reference SP226	Poppy Seeds Purchased from Grass Roots, Great Western Road, Glasgow. Supplied by Green City, Glasgow. Tel. 041-556 4469. Country of origin: Australia.
Reference SP227	Sesame Seeds Purchased from Grass Roots, Great Western Road, Glasgow. Supplied by Green City, Glasgow. Tel. 041-556 4469. Country of origin: China. Crushed using pestle & mortar prior to irradiation.
Reference SP228	Saffron Purchased from Grass Roots, Great Western Road, Glasgow. Supplied by Green City, Glasgow. Tel. 041-556 4469. Country of origin: Spain.
Reference SP229	Spearmint Purchased from Grass Roots, Great Western Road, Glasgow. Supplied by Green City, Glasgow. Tel. 041-556 4469. Country of origin unknown.
Reference SP230	Nutmeg oleoresin supplied by Spicemanns, Kelvin Avenue, Glasgow, G52 4LR. Received by post 9.3.88.
Reference SP231	Pepper oleoresin supplied by Spicemanns, Kelvin Avenue, Glasgow, G52 4LR. Received by post 9.3.88.

SAMPLE LIST

eference SP232	Sage oleoresin supplied by Spicemanns, Kelvin Avenue, Glasgow, G52 4LR. Received by post 9.3.88.
Reference SP233	Chicken bones supplied by CS 14.3.88.
Reference SP234	Lamb bones supplied by DCWS 14.3.88.

Appendix D

RUN SHEET

RUN NUMBER(S): 31-38 DATE(S): 13.1.88

Attempt to establish whether TL components can be separated from irradiated spices using a high density liquid.

(a) Procedure

(i) A 100mg sample was placed in a clean centrifuge tube, which had been marked with a 5cm level.
(ii) Sodium polytungstate (1.5046g/cc) was added to the marked level and the sample was aggitated to break up and disperse the spice.
(iii) The tubes were shaken in the ultrasonic bath for one minute and centrifuged for 30s at speed 1 (500g)
(iv) The upper layer was decanted through a filter into a clean centrifuge tube. The sides of the sample tube were cleaned using a small tissue. The undiluted density fluid was placed back in the bottle.
(v) The mineral fraction was washed with deionised water and centrifuged twice, pouring the liquid phase through the same filter as before. The diluted density fluid was retained for reconcentration.
(vi) The mineral phase was washed in 1M.HCl to a depth of 1cm for 30 minutes. The acid was diluted to the mark and centrifuged for 30s. The liquid phase was discarded, and the residue was washed in deionised water and centrifuged twice.
(vii) The mineral phase was washed in acetone and allowed to stand for 5 minutes, twice.
(viii) A clean disc was placed in each tube with 1-2cm acetone. The tubes were placed in an oven at 80C to drive off the acetone.
(ix) Meanwhile, the filter papers were washed twice with water and twice with acetone and allowed to dry in the oven. The residue from the filter papers was dispensed onto clean stainless steel discs, sprayed with silicone grease.
(x) The discs were read on the TL reader using the "SURRC TL package 16.3.87" system disc.

RUN SHEET

Date: 13.1.88

Batch 2: Exploratory separation of mineral & organic fractions of samples stored for 6 days at ambient temperature.

(b) Results

Filename*	Sample Mass/mg	Dose/ kGy	Phase	Specific TL 200'C
CINNAMON/2.31.1	1.02	0	mineral	690
CINNAMON/2.31.2	3.00	0	organic	543
CINNAMON/2.35.1	0.18	10	mineral	2262447
CINNAMON/2.35.2	1.69	10	organic	1633
PAPRIKA/2.32.1	0.07	0	mineral	3750
PAPRIKA/2.32.2	1.46	0	organic	874
PAPRIKA/2.36.1	0.10$	10	mineral	29970
PAPRIKA/2.36.2	3.01	10	organic	2902
PARSLEY/2.33.1	0.11	0	mineral	4272
PARSLEY/2.33.2	1.71	0	organic	1515
PARSLEY/2.37.1	0.10$	10	mineral	4263850
PARSLEY/2.37.2	2.05	10	organic	4508
TARRAGON/2.34.1	0.06	0	mineral	5375
TARRAGON/2.34.2	2.96	0	organic	941
TARRAGON/2.38.1	0.10$	10	mineral	444515
TARRAGON/2.38.2	3.46	10	organic	3906

$ Nominal mass where second weight of disc was less than first weight.

(c) Discussion

Most of the TL signal was concentrated in the organic phase. Separation of the mineral and organic phases was incomplete, but with more care better separation should be possible. It is interesting to note that the TL signal of the blank samples is concentrated in the mineral phase. This supports our hypothesis that the TL signal orginates from mineral particles adhering to the samples. The results were promising enough to merit further investigation.

*Filename=Sample name/Batch.Run.Disc

RUN SHEET

RUN NUMBER(S): 39-46 DATE(S): 11.1.88-

TL Fading & Stability (Batch 2)

(a) Procedure

The crude herbs and spices were sprinkled onto a clean stainless steel disc (10mm diam, 0.25mm thick), which had been sprayed with a thin layer of silicone grease compound, and preweighed. The discs were reweighed and the mass of sample taken was calculated in mg.

The sample discs were read on the TL reader using the "SURRC TL Package 16.3.87" disc.

The TL of the samples was measured on a logarithmic time scale, beginning 3.5 days after irradiation. The samples were stored under dark conditions at -20C, 5C & ambient temperatures.

After 7 days storage at ambient temperature, two discs were prepared and exposed to daylight for 4 hours. The samples chosen were the blank and 10kGy samples of cinnamon.

(b) Results

Details of the samples taken are on pages R.30-3 .

Loss of signal after exposure to light.

Sample: SP1 CINNAMON

Storage temperature: ambient.

Days after irradiation: 7.

	Specific TL at temperature/'C				
	200	250	300	350	400
Disc protected from light	33586	35704	15012	11145	8611
Disc exposed to light for 4 hours.	27273	29548	10197	5992	3356
% loss of signal	18.80	17.24	32.07	46.23	61.03

(c) Discussion

RUN SHEET

RUN NUMBER(S): 53-84 DATE(S): 28.1.88-

TL Fading & Stability (Batches 3 & 4)

(a) Procedure

Six samples from Batch 3 and six from Batch 4 were selected for stability tests.

The samples were stored under dark conditions at -20'C, 5'C, 30'C and 55'C. The TL of the samples was measured on a logarithmic time scale beginning 3.5 days after irradiation.

The crude herbs and spices were sprinkled onto a clean stainless steel disc (10mm diam, 0.25mm thick), which had been sprayed with a thin layer of silicone grease compound, and preweighed. The discs were reweighed and the mass of sample taken was calculated in mg.

The sample discs were read on the TL reader using the "SURRC TL Package 16.3.87" disc.

(b) Results

Details of the samples taken are on pages R.36- .

RUN SHEET

RUN NUMBER(S): 47-96 DATE(S): 28.1.88-

TL Fading & Stability (Batch 3)

(a) Procedure

The crude herbs and spices were sprinkled onto a clean stainless steel disc (10mm diam, 0.25mm thick), which had been sprayed with a thin layer of silicone grease compound, and preweighed. The discs were reweighed and the mass of sample taken was calculated in mg.

The sample discs were read on the TL reader using the "SURRC TL Package 16.3.87" disc.

The irradiated samples plus blanks were stored at four temperatures; T1= -20'C
T2= 5'C
T3= 30'C
T4= 55'C , for subsequent stability tests.

Repeat readings were made on 7.3.88 & 14.3.88 of those samples which had high blanks or low Specific TL values for irradiated samples, in order to confirm these results.

(b) Results and Discussion

Details of the samples taken are shown on pages R.51 & R.52.

Ref.	Sample Type	Specific TL @ 200'C Blank	10kGy
SP5	Ground Allspice	743	5818
SP6	Ground Cinnamon	206	5060
SP7	Ground Cloves	614	3272
SP8	Ground Ginger	909	64214
SP9	Ground Mace	880	2775
SP10	Ground Nutmeg	37	97
SP11	Apple Pie Spice	38	17985
SP12	Mixed Spice	640	13184
SP13	Ground Black Pepper	299	445
SP14	Ground White Pepper	371	585
SP15	Cayenne Pepper	265	29936
SP16	Hot Chili Powder	30	5218
SP17	Paprika	186	18141
SP18	Ground Coriander	332	3136
SP19	Ground Cumin	853	6830
SP20	Turmeric	69	7110
SP21	Curry Powder	266	81935
SP22	Garam Masala	180	3188
SP23	Basil	217	14087
SP24	Ground Bay Leaves	3038	19091
SP25	Chives	240	2351
SP26	Dill Weed	125	3656
SP27	Marjoram	327	89706
SP28	Mint	158	7841
SP29	Oregano	216	15676

RUN SHEET

RUN NUMBER(S): 97-148 DATE(S): 28.1.88-

TL Fading & Stability (Batch 4)

(a) Procedure

The crude herbs and spices were sprinkled onto a clean stainless steel disc (10mm diam, 0.25mm thick), which had been sprayed with a thin layer of silicone grease compound, and preweighed. The discs were reweighed and the mass of sample taken was calculated in mg.

The sample discs were read on the TL reader using the "SURRC TL Package 16.3.87" disc.

The irradiated samples plus blanks were stored at four temperatures; T1= -20'C
T2= 5'C
T3= 30'C
T4= 55'C , for subsequent stability tests.

Repeat readings were made on 7.3.88 of those samples which had high blanks or low Specific TL values for irradiated samples, in order to confirm these results.

(b) Results and Discussion

Details of the samples taken are shown on pages R.55 & R.56.

Ref.	Sample Type	Specific TL @ 200'C Blank	10kGy
SP30	Parsley	132	3412
SP31	Rosemary	416	3165
SP32	Rubbed Sage	283	11862
SP33	Tarragon	586	2586
SP34A	Thyme	474	24629
SP34B	Thyme	315	6697
SP35	Herbes de Provence	415	5682
SP36	Mixed Herbs	301	40180
SP37	Garlic Granules	50	323
SP38	Garlic Pepper	195	80009
SP39	Garlic Salt	9	282065
SP40A	Onion Salt	31	805987
SP40B	Onion Salt	45	569154
SP41	Onion Granules	199	3315
SP42	Barbecue Seasoning	159	87371
SP43	Casserole Seasoning	117	207534
SP44	Celery Seasoning	795	281839
SP45	Chicken Seasoning	37	303242
SP46	Chinese Seasoning	246	265399
SP47	Fish Seasoning	134	246416
SP48	Grill Seasoning	126	47228
SP49	Italian Seasoning	61	15427
SP50	Pizza Seasoning	149	5298
SP51	Pork Seasoning	218	262029
SP52	Steak Seasoning	191	110825

RUN SHEET

RUN NUMBER(S): 257-296 DATE(S): 11.2.88-

TL Fading & Stability (Batch 7)

(a) Procedure

The crude herbs and spices were sprinkled onto a clean stainless steel disc (10mm diam, 0.25mm thick), which had been sprayed with a thin layer of silicone grease compound, and preweighed. The discs were reweighed and the mass of sample taken was calculated in mg.

The sample discs were read on the TL reader using the "SURRC TL Package 16.3.87" disc.

The irradiated samples plus blanks were stored at four temperatures; T1= -20'C
T2= 5'C
T3= 30'C
T4= 55'C , for subsequent stability tests.

Repeat readings were made on 7.3.88 & 14.3.88 of those samples which had high blanks or low Specific TL values for irradiated samples, in order to confirm these results.

(b) Results and Discussion

Details of the samples taken are shown on page R.66.

Ref.	Sample Type	Specific TL @ 200'C Blank	10kGy
SP108	Chilli Powder	78	21244
SP109	Ground Cinnamon	182	1904
SP110	Ground Ginger	360	3340
SP111	Paprika	90	8286
SP112	Ground Black Pepper	205	15804
SP113	Turmeric	17	1947
SP114	Caraway Seeds	21	1330
SP115	Oregano	184	6019
SP116	Parsley	157	13309
SP117	Rosemary	262	1611
SP118	Cayenne Pepper(Chilli)	75	7707
SP119	Ground Cinnamon	98	10225
SP120	Ground Ginger	279	43101
SP121	Garlic Powder	135	7321
SP122	Ground Black Pepper	95	152666
SP123	Ground White Pepper	114	2500
SP124	Dried Mint	27	1482
SP125	Dried Oregano	79	3228
SP126	Dried Parsley	17	3358
SP127	Dried Sage	57	2217

In this batch of samples there is a significant difference between the Specific TL @ 200'C of all the unirradiated and irradiated samples. It should be noted that two samples of black pepper (SP112 & SP122) have a very large difference between the 10kGy samples and the blank compared with SP13, Batch 3. Also this sample of garlic powder shows TL properties in irradiated sample. (cf SP37 Batch 4)

RUN SHEET

RUN NUMBER(S): 297-338 DATE(S): 12.2.88-

TL Fading & Stability (Batch 8)

(a) Procedure

The crude herbs and spices were sprinkled onto a clean stainless steel disc (10mm diam, 0.25mm thick), which had been sprayed with a thin layer of silicone grease compound, and preweighed. The discs were reweighed and the mass of sample taken was calculated in mg.

The sample discs were read on the TL reader using the "SURRC TL Package 16.3.87" disc.

The irradiated samples plus blanks were stored at four temperatures; T1= -20'C
T2= 5'C
T3= 30'C
T4= 55'C , for subsequent stability tests.

Repeat readings were made on 7.3.88 & 14.3.88 of those samples which had high blanks or low Specific TL values for irradiated samples, in order to confirm these results.

(b) Results and Discussion

Details of the samples taken are shown on page R.70 & R.71.

Ref.	Sample Type	Specific TL @ 200'C Blank	10kGy
SP128	Cayenne Pepper	114	30374
SP129	Ground Cinnamon	229	18356
SP130	Ground Ginger	240	25541
SP131	Ground Nutmeg	10	51
SP132	Ground Black Pepper	106	7592
SP133	Ground White Pepper	154	276
SP134	Paprika	No Specific TL data stored	
SP135	Dried Basil	52	4239
SP136	Dried Chives	69	296
SP137	Dried Marjoram	180	2917
SP138	Dried Mint	58	1958
SP139	Dried Oregano	251	1844
SP140	Dried Parsley	25	4048
SP141	Dried Rosemary	343	1561
SP142	Dried Sage	150	520 *
SP143	Dried Thyme	110	703 *
SP144	Ground Garlic	120	212
SP145	Paprika	45	1347
SP146	Ground Cinnamon	95	2542
SP147A	Ground Ginger	231	78056
SP147B	Ground Ginger	122	34844

* The readings for the 10kGy samples are very low compared to other samples of sage (SP32 & SP164) and thyme (SP34A+B & SP152). This warrants further investigation.

Ground nutmeg, white pepper & garlic again do not exhibit significant TL in the irradiated samples. (cf Batch 3, page R.50.

RUN SHEET

RUN NUMBER(S): 339-376 DATE(S): 18.2.88-

TL Fading & Stability (Batch 9)

(a) Procedure

The crude herbs and spices were sprinkled onto a clean stainless steel disc (10mm diam, 0.25mm thick), which had been sprayed with a thin layer of silicone grease compound, and preweighed. The discs were reweighed and the mass of sample taken was calculated in mg.

The sample discs were read on the TL reader using the "SURRC TL Package 16.3.87" disc.

The irradiated samples plus blanks were stored at four temperatures; T1= -20'C
T2= 5'C
T3= 30'C
T4= 55'C , for subsequent stability tests.

Repeat readings were made on 7.3.88 of those samples which had high blanks or low Specific TL values for irradiated samples, in order to confirm these results.

(b) Results and Discussion

Details of the samples taken are shown on page R.74

Ref.	Sample Type	Specific TL @ 200'C Blank	10kGy
SP148	Paprika	109	26012
SP149	Basil	251	31371
SP150	Oregano	231	6764
SP151	Parsley	185	9779
SP152	Thyme	665	11519
SP153	Cayenne	51	13633
SP154	Chilli Powder	178	58951
SP155	Ground Cinnamon	272	8860
SP156	Ground Ginger	505	37593
SP157	Turmeric	133	410949
SP158	Basil	358	25225
SP159	Chives	240	11281
SP160	Marjoram	621	13826
SP161	Mint	96	19885
SP162	Parsley	130	15005
SP163	Rosemary	2249	6922
SP164	Sage	638	12370
SP165	Tarragon	1070	8526
SP166	Thyme	145	20336

SP163 Rosemary has a low signal to blank ratio due to the very high blank. SP165 Tarragon also has a high blank.

RUN SHEET

RUN NUMBER(S): 377-418 DATE(S): 25.2.88-

TL Fading & Stability (Batch 10)

(a) Procedure

The crude herbs and spices were sprinkled onto a clean stainless steel disc (10mm diam, 0.25mm thick), which had been sprayed with a thin layer of silicone grease compound, and preweighed. The discs were reweighed and the mass of sample taken was calculated in mg.

The sample discs were read on the TL reader using the "System 2.3/ 22.2.88" disc.

The irradiated samples plus blanks were stored at four temperatures; T1= -20'C
T2= 5'C
T3= 30'C
T4= 55'C , for subsequent stability tests.

Repeat readings were made on 7.3.88 of those samples which had high blanks or low Specific TL values for irradiated samples, in order to confirm these results.

(b) Results and Discussion

Details of the samples taken are shown on page R.78.

Ref.	Sample Type	Specific TL @ 200'C Blank	10kGy	
SP167	Ground Aniseed	389	14474	
SP168	Ground Star Anise	319	3040	
SP169	Ground Caraway	111	1084	
SP170	Ground Cardamom	302	5560	
SP171	Ground Cassia	86	23209	
SP172	Ground Cinnamon	249	36115	
SP173	Ground Coriander	677	1240	
SP174	Ground Cloves	200	11022	
SP175	Ground Cloves	109	552	‡
SP176	Ground Clove Stems	397	2704	
SP177	Ground Cumin	76	3566	
SP178	Ground Dill	98	75909	
SP179	Ground Fennel	98	14094	
SP180	Ground Fenugreek	32	1186	
SP181	Garlic Powder	155	3270	
SP182	Ground Ginger	544	23002	$
SP183	Ground Ginger	68	4300	$
SP184	Ground Mace	408	6776	$
SP185	Ground Mixed Spice	94	68945	
SP186	Ground Mustard	62	1252	
SP187	Ground Nutmeg	14	1060	$

$ Sample contaminated by salt and therefore results illiminated from study.
‡ SP175 Cloves. This sample has a very low reading compared to SP174 and therefore needs further investigation.

RUN SHEET

RUN NUMBER(S): 419-462 DATE(S): 26.2.88-

TL Fading & Stability (Batch 11)

(a) Procedure

The crude herbs and spices were sprinkled onto a clean stainless steel disc (10mm diam, 0.25mm thick), which had been sprayed with a thin layer of silicone grease compound, and preweighed. The discs were reweighed and the mass of sample taken was calculated in mg.

The sample discs were read on the TL reader using the "System 2.3/ 22.2.88" disc.

The irradiated samples plus blanks were stored at four temperatures; T1= -20'C
T2= 5'C
T3= 30'C
T4= 55'C , for subsequent stability tests.

Repeat readings were made on 7.3.88 & 14.3.88 of those samples which had high blanks or low Specific TL values for irradiated samples, in order to confirm these results.

(b) Results and Discussion

Details of the samples taken are shown on pages R.82 & R.83.

Ref.	Sample Type	Specific TL @ 200'C Blank	10kGy	
SP188	Ground Cayenne	30	9655	
SP189	Chilli Powder	27	39553	
SP190	Ground Paprika	76	1050	*
SP191	Ground Paprika	62	9358	
SP192	Ground Black Pepper	131	2834	
SP193	Ground Black Pepper	79	306	$
SP194	Ground White Pepper	70	149	
SP195	Ground White Pepper	81	4640	$
SP196	Ground Turmeric	337	77772	
SP197	Ground Basil	261	30762	
SP198	Ground Bay Leaves	588	3083	
SP199	Ground Celery	287	121167	
SP200	Ground Marjoram	339	122507	
SP201	Ground Mint	99	43789	
SP202	Ground Oregano	88	9048	
SP203	Ground Parsley	214	94053	
SP204	Ground Rosemary	2327	23870	
SP205	Ground Sage	843	5959	
SP206	Ground Thyme	351	232409	
SP207	Nutmeg Extract (Salt Base)	9	383225	
SP208	Pepper Extract (Salt Base)	62	119790	<
SP209	Sage Extract (Salt Base)	0	282060	

$ Sample contaminated by salt or moisture and therefore results illiminated from study.
* SP190 Paprika. This sample has a very low reading compared to SP191, SP148 & SP17 and therefore needs further investigation.
< Reading after 11 days due to dispensing error on Day 3.

RUN SHEET

RUN NUMBER(S): 463-502 DATE(S): 4.3.88-

TL Fading & Stability (Batch T2)

(a) Procedure

The crude herbs and spices were sprinkled onto a clean stainless steel disc (10mm diam, 0.25mm thick), which had been sprayed with a thin layer of silicone grease compound, and preweighed. The discs were reweighed and the mass of sample taken was calculated in mg.

The sample discs were read on the TL reader using the "System 2.3/ 22.2.88" disc.

The irradiated samples plus blanks were stored at four temperatures; T1= -20'C
T2= 5'C
T3= 30'C
T4= 55'C , for subsequent stability tests.

(b) Results and Discussion

Details of the samples taken are shown on page R.86.

Ref.	Sample Type	Specific TL @ 200'C Blank	10kGy
SP210	Ground Allspice	418	2462
SP211	Green Anise	541	5263
SP212	Ground Cardamom	12190	15541 *
SP213	Caraway Seeds	26	277
SP214	Celery Seeds	30	3263
SP215	Chervil	103	34539
SP216	Fennel Seeds	55	10995
SP217	Fennel Herb	252	5171
SP218	Ground Fennel	651	16504
SP219	Fenugreek Seeds	8	77
SP220	Methi Leaves	85	526669
SP221	Mint	62	3421
SP222	Yellow Mustard Seeds	36	138
SP223	Black Mustard Seeds	119	153
SP224	Ground Mustard	80	3128
SP225	Onion Powder	55	1762
SP226	Poppy Seeds	21	42
SP227	Sesame Seeds	48	706
SP228	Saffron	2	64207
SP229	Spearmint	106	1628

* SP212 Ground Cardamom. This sample had an exceptionally high blank. One possible explanation would be that the sample had already been irradiated, but further investigations are necessary to support this hypothesis.

Whole seeds, with the exception of celery seed, gave very low signals from the irradiated samples. This type of sample has a very small surface area to volume ratio, as has nutmeg, when compared to leafy types of material.

Continued on page R.87

RUN SHEET

RUN NUMBER(S): 509-512 DATE(S): 14.3.88-

Exploratory TL of Bones (Batch 13)

(a)Procedure

Boiled bones from chicken and lamb were cut into 200um slices using a rock saw. Two slices of each were irradiated for 1 hour-equivalent to a dose of 2.5 kGy.

The bones were cut into smaller pieces using a scalpel for the chicken bones, and a pair of pliers for the lamb bones. Two or three small pieces were placed on a clean stainless steel disc (10mm diam., 0.25mm thick), which had been sprayed with a thin layer of silicone grease compound.

The sample discs were read on the TL reader using the "System 2.3/22.2.88" disc.

(b)Results

Filename	Sample Mass/mg	Dose/ kGy	Specific TL 200'C
SP233.T3.509.1	4.87	0	8.7
SP233.T3.510.1	11.51	2.5	74.2
SP234.T3.511.1	3.38	0	12.0
SP234.T3.512.1	2.62	2.5	1715.1

SP233= Chicken femur
SP234= Lamb humerus

(c)Discussion

From this preliminary study, it appears that lamb bones have better TL properties than chicken bones. This could be due to the different degree of ossification of the bones.

The method shows promise as a means of identifying irradiated meat and poultry products, but further studies will need to be conducted.

RUN SHEET

RUN NUMBER(S): 503-508 DATE(S): 14.3.88

Exploratory TL of Spice Oleoresins (Batch 14)

(a)Procedure

Oleoresinous extracts of nutmeg (SP230), pepper (SP231) and sage (SP232) were irradiated to a dose of 10kGy.

Samples of the unirradiated and irradiated oleoresin were deposited on a clean stainless steel disc (10mm diam., 0.25mm thick), using a glass capillary tube.

The sample discs were read on the TL reader using the "System 2.3/22.2.88" disc.

(b)Results

Filename	Sample Mass/mg	Dose/ kGy	Specific TL 200'C
SP230.T3.503.1	1.24	0	9.7
SP230.T3.504.1	1.37	10	96.7
SP231.T3.505.1	7.42	0	56.1
SP231.T3.505.2	4.55	0	78.0
SP231.T3.506.1	4.54	10	92.7
SP232.T3.507.1	3.08	0	81.3
SP232.T3.508.1	3.23	10	211.9

(c)Discussion

In our experiments using the crude herbs and spices, most of the unirradiated samples had specific TL values at 200'C of less than 1000, and most of the 10kGy samples had values of greater than 1000. All of the above readings are significantly below this arbitrary value.

The results of this experiment together with the results of the experiment where we attempted to separate the mineral fraction of the sample from the organic fraction confirm our hypothesis that the source of the TL signal lies on the samples rather than in them, and is due to mineral fragments adhering to the vegetable matter rather than organic components of them.

Appendix E

BATCH LIST

Batch

B.5 Samples SP54-SP82 were irradiated for 4 hours in the 200TBq Co-60 source on 1.2.88. Four Harwell Red 4034 dosimeters were placed in/on the pack;
(i) 2 taped to the sides of the pack on the outer wrapper (1&2),
(ii) 2 inside the pack in the middle of the sample, one taped horizontally and one taped vertically (3&4)

Time in: 11-00 Time out: 15-00 Time elapsed:4h.

Dosimeter no.	Absorbance A	Disc Thickness Dx cm	Specific Absorbance A/Dx	Dose kGy	Dose Rate Gy/s
1	0.269	0.326	0.825	10.17	0.706
2	0.275	0.310	0.887	11.30	0.784
3	0.238	0.315	0.898	11.50	0.799
4	0.251	0.323	0.777	9.37	0.650

B.6 Samples SP83-SP107 were irradiated for 4 h in the 200TBq Co-60 source on 2.2.88. Four Harwell Red 4034 dosimeters were placed in/on the pack;
(i) 2 taped to the sides of the pack on the outer wrapper (1&2),
(ii) 2 inside the pack in the middle of the sample, one taped horizontally and one taped vertically (3&4)

Time in: 10-00 Time out: 14-00 Time elapsed:4h.

Dosimeter no.	Absorbance A	Disc Thickness Dx cm	Specific Absorbance A/Dx	Dose kGy	Dose Rate Gy/s
1	0.269	0.305	0.882	11.20	0.778
2	0.265	0.298	0.889	11.33	0.787
3	0.250	0.297	0.842	10.47	0.727
4	0.275	0.314	0.876	11.09	0.770

BATCH LIST

Batch

B.7 Samples SP108-SP127 were irradiated for 4 hours in the 200TBq Co-60 source on 8.2.88. Four Harwell Red 4034 dosimeters were placed in/on the pack;
(i) 2 taped to the sides of the pack on the outer wrapper (1&2),
(ii) 2 inside the pack in the middle of the sample, one taped horizontally and one taped vertically (3&4)

Time in: 10-05 Time out: 14.10 Time elapsed:4.1h

Dosimeter no.	Absorbance A	Disc Thickness Dx cm	Specific Absorbance A/Dx	Dose kGy	Dose Rate Gy/s
1	0.325	0.336	0.966	12.85	0.874
2	0.260	0.302	0.860	10.80	0.734
3	0.305	0.341	0.893	11.41	0.776
4	0.290	0.334	0.868	10.94	0.744

B.8 Samples SP128-SP147 were irradiated for 4 h in the 200TBq Co-60 source on 9.2.88. Four Harwell Red 4034 dosimeters were placed in/on the pack;
(i) 2 taped to the sides of the pack on the outer wrapper (1&2),
(ii) 2 inside the pack in the middle of the sample, one taped horizontally and one taped vertically (3&4)

Time in: 10-00 Time out: 14-00 Time elapsed:4h.

Dosimeter no.	Absorbance A	Disc Thickness Dx cm	Specific Absorbance A/Dx	Dose kGy	Dose Rate Gy/s
1	0.292	0.342	0.855	10.70	0.743
2	0.330	0.348	0.948	12.49	0.867
3	0.274	0.314	0.873	11.03	0.766
4	0.246	0.297	0.827	11.21	0.709

BATCH LIST

Batch

B.9 Samples SP148-SP166 were irradiated for 4 hours in the 200TBq Co-60 source on 15.2.88. Four Harwell Red 4034 dosimeters were placed in/on the pack;
(i) 2 taped to the sides of the pack on the outer wrapper (1&2),
(ii) 2 inside the pack in the middle of the sample, one taped horizontally and one taped vertically (3&4)

Time in: 10-00 Time out: 14.00 Time elapsed:4.1h

Dosimeter no.	Absorbance A	Disc Thickness Dx cm	Specific Absorbance A/Dx	Dose kGy	Dose Rate Gy/s
1	0.303	0.334	0.907	11.68	0.811
2	0.245	0.291	0.842	10.47	0.727
3	0.234	0.300	0.780	9.46	0.653
4	0.280	0.323	0.867	10.92	0.759

B.10 Samples SP167-SP187 were irradiated for 4 h in the 200TBq Co-60 source on 22.2.88. Six Harwell Red 4034 dosimeters were placed in/on the pack;
(i) 2 taped to the sides of the pack (1&2)
(ii) 1 taped to the top (3), and 1 taped to the bottom (4)
(iii) 2 inside the pack in the middle of the sample (5&6).
Dimensions of package:150mm*130mm*130mm.
Batches 10 & 11 were irradiated together.
Batch 11 was placed on top of Batch 10.
Overall dimensions of package:195mm*130mm*130mm.

Time in: 10-00 Time out: 14-00 Time elapsed:4h.

Dosimeter no.	Absorbance A	Disc Thickness Dx cm	Specific Absorbance A/Dx	Dose kGy	Dose Rate Gy/s
1	0.282	0.315	0.895	11.45	0.795
2	0.283	0.321	0.882	11.20	0.778
3	0.264	0.342	0.772	9.27	0.644
4	0.230	0.291	0.780	9.57	0.665
5	0.262	0.330	0.794	9.64	0.669
6	0.241	0.307	0.785	9.49	0.659

BATCH LIST

Batch

B.11 Samples SP188-SP209 were irradiated for 4 h in the 200TBq Co-60 source on 22.2.88. Six Harwell Red 4034 dosimeters were placed in/on the pack;
(i) 2 taped to the sides of the pack (1&2)
(ii) 1 taped to the top (3), and 1 taped to the bottom (4)
(iii) 2 inside the pack in the middle of the sample (5&6).
Dimensions of package:110mm*100mm*40mm.
Batches 10 & 11 were irradiated together.
Batch 11 was placed on top of Batch 10.
Overall dimensions of package:195mm*130mm*130mm.

Time in: 10-00 Time out: 14-00 Time elapsed:4h.

Dosimeter no.	Absorbance A	Disc Thickness Dx cm	Specific Absorbance A/Dx	Dose kGy	Dose Rate Gy/s
1	0.233	0.307	0.759	9.06	0.629
2	0.202	0.294	0.687	7.95	0.552
3	0.175	0.314	0.557	6.17	0.429
4	0.224	0.326	0.687	7.95	0.552
5	0.187	0.291	0.643	7.32	0.508
6	0.180	0.303	0.595	6.66	0.463

B.12 Samples SP210-SP229 were irradiated for 4 h in the 200TBq Co-60 source on 1.3.88. Five Harwell Red 4034 dosimeters were placed in/on the pack;
(i) 2 taped to the sides of the pack (1&2)
(ii) 1 taped to the top (3), and 1 taped to the bottom (4)
(iii) 1 inside the pack in the middle of the sample (5).
Dimensions of package:105mm*110mm*95mm.

Time in: 11-00 Time out: 15-00 Time elapsed:4h.

Dosimeter no.	Absorbance A	Disc Thickness Dx cm	Specific Absorbance A/Dx	Dose kGy	Dose Rate Gy/s
1	0.295	0.326	0.905	11.64	0.808
2	0.294	0.328	0.896	11.47	0.796
3	0.254	0.322	0.789	9.56	0.664
4	0.296	0.340	0.871	11.00	0.764
5	0.254	0.305	0.833	10.31	0.716

BATCH LIST

Batch

B.13 Samples SP233-SP234 were irradiated for 1 h in the 200TBq Co-60 source on 14.3.88. One Harwell Red 4034 dosimeter was placed in the pack;

Time in: 10-30 Time out: 11-30 Time elapsed: 1h.

Dosimeter no.	Absorbance A	Disc Thickness Dx cm	Specific Absorbance A/Dx	Dose kGy	Dose Rate Gy/s
1	0.060	0.345	0.174	2.31	0.642

B.14 Samples SP230-SP232 were irradiated for 4 h in the 200TBq Co-60 source on 14.3.88. One Harwell Red 4034 dosimeter was placed in the pack;

Time in: 10-30 Time out: 14-30 Time elapsed: 4h.

Dosimeter no.	Absorbance A	Disc Thickness Dx cm	Specific Absorbance A/Dx	Dose kGy	Dose Rate Gy/s
1	0.253	0.299	0.846	10.54	0.732

BATCH LIST

Batch

B.1 Samples SP1,SP2,SP3& SP4 were irradiated to 2.5,5.0 7.5,10.0,12.5,15.0 kGy doses in the 200TBq Co-60 source on 29/4/87 for prompt TL studies. Dosimetry was by timing using the working value of 2.5 kGy/h in the centre of the large irradiation cannister. Approximately 1g. aliquots were used for each dose. Delayed TL measurements in Jan. 1988 were positive.

B.2 Samples SP1,SP2,SP3,&SP4, were irradiated to a dose of 10 kGy in the 200TBq Co-60 source on 8/1/88 for TL studies.Dosimetry was by timing using the working value of 2.5 kGy/h in the centre of the large irradiation cannister. The samples of approx. 5g were irradiated for 4 hours.

B.3 Samples SP5-SP29 were irradiated for 4 hours in the 200TBq Co-60 source on 25.1.88. Three Harwell Red 4034 dosimeters were placed in/on the pack;
(i) taped to the top of the pack on the outer wrapper,
(ii) inside the pack in the middle of the sample,
(iii) taped to the bottom of the pack on the outer wrapper.
Time in: 10-05 Time out: 14-05 Time elapsed:4h.

Dosimeter no.	Absorbance A	Disc Thickness Dx cm	Specific Absorbance A/Dx	Dose kGy	Dose Rate Gy/s
1	0.295	0.315	0.937	12.27	0.852
2	0.232	0.301	0.771	9.26	0.643
3	0.330	0.343	0.962	12.77	0.886

B.4 Samples SP30-SP53 were irradiated for 4 hours in the 200TBq Co-60 source on 25.1.88. Three Harwell Red 4034 dosimeters were placed in/on the pack;
(i) taped to the top of the pack on the outer wrapper,
(ii) inside the pack in the middle of the sample,
(iii) taped to the bottom of the pack on the outer wrapper.
Time in: 10-05 Time out:14-05 Time elapsed:4.08h

Dosimeter no.	Absorbance A	Disc Thickness Dx cm	Specific Absorbance A/Dx	Dose kGy	Dose Rate Gy/s
4	0.313	0.337	0.929	12.11	0.841
5	0.286	0.343	0.834	10.33	0.717
6	0.329	0.335	0.982	13.19	0.916

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