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A RISK-BASED APPROACH TO CHEMICAL RESIDUE PREVENTION

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Dans de nombreux pays, les systèmes de surveillance des résidus chimiques chez les animaux abattus dépendent largement d'un échantillonnage aléatoire. Des simulations ont été faites avec les données disponibles en vue d'évaluer l'efficacité de cette approche traditionnelle. On a ensuite artificiellement augmenté l'intensité spatiale et temporelle des résidus pour tester la sensibilité et la spécificité des procédures de détection statistique. Un système d'aide à la décision a été établi qui fournirait une meilleure assurance aux consommateurs d'être protégés contre le danger des résidus chimiques. Cinq étapes ont été identifiées au cours desquelles la probabilité de non détection d'un produit pouvait être évaluée et/ou réduite. La première étape concerne les bonnes pratiques de manipulation qui établissent les niveaux attendus de non-détection. La seconde, cible les catégories d'animaux à l'origine de produits pouvant conduire à une non-détection. L'étape suivante identifie les fermes à haut risque, soit à cause de non détection antérieure, soit à cause d'autres facteurs de risque. La quatrième étape réduit le risque de non-détection en orientant le programme d'échantillonnage vers des produits à risque supérieur à la moyenne. La dernière étape prend en considération les programmes de certification des fermes. Ce système d'aide à la décision a l'avantage d'être une approche cohérente et structurée vers la sécurité alimentaire. La transparence du modèle et la sensibilité du dépistage sont de nature à entraîner la confiance des consommateurs dans la qualité des produits qu'ils mangent.

INTRODUCTION

Consumers expect to be supplied with animal products which do not contain concentrations of veterinary drugs or other exogenous chemicals sufficient to pose any health hazard to them. Prevention of such chemical residue contamination relies in most countries to a large degree on the use of national monitoring systems in which a sampling strategy is pursued, and individual samples which are found to contain greater than a specified level of a given chemical are declared non-compliant, sometimes resulting in quite severe economic effects for an individual producer or a country. Sampling procedures are limited by the high cost of testing each sample, and the wide range of chemicals which could potentially be found in any sample, especially when sampling is random rather than targeted. There is a need to allocate resources to various elements of an overall food safety program according to their ability to reduce food-borne hazards (Hathaway and McKenzie, 1991).

SIMULATIONS WITH EXISTING DATA SETS

In order to test the effectiveness of the traditional sampling approach which is currently used by most countries, actual data from monitoring programs for various chemicals were used to create sample sets of chemical residue data, in which any non-compliant values which occurred were simply random outliers in a sample stream which overall was compliant with residue requirements. Sample results were linked to dates and to specific geographical locations within New Zealand. Temporal and spatial "residue incidents" of progressively increasing severity were then artificially created in the data sets for a number of specific chemicals by inserting groups of non-compliant values, and the ability of various statistical methods to identify these was evaluated. Detection of non-compliant temporal runs within the sample streams was very poor for all severities of incidents at all realistic levels of sampling, and detection of spatially clumped non-compliant residue patterns was somewhat better, but still poor (van der Logt, 1996). This was because the naturally occurring variation in each data set was large enough to render the various detection statistics unable to discriminate abnormal incidents from background variation. Questions must therefore be raised as to whether monitoring systems for chemical residues, as currently accepted for international trade, meet the objective of detecting genuinely abnormal spatial and temporal patterns of residues despite their high cost. More discerning and cost-effective methods would seem to be needed to enhance mechanisms of consumer protection.

RISK-BASED CONTROL SYSTEM OF CHEMICAL RESIDUES

A new approach was therefore developed to the prototype stage, in which an expert system in conjunction with a quantitative risk analysis procedure is used to identify an effective (and potentially least-cost) risk reduction method which ensured with a very high level of confidence that consumption of a normal diet did not expose a consumer to sufficient of a particular chemical to represent any possibility of a health risk. A Decision Support System (DSS) to carry out this procedure has been designed, and will be described below. The objective of the approach outlined is to build on existing systems, but combine them as integrated components of a structured risk reduction system.

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RISK-REDUCTION MODEL

The DSS requires user input regarding the period of interest (eg one year), the number of edible portions eaten per day and the weight of an edible portion. Then the model will ask for input on items related to five different hazard reduction stages. It then calculates the gain in consumer protection achieved by implementing some or all of the hazard reduction steps available. For some items used by the DSS accurate figures may be available (eg the number of animals slaughtered). However, frequently uncertainty will exist and estimates will be calculated stochastically using the best available data. The DSS has been developed in '@Risk', risk analysis software which is a spreadsheet add-in. This enables the stochastic modelling of decisions made under risk.

Stage 1 Good handling practice

A national licensing authority can approve a chemical 'A' after evaluating the relevant information. Maximum residue levels, withholding periods (WHP) and dose-rates are established for the various livestock classes to protect the public health and ensure the effectiveness of animal treatment. However even with soundly-based registration procedures and handling practices, some non-compliance will inevitably occur. For example, natural variation in metabolism and excretion rates in an animal population or possibly the influence of disease on metabolism may result in the potential for some animals to be non-complying at the time of slaughter. Furthermore, user error can lead to some non-compliance. These factors include slaughter within the WHP, application of a dose which is too high, incorrect application of the chemical and the application of the chemical although not licensed for the particular livestock class. Different probabilities of non-compliance will apply to the respective livestock classes. Combining the various probabilities results in the total probability that product from a particular animal might contain above an upper limit of the chemical. Not all animals receive chemical 'A' and estimates of the proportion of animals receiving it are included in the model. The number of slaughtered animals per livestock class is used to calculate the quantity of product which is subsequently consumed, as numbers of edible portions per year per livestock class. The number of consumer portions per year and livestock class which are above the desired upper limit can then be estimated, and from that data the probability of a single edible portion being non-complying can be estimated.

The number of non-complying portions eaten by the representative consumer per year is then used to assess the risk that this consumer faces of being exposed to an amount of chemical sufficient to cause concern. Stochastic simulation of this risk level produces an estimator which can be used to assess performance of the chemical residue programme. In many cases, the probability of consuming during a year an amount of chemical A sufficient to cause concern may be so low that no further action is required. In other cases, hazard or risk reduction steps may be required to reach the target consumer safety level, and in such cases the effect on performance indicators of each possible additional step can be calculated against the situation without special intervention.

Stage 2 Targeted livestock classes

The probability of a non-compliance for each livestock class was quantified above, and the number of non-complying portions was calculated. Distributions which represent the effectiveness of reducing the amount of non-complying product for the various livestock classes while keeping the hazard reduction resources allocated to each livestock class the same were estimated. The reduction in the numbers of non-complying portions if the risk reducing programmes were used for each of the livestock classes are calculated, showing how many portions exceeding acceptable maxima will remain. The model thus shows which strategy is most effective in reducing the number of non-complying portions. Resources would be allocated where they are of greatest benefit. The remaining non-complying portions of all livestock classes after targeting (or not) are calculated and then summed. The ratio of these remaining non-complying portions and the previous number of non-complying portions is used to model the proportional reduction of non-compliances achieved.

Stage 3 Targeted high risk farms

Several types of high risk farms can be distinguished. For example, there are farms which submitted at least one animal exceeding the maximum desired level over a certain period of time. The probability of detecting individual non-complying farms needs to be estimated, since detection effectiveness is inescapably low, as described above. Next an estimate should be made of the effectiveness of a programme to reduce the number of subsequent non-complying incidents for farms which have a history of non-compliance. The product of these estimates is the reduction of non-compliance by individual high risk farms.

In addition, spatial and temporal clustering of non-compliance may occur on a scale larger than the individual farm. Available data are assessed by statistical methods to determine whether or not such clustering is likely to have occurred. It should be noted that there are difficulties of detecting clustering, but the use of risk factor information as a detection tool may assist in determining whether a true incident has occurred. The effectiveness of programmes targeting clustering in space and in time is estimated in the model. The product of these various components constitute the factor that denotes the effectiveness of risk reducing programmes based on targeting high risk farms.

Stage 4 Targeted sampling

Random sampling is often seen as the corner stone of chemical residue sampling systems. Sampling has at least two important functions. It monitors the level of compliance and it functions as a deterrent to any unintentional or careless non-compliance. However the probability of detecting a genuinely non-complying farm by using a random sampling programme is slim. Thus the development and use of a set of «risk profiles» which

would allow sampling to concentrate on categories of farms most at risk of non-compliance could substantially improve the compliance gain per sample collected. Targeting may be based on history of the farm, recorded use of particular chemicals, production system, age of animals at slaughter, etc. It can also be based on the percentage of non-complying meat by livestock class and chemical. Targeted sampling systems will increase the probability of non-complying farms being detected and therefore they will have a stronger deterrent function than random sampling systems. The reduction in non-compliances for certain product will be a function of the number of samples taken which are relevant to them. The number of remaining non-complying portions with chemical 'A' after a targeted sampling plan is then calculated. The seriousness of non-compliance with respect to different chemicals can be factored into the DSS.

Stage 5 Farm certification programme
Farm certification programmes are currently being developed by various livestock industries in New Zealand (eg pigs and deer). Such programmes include codes for farm management practices conducive to marketing of high quality products, including strict measures to prevent possible chemical residues in meat. As a result the number of non-compliances per livestock class is likely to decline. The proportion of farms that are participating per livestock class can be established and the effectiveness of the various programmes for the participating farms can be estimated. The product of the number of non-complying portions per livestock class, the proportion of participating farmers and the effectiveness of the programme provides the number of non-complying portions from farms that participate in the certification program. The proportion of non-certified product multiplied by the number of non-complying portions per livestock class results in the number of non-certified portions of product exceeding desired maxima. The sum of these two groups of non-complying portions provides the total number of portions above the limits. The reduction in the number of non-complying portions after the implementation of farm certification programmes is thus calculated. This is the final stage of the risk reduction programme. This outcome enables a comprehensive estimate of the probability of a person eating above the desired maximum level. The goal of the system is that this probability is so low in each case that it can be confidently stated that sufficient measures are in place for each chemical of concern to ensure that consumers do not face any health hazard in consuming product from the country, because effective and precisely targeted risk management strategies are in place.

DISCUSSION

It is to the benefit of both consumers and producers that a more structured epidemiological approach is developed to ensure the safety of food with regard to chemical residues. An analysis confirmed the limited role which random residue monitoring alone can play in this process, despite its high cost. The decision support tool described above is able in principle to determine, through a number of steps, the level of exposure to chemical residues likely to be encountered by a person with current accepted practices. For many chemicals, no further action is required to protect the consumer. However if further action is required, the proposed system would allocate resources to effectively reduce consumer exposure, using an epidemiologically designed mix of measures tailored to the chemical and ways in which it might enter the food chain. Because the approach adopted is a standard risk analysis one consistent with that used under the World Trade Organization for such purposes, it should meet international standards. Although imprecise estimates must be used in various steps of the calculations, the use of stochastic simulation to estimate both expected outcomes and variation about the expected values will assist in making informed decisions. By explaining how these estimates were made (transparency) and by showing how much influence they have on the intermediate results and the end result (through sensitivity testing) consumers can have confidence that health assurances are valid. The DSS has a large degree of flexibility. A number of 'what-if' scenarios can be run to determine the effectiveness of various steps to reduce the probabilities, and optimum combinations can be established.

While a number of issues will need to be considered in further depth to make this DSS a practical tool, none of them are intractable. In addition the cost of operating the DSS in relation to the benefits is an important consideration. It seems likely that this risk-based system should be both more cost-effective than random sampling and more effective in ensuring that consumers do not ingest product with undesirable levels of residues.

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