



Public acceptance of radiocontamination in food products: what can we learn for a better decision-making?

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Abstract

This contribution investigates consumer's risk perception and attitude towards food products containing residual radioactivity. The data originate from a large-scale public opinion survey carried out in Belgium in the summer of 2009 on the basis of computer assisted personal interviews. It is assumed that the products under discussion satisfy the legal norms concerning the maximal allowable levels of radioactive substances in food.

Risk perception of residues of radioactivity in food products, consumer's attitude and a number of factors that could influence it are explored in our study: acceptance of food legal norms, attitude towards nuclear energy and psychometric factors such as disaster potential and tampering with nature. The results are interpreted in the context of practical implications for the decision making process in nuclear emergency management.

Introduction

After a nuclear event with subsequent contamination of the environment, one of the key issues to be dealt with is management of contaminated food production systems. The main challenges are mitigating the health effects to the population consuming such products and bringing social reassurance, while limiting economic loss and restoring normal life.

The European norms (also adopted in the Belgian legislation) for marketing food products after a future radiological accident are the Council Food Intervention Levels (CEC, 1989). These are subject to approval or modification by the experts of Article 31 of the EURATOM Treaty in the first 3 months after the accident. In practice, it is likely that the type and scale of the release, as well as various socio-economic factors, will bear a heavy influence on the decisions taken with regards to food safety. While public acceptance of the policy is important for the obvious social and political reasons, consumer's attitude towards potentially affected food products may have important economic consequences. A better insight in consumer's attitude can thus contribute to a better preparedness and a more efficient decision-making.

Residual radioactivity in food is not a matter of daily concern for the consumer. Some lessons can yet be drawn from past experiences with food contaminations of



other nature, which show that consumption levels for products affected by a food chain crisis decreased in both claimed and reported consumer behaviour (Verbeke, 2001).

The first aim of this study is to investigate general risk perception of residual radioactivity in food. The second is to explore related consumer's attitude in a post-accidental framework. We thus tackle the following research questions:

- are risk perception or confidence in authorities for managing risks from residues of radioactivity in food different than for harmful substances in food in general?
- what is the consumer's attitude towards radioactive contamination of meat?
- what is the relationship between consumer's attitude and potentially explanatory variables, such as acceptance of food legal norms, attitude towards nuclear energy or psychometric risk characteristics.

Throughout the paper, it is assumed that the food products under discussion satisfy legal norms concerning maximal allowable levels of radioactive substances in food and therefore can be freely marketed.

The interpretation of results aims at highlighting practical implications for nuclear emergency management and for the associated decision-making process.

Material and methods

Starting from 2002, the Belgian Nuclear Research Centre SCK-CEN conducts periodically large-scale public opinion surveys among a representative sample of the Belgian population (Carlé and Hardeman, 2003; Van Aeken et al., 2007; Perko et al., 2010). Alongside with recurrent issues such as perception of various risks, confidence in risk regulators or the use of nuclear energy, the surveys include detailed research sections on topics such as emergency planning, food safety or communication.

The data in this study originate from the SCK-CEN survey carried out in 2009.

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| <ol style="list-style-type: none"> 1. Background Variables 2. Risk perception and confidence in authorities for 17 risk items 3. Attitude towards: <ol style="list-style-type: none"> 3.1. Science and technology 3.2. Stakeholders engagement in decision process related to industrial installations with risks 3.3 Nuclear energy 4. Acceptance of legal norms for food products 5. Use of different information media 6. Evaluation of different actors in the nuclear domain <ol style="list-style-type: none"> 6.1. Knowledge, competence and confidence in various actors 6.2. Confidence in authorities for management of nuclear installations 6.3. Confidence in authorities for radioactive waste management 7. Risk perception of an accident in a nuclear installation 8. Safety behaviour and anxiety 9. Knowledge about the nuclear domain <ol style="list-style-type: none"> 9.1 Protective measures in nuclear emergencies 9.2 General knowledge about nuclear technology and nuclear energy 9.3 Experiences with the 'nuclear' |
| Newsflash: TV-report about topics related to preparedness for nuclear emergencies <ol style="list-style-type: none"> 10. Reception & acceptance of messages communicated in the TV-report 11. Reception & acceptance of the iodine predistribution / information campaign 12. Reception & acceptance of messages communicated by authorities during the Fleurus event in 2008 13. Consumer's attitude towards food with radioactive contamination |

Fig. 1 Main topics of the SCK-CEN risk barometer survey in 2009



The content of the entire survey is summarised in Fig.1, but more details can be found in Perko et al. (2010). In this paper we resume to presenting results relevant for consumers' risk perception and attitude towards food with radioactive contamination.

Sampling procedure

The field work in the SCK•CEN 2009 survey was performed by a market research bureau using CAPI - computer assisted personal interviews. These interviews were carried out at the home of the respondent, the answers being directly recoded and stored on a portable computer's hard disk. The bulk data of the 2009 survey consisted of 1031 interviews in a chosen language (French or Dutch). This sample is representative for the Belgian adult population with respect to province, region, level of urbanization, gender, age and professionally active status. Stratified sampling was applied by i) cross-tabulating the 11 Belgian provinces with four levels of urbanisation; ii) drawing a selected sample of communities from each resulting cell; and iii) random selection of dwellings in the 108 communities. Interviews were organised such that predefined quota were respected for gender, age (divided in three categories), professionally active status and social class.

In addition, the 2009 edition included 104 interviews organized in the Fleurus area (commune in Wallonia, the French speaking part of Belgium), where the authorities advised against eating fresh vegetables and fruit from the gardens after the iodine release event in August 2008. Results for this specific population group will be compared -where appropriate- with those obtained for the French-speaking part of the Belgian population and the region of Wallonia, respectively.

Scaling

Wherever latent concepts were measured by more than one item, in order to reduce measurement errors and/or to capture multiple aspects of that concept, exploratory factor analysis using principal axis factoring was performed to examine each of the scales. In addition, the reliability of the scales was assessed with Cronbach's alpha reliability coefficient. The high reliability estimates (> 0.7) and factor loadings (> 0.5) obtained for each of these scales suggest high construct validity. The content of the constructed scales will be discussed in later subsections.

Risk perception and confidence in authorities

Perception of risk from "*residues of radioactivity in food*" and confidence in authorities for managing this risk were measured by direct questions, alongside with other risk topics: "*"How do you evaluate the risks for an ordinary citizen of Belgium for ..."*" and "*"Please state how much confidence you have in the authorities for the actions they undertake to protect the population for ..."*". In the results section these shall be presented and discussed in comparison with risks from harmful substances in food in general.

Acceptance of food legal norms

The term "food legal norms" was used with the meaning of maximal amounts of toxic substances allowed in that food products. This was briefly explained by the interviewer through a short introductory text: "*The government plays an active role by limiting the*



quantity of toxic substances a particular foodstuff may contain. These upper limits are laid down by the government as legal norms. Such a norm may tell us for instance how much dioxin may chicken meat contain or how much preservatives may be present in cookies“.

Based on previous research (Van Aeken et al., 2006), a set of six items related to legal norms was used, reflecting the content, the enforcement and the legitimacy of the norms. These items were formulated as statements with respect to which the respondents expressed their level of agreement on a 5-point Likert scale, ranging from 1="strongly disagree" to 5="strongly agree". Kaiser-Meyer-Olkin measure of sample adequacy (0.81) and Bartlett's test of sphericity ($\chi^2=2585$, df = 15, Sig.<0.001) suggest that conducting a factor analysis on these items is appropriate (see results in Table 1). Two norm items were inverted to enable the calculation of the reliability coefficient. Factor analysis revealed one factor, all items having loadings larger than the cut-off value 0.5.

Table 1. Factor loadings and scale reliability for the acceptance of food legal norms

Acceptance of food legal norms (N=935)	Factor loading Principal axis factoring Rotation: Oblimin	Reliability Cronbach's alpha
Legal norms for food products offer sufficient protection to all citizens, including children and the elderly.	.818	
A food product that complies with the legal norms can be safely consumed.	.772	
Legal norms for food products are the result of sound reasoning by the government.	.745	0.85
There is sufficient control on food products.	.728	
(inv) The legal norms are not strict enough.	.575	
(inv) The government is inadequately organized to secure food safety	.530	

Attitude towards nuclear energy

Attitude towards nuclear energy was first assessed by three general statements to which the respondents had to state their agreement degree on a 5-point Likert scale (from 1="strongly disagree" to 5="strongly agree").

Table 2. Factor loadings and scale reliability for the attitude towards nuclear energy

Attitude towards nuclear energy (N=892)	Factor loading Principal axis factoring Rotation: Oblimin	Reliability Cronbach's alpha
(inv) Opinion about nuclear energy (INVERTED scale)	.818	
Benefits of nuclear energy outweigh disadvantages	.772	0.84
Keeping NPP's open necessary for a secure energy supply	.745	
(inv) Reduction of NPP's is good cause	.728	



These items assessed the extent to which the respondents agreed that benefits/advantages of nuclear energy outweigh the disadvantages, that keeping NPP's open secures energy supply and that reduction of the number of NPP's in the E.U. is a good cause (first three items in Table 2). Subsequently, opinion about nuclear energy was measured through a direct question whether the respondent was in favour of nuclear energy or not (from "1=very much in favour" to 5="very much opposed").

Before conducting a factor analysis (see results in Table 2), two items were inverted such that high scores indicate always a strong support for nuclear energy. A scale was formed with these items using the resulting factor.

Consumer's attitude towards meat products with radioactive contamination below legal norms, after a nuclear accident

In 2006 an extensive study (Van Aeken et al, 2007; Turcanu et al., 2007; Turcanu et al., 2008) was dedicated to the management of contaminated milk. In the 2009 edition of the SCK•CEN barometer, the focus was on meat products. These generally represent an important part of the daily diet in Belgium: almost half (47%) of the respondents consider meat as important or very important daily food product, whereas 29% think it is moderately important.

In order to assess consumer's attitude towards meat products with residual radioactivity, a short introductory text was used to set the framework: "*Suppose that after a nuclear accident there is a contamination of meat with radioactive substances, and that the authorities ensure that radioactivity level is below the legal norms*". Consumer's attitude was then measured by the level of agreement with the statement: "*I would buy meat and consume it as usual in the first few months after the accident*", on a 5-point Likert scale ranging from 1="strongly disagree" to 5="strongly agree".

Characteristics of risk perception of meat products with radioactive contamination below legal norms, after a nuclear accident

Ten items selected and adapted from the extended psychometric model (Sjöberg, 2000) were used to asses the latent constructs behind risk perception of radioactive contamination in meat products after an accident in a nuclear installation. Respondents were asked to express their level of agreement with these statements, introduced with the following text "*Even for a contamination below legal norms, the presence of radioactivity in meat after an accident in a nuclear power plant...*"

Measurements were done on a 5-point scale ranging from 1="strongly disagree" to 5="strongly agree", high scores indicating strong adherence to a psychometric risk characteristic. Three characteristics of risk were measured: "Disaster potential" (four items), "Tampering with nature" (three items) and "New and unknown risk" (three items).

Kaiser-Meyer-Olkin measure of sample adequacy (0.92) and Bartlett's test of sphericity ($\chi^2=7298$, df=45, Sig.<0.001) indicate the suitability of conducting a factor analysis. Three factors were extracted (see Table 3), based on the theory (Sjöberg, 2000), scree plots analysis, explained variance in the data and eigenvalues larger than or close to 1.

Table 3. Factor loadings and scale reliability for psychometric characteristics of risk perception of meat products with radioactive contamination below legal norms, after a nuclear accident

Psychometric risk characteristic	Factor loading Principal axis factoring Rotation: Varimax	Reliability Cronbach's alpha
Disaster potential (N=917)		
Has large consequences for consumers	.782	
Will cause cancer for consumers	.802	0.95
Will harm children and future generations	.804	
Will have effects that cannot be reversed for consumers	.775	
Tampering with nature (N=942)		
Is the result of an activity which is contrary to nature	.738	
Is the result of humans trying to influence the basic processes and structures of nature	.874	0.89
Is a warning that much worse things might happen	.572	
New and unknown (N=944)		
Has effects that are hard to understand for consumers	.667	0.81
Has effects that are not sufficiently known by science	.652	
Would be something new and unknown to consumers	.690	

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Results

Risk perception and confidence in authorities for residues of radioactivity in food

Outside of the context of a nuclear accident, “*residues of radioactivity in food*” are generally perceived as a low to moderate risk for an ordinary citizen of Belgium: 47% of the respondents perceive it as a low or very low risk and 27% as a moderate risk.

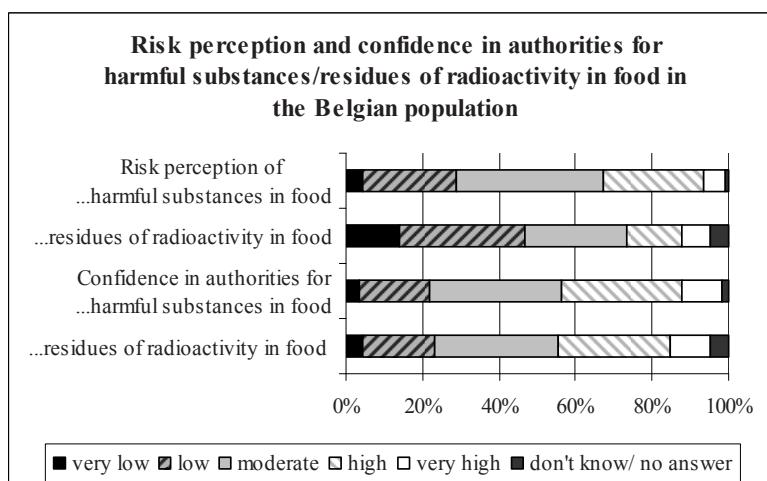


Fig. 2 Risk perception and confidence in authorities for harmful substances/ residues of radioactivity in food in the Belgian population

Compared to this, perception of harmful substances in food (in general) is slightly higher (see Fig. 2), which suggests that there is no a priori fear of radioactivity in food.

Concerning confidence in authorities for managing risks from residues of radioactivity in food, 40% of the respondents expressed high or very high confidence, while 32% a moderate level of confidence. The difference compared to “harmful substances in food” is considerably smaller than for risk perception (see also Fig. 2).

The same analysis for the population sampled in the area of Fleurus (Fig. 3) reveals that risk perception is more clearly outspoken for “radioactivity in food” than for “harmful substances in food” in general: the percentage of people with a moderate risk perception is lower for risks from residual radioactivity in food. However no clear tendency towards a high or a low risk perception is observed.

Confidence in authorities is again similar for the two types of food risks.

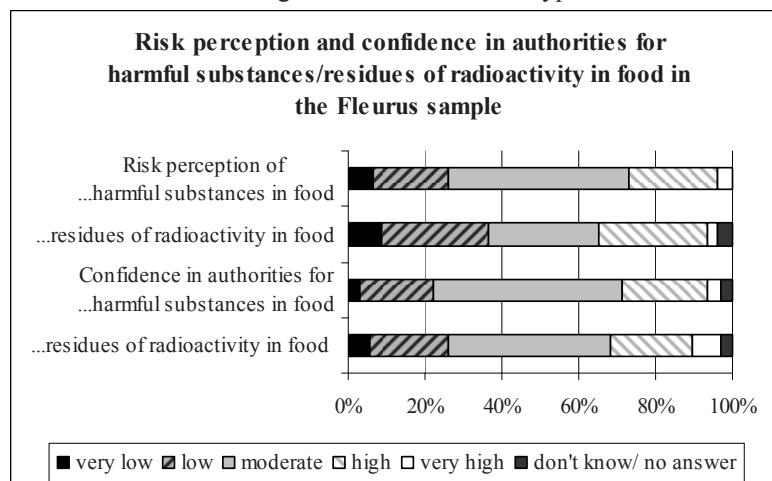


Fig. 3 Risk perception and confidence in authorities for harmful substances/ residues of radioactivity in food in the Fleurus area

Looking at residues of radioactivity in food, we notice that only 36% of the respondents from the Fleurus sample have low or very low risk perception compared to 43.8% in the French speaking part of the population and 51% in Wallonia; 30% of the respondents from the Fleurus sample have high or very high risk perception against only 9.1% in the French speaking population and 18% in Wallonia. With respect to the confidence in authorities, this accounts for 26% of respondents with low or very low confidence and 29% with high or very high confidence in authorities in the Fleurus area, which is quite in line with results from the French speaking population and Wallonia region: 29% with low or very low confidence among the French speaking and 31% in Wallonia, against and 30% with high or very high confidence in authorities among the French speaking and 33% in Wallonia.

Consumer's attitude towards meat with radioactive contamination

Almost half of the respondents (48%) stated their disagreement with buying and consuming meat as usual, even if authorities ensure that contamination is below legal

norms (see Fig. 4). About 17% of the respondents do not have a definite opinion, while 30% agree or strongly agree with buying and consuming such meat products as usual.

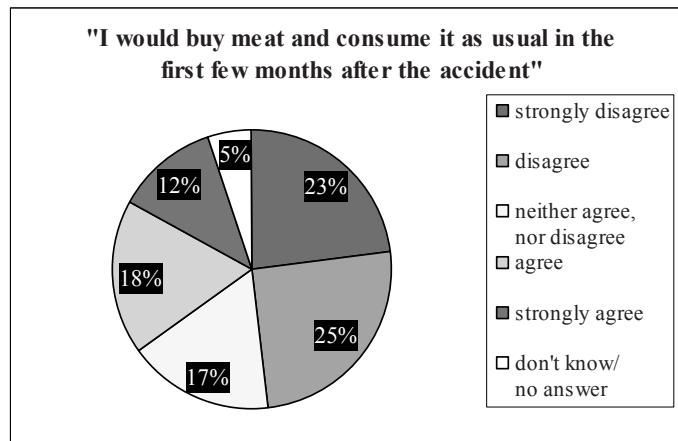


Fig. 4 Consumer's attitude towards meat with radioactive contamination below legal norms

The study of potential associations between consumer's attitude and socio-demographic characteristics revealed significant associations with language ($\chi^2=50.10$, $p<0.001$), education level ($\chi^2=51.24$, $p<0.001$), region ($\chi^2=56.45$, $p<0.001$), habitat ($\chi^2=47.96$, $p=0.001$) and importance of meat in the daily diet ($\chi^2=137.6$, $p=0.001$). We note that no significant associations with gender, social class or age were detected.

Respondents with primary education or with university degree strongly disagree with buying and consuming meat products with radioactive contamination below legal norms more often than people with other education levels: 40.5% with university education and 31.5% with primary education strongly disagree with buying and consuming meat with radioactive contamination, while for other education levels this is only between 20 and 25%. However, strong agreement decreases with the education level (from 20.2% for primary school to 4.1% among the holders of a university diploma) and increases when moving from urban to rural environment. In large cities only 18.1% respondents agree or strongly agree with consuming such meat products, while in other habitats this accounts to more than 35%. Brussels stands out as expressing the strongest disagreement (33.7% strongly disagree) with buying and consuming meat products as usual, followed by Wallonia (27.5%) and Flanders (21%).

Strong agreement with buying and consuming meat products as usual when contamination is below legal norms also grows with the importance of meat in the daily diet, e.g. 30.8% of those for whom meat is a very important food product strongly agree with buying and consuming meat as usual, while this is valid for only 5.2% of the respondents who state that meat is moderately important in the daily diet.

Potential predictors for consumer's attitude towards meat with radioactive contamination

Ordinal logistic regression was employed to study potential predictors for the consumer's attitude using the R package (library Design). The regression coefficients

and the results of the Wald test for significance of the coefficients are presented in Table 4.

Table 4. Results of ordinal logistic regression for consumer's attitude (N=722)

Cut-off point/ Independent variable	Coefficient	Std. error	Wald stat.	Z	P
y>=disagree	0.14	0.24			
y>=neither agree, nor disagree	-1.28	0.24			
y>=agree	-2.18	0.25			
y>=strongly agree	-3.62	0.27			
Importance of meat in daily diet	0.376	0.068	5.51	<0.001	
Acceptance of food legal norms	0.289	0.083	3.48	<0.001	
Attitude towards nuclear energy	0.202	0.084	2.41	0.016	
Disaster potential	-0.756	0.082	-9.18	<0.001	
Tampering with nature	-0.549	0.076	-7.19	<0.001	
New	-0.329	0.085	-3.88	<0.001	

Likelihood ratio $\chi^2=283$; df=6; Sig.<0.001(statistically significant model); c-statistic C=0.74;
 Pseudo-R² = 0.35 (moderate effect size).

Psychometric risk characteristics are negatively associated with the tendency to accept food products with contamination below legal norms, whereas e.g., importance of meat in the daily diet is positively associated with the latter. For every unit increase in the importance of meat in daily diet, we expect a 0.4 increase in the expected log odds to move to a higher category of consumer's attitude (more acceptance), i.e. an increase in odds by a factor $\exp(0.376)=1.45^1$.

Discussion

The study of general risk perception of residual radioactivity in food shows that this risk is not a matter of special concern in the Belgian population. In the Fleurus sample, perception of this risk is slightly higher than overall in the French speaking population or in Wallonia. However, this cannot be pinpointed as a direct effect of the radioactive iodine release incident in 2008, since no measurements of risk perception were performed prior to the incident. In what concerns confidence in authorities, similar results were obtained for risks from residues of radioactivity in food and harmful substances in food, both for the Belgian population and for the Fleurus sample.

In a post-accidental situation, even if food products complying with legal norms may be deemed as fit for consumption, this does not necessarily lead to consumer's willingness to buy food products with residual radioactive contamination, which confirms the findings of the 2006 survey (Turcanu et al, 2007). When asked if a food product complying with legal norms can be safely consumed, an overwhelming 68% of the respondents agree or strongly agree with this statement. However, only 30% agree or strongly agree with buying and consuming meat products with radioactive contamination below legal norms after a nuclear accident.

Significant effects on consumer's attitude towards meat products with contamination below legal norms in a post-accidental context were detected for psychometric risk characteristics, importance of meat in daily diet, acceptance of food

¹ The log odds scale is given by $\text{logit}(p)=\log(p/(1-p))$, where $p/(1-p)=$ odds of an event with probability p



legal norms and attitude towards nuclear energy. For instance, respondents with higher acceptance of food legal norms or less adherence to the psychometric risk characteristics studied are more likely to agree with consumption of such food products.

Conclusions

A good preparedness is the cornerstone of an efficient response to emergencies, one of the important issues to be dealt with being the management of contaminated food. Our study aimed at gaining a better insight in consumer's attitude towards food products with radioactive contamination. Results show that, although radioactivity in food is generally not perceived as a high risk, a large scale post-accidental contamination would bring about complex policy issues. Effective communication and information of the public in such a circumstance are certainly needed and could help alleviate social concerns.

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