



**AgEcon** SEARCH  
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search  
<http://ageconsearch.umn.edu>  
[aesearch@umn.edu](mailto:aesearch@umn.edu)

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

# **Assessing Food Safety Concepts on the Dairy Farm: the Case of Chemical Hazards**

**Natalia I. Valeeva, Miranda P.M. Meuwissen, A.G.J.M. Oude Lansink, Ron H.M. Bergevoet and Ruud B.M. Huirne**

Institute for Risk Management in Agriculture (IRMA), Wageningen, The Netherlands  
Business Economics Group, Wageningen University, Wageningen, The Netherlands



**Paper prepared for presentation at the 84<sup>th</sup> EAAE Seminar  
'Food Safety in a Dynamic World'  
Zeist, The Netherlands, February 8 - 11, 2004**

*Copyright 2004 by [Natalia I. Valeeva, Miranda P.M. Meuwissen, A.G.J.M. Oude Lansink, Ron H.M. Bergevoet and Ruud B.M. Huirne]. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.*

# ASSESSING FOOD SAFETY CONCEPTS ON THE DAIRY FARM: THE CASE OF CHEMICAL HAZARDS

Natalia I. Valeeva<sup>1,2\*</sup>, Miranda P.M. Meuwissen<sup>1,2</sup>, A. G. J. M. Oude Lansink<sup>1</sup>, Ron H. M. Bergevoet<sup>2</sup> and Ruud B.M. Huirne<sup>1,2</sup>

<sup>1</sup> Institute for Risk Management in Agriculture (IRMA), Wageningen, The Netherlands

<sup>2</sup> Business Economics Group, Wageningen University, Wageningen, The Netherlands

\*Corresponding author. E-mail: natasha.valeeva@wur.nl

## Abstract

Adaptive conjoint analysis was used to elicit farmers' and experts' preferences for attributes of improving food safety with respect to chemical hazards on the dairy farm. Groups of respondents were determined by cluster analysis based on similar farmers' and experts' perceptions of food safety improvement. Results show differences in priority of the more important attributes. However, respondents in all groups valued 'identification of treated cows' as one of the most important attributes. The results provide the processing industry and extension service with a better understanding of aspects that may form farmers' perceptions of improving food safety, and thus help to define the message for targeting different farmer groups.

**Key words:** food safety, dairy farm, conjoint analysis, cluster analysis

## Introduction

The increase in consumer demand for greater food safety together with the complex nature of food safety hazards have highlighted an integrated approach of controlling food safety throughout the entire food production chain ('farm to table'). This approach emphasizes the primary responsibility for food safety of all participants in the chain (Commission of the European Communities, 2000). At the same time, all chain participants themselves look for food safety assurance from the preceding participants (Valeeva *et al.*, 2004). These trends have brought greater attention to food safety assurance on the farm being one of the more important stages of the food chain.

New regulations have been developed and introduced to improve food safety at the farm level. The Supply Chain Management System is an example of such a regulation to ensure quality of farm milk in The Netherlands in order to meet the demands of the dairy processing industry. These regulations focus on attributes of food safety improvement relating not only to the farm structure and the types of inputs used but also to those farm production practices that require day-to-day management actions to control food safety hazards. As a result, farmers have a wide choice of attributes to control the many potential and emerging hazards on their farm. Among these attributes they have to select the most efficient (critical) attributes, as it is hardly possible to deal with all attributes at the same time. This choice is far from easy, among others because the effectiveness of many attributes is not clear. To evaluate whether farmers are well informed and able to select the best attributes from the many possible ones, it is essential to understand farmers' perceptions of food safety improvement. Therefore, the primary objective of this study was to determine the most important attributes for food safety improvement at the farm level according to farmers' perceptions and to compare them with those according to experts' perceptions. The dairy farm producing raw milk intended for further processing was used as a case study. Previous analysis (Valeeva *et al.*, 2004) has discussed the aggregate experts' perceptions of the importance of the attributes on a dairy farm and has identified that there was not a strong agreement among the experts on their preferences. However, aggregate preferences might have masked the nature of the different attitudes toward food safety improvement attributes. Thus, the secondary objective of this paper was to explore whether experts and farmers differ in individual preferences on food safety improvement.

Because the attributes of food safety improvement at the dairy farm level are considered as one of the critical attributes along the dairy production chain (Valeeva *et al.*, 2004), the findings of this study aid in getting better insight into possibilities of farm-level improvement of food safety. This information is useful for identifying in what direction more effort is to be made to improve food safety on the farm. The findings also provide the processing industry and extension service with a better understanding of aspects that may form farmers' perceptions of improving food safety. It helps them to define the message for

farmers to get a higher awareness of the most important attributes of food safety improvement and to ensure a higher level of food safety in farm production.

## **Materials and methods**

### *Adaptive Conjoint Analysis Application*

In general, conjoint analysis has received considerable academic (Manalo, 1990) and industry (Wittink *et al.*, 1994) attention as a major set of techniques for measuring consumers' tradeoffs among multiattributed products (Green and Srinivasan, 1990). Conjoint is a multiattribute model, which assumes that consumers purchase products (e.g. apple) based on their characteristics, or attributes (e.g. flavor) and that each attribute may have two or more levels (e.g. sweet, tart, bitter). Then the individual's utility for a product concept can be expressed in a simple way as a sum of utilities for its attributes.

Conjoint analysis relies on the ability of respondents to evaluate a product concept by combining the separate amounts of utility provided by each attribute of the concept. A set of hypothetical concepts is constructed, where each product concept, or so-called profile, stands for a specific combination of attribute levels. Respondents are asked to estimate their overall preference for each profile. The basic aim is to determine the attribute the respondents most prefer. Then conjoint analysis estimates how much each of the attributes is valued on the basis of the choices respondents make along product concepts that are varied in systematic ways. The utilities, or part-worths, for each single level of each attribute are the result from such a process. These utilities can be used to determine relative importance of each attribute in developing a new product concept. For a comprehensive overview of conjoint analysis and related methods, see Green and Srinivasan (1990).

In this study the method of ACA from Sawtooth Software is applied to find out the attributes the respondents most prefer within a concept of food safety improvement (ACA Version 5.1, Sawtooth Software, Inc.). The ACA system collects individual respondents' preference data in a computer-interactive mode that increases respondent interest in and involvement with the task (Green and Srinivasan, 1990).

ACA combines aspects of composition (self-explicated task, i.e. respondents rate the importance of the difference between the best and worst levels, separately for each attribute) and decomposition approaches (conjoint task, i.e. respondents indicate preference intensity judgements for paired partial profiles) (Wittink *et al.*, 1994). It obtains the final preference function coefficients by pooling the two types of data (Wittink and Bergestuen, 1999). The use of personal computers allows ACA to customize the partial profile characteristics based on each respondent's self explicated data. This implies that during the conjoint task the respondents are interviewed in detail about only those attributes that they regard as more important. Part-worths for these more important attributes then are refined through a series of graded paired comparisons where the respondent's previous answers are used at each step to select the next paired comparison question so as to provide most information. This allows ACA to investigate many attributes without asking the respondents to deal with too much information on the computer screen at the same time (Green and Srinivasan, 1990).

### *Survey Design*

This study investigates the attributes of improving food safety that affect the food safety level of the raw milk intended for further production of consumed pasteurized milk. Specifically, improving food safety with respect to chemical hazards is explored. Considered chemical hazards include antibiotics and dioxin. Hazards were selected after literature research (Gould *et al.*, 2000) and consultations with experts from research and practical field.

Based on a review of the scientific literature on the control of the considered hazards, current regulations and individual and group consultations with experts, a concept of food safety improvement was assembled with a final set of 13 independent key attributes. In particular, the attributes refer to type of incoming compound feed, own feed production (grazing), cattle movement and traceability, herd health and treatment, milking procedures, maintenance of the equipment, water management and hygiene level on the farm. Each attribute consisted of a number of mutually exclusive levels (two to five) representing control measures differently affecting food safety. For instance, the attribute 'outdoor drinking system while grazing' comprised the three levels: a) outdoor water trough, *fence* to prevent access to ditch and surface water while grazing, b) outdoor water trough, *no fence* to prevent access to ditch and surface water while grazing, c) no outdoor water trough, access to ditch and surface water while

grazing. Experts were consulted to ensure relevance of the selected attributes and their levels. Some of these experts provided a review of the complete list of the attributes and their levels<sup>1</sup>.

A computerized ACA questionnaire was organized into five sections. Through the first two sections approximate preferences for attributes and their levels were estimated (self-explicated task). In the first section, the respondent rated the attribute levels using a seven-point scale (1 = least preferred, 7 = most preferred). In the second section, the respondent indicated on a seven-point scale (1 = not important, 7 = extremely important) the importance of differences between the attribute levels the respondent had stated as 'most preferred' and 'least preferred' in the first section. The third section refined the estimated preferences through adapted paired-comparison trade-off questions (conjoint task). In each question, the respondent was shown two hypothetical concepts of food safety improvement specified and differing on two or three attributes. Using a nine-point scale the respondent expressed the preference and its' strength for one of the proposed concepts (1 = strong preference for one concept, 9 = strong preference for the other concept). Pairings were composed in such a way that respondents were nearly indifferent between the choices. With each choice respondents' utilities were updated. The final section investigated the consistency of model predictions. Five validation profiles of food safety concepts were specified based on five attributes determined to be most important in the previous sections. For each validation profile, the respondents indicated a likelihood of implementing the concept if it were possible right now (0 = definitely would not implement, 100 = definitely would implement). For each respondent, the fit ( $R^2$ ) between scores of likelihood estimated by the ACA model and actual scores of validation profiles was measured.

Throughout the questionnaire there was a reminder for respondents to focus on the food safety aspects of the attributes and not on other aspects such as costs. In addition, handouts were provided to describe attributes such as 'best farm practices performance'. A questionnaire pretest was conducted to improve clarity of the questionnaires, minimize ambiguities and misinterpretations and to ensure that respondents get easy familiar with the applied techniques. The pretest included 8 staff members of the Business Economics Department of Wageningen University, who were all familiar with the subject of food safety at the farm level.

### *Data Collection*

To collect the data on farmers' perceptions of food safety improvement at the farm level, two workshops were conducted in February and September 2003. The two groups of farmers, one from the north and one from the south of The Netherlands, included 52 farmers. They were milk suppliers of the two large dairy processing companies located in the north (Friesland Coberco Dairy Foods) and in the south (Campina Melkunie) respectively. The farmers were selected in cooperation with a farm consultancy firm, the dairy processing companies and a farmer organization. Farmers from both groups are actively involved in education programs on food safety improvement on their farms. They were considered representative for farmers with good future perspectives.

The workshops were held in computer rooms of two agricultural colleges. Full compensation for traveling expenses was included to encourage participation in the 2.5-hour evening workshop. The farmers were also assured of anonymity and confidentiality of their responses. The workshops started with a short introduction to the topic including the considered hazards, followed by instructions about the computerized questionnaires. While answering the questionnaires participants worked individually with a personal computer at own speed, so that the influence from others was limited. After all responses were collected and stored, the workshops ended by a general discussion about food safety issues at the farm level.

The data on food safety improvement perceptions of 14 farm experts (14 in total) were gathered likewise (Valeeva *et al.*, 2004). The computerized questionnaire was identical both for farmer and expert respondents.

### *Data Analysis*

A two-step approach was used to define most important attributes for food safety improvement on the farm and to explore possible differences in individual preferences of experts and farmers on these attributes. In the first step, ACA was used to estimate individual preference functions of food safety improvement attributes, i.e. utility provided by each attribute for each respondent. In the second step, respondents' groups were constructed on the basis of the each individual preference function so that there

is as much homogeneity within groups and heterogeneity between groups as possible. A two-stage cluster analysis methodology (Punj and Stewart, 1983) was used. The utilities for each single level of each attribute were used as variables to perform clustering. In the first stage Ward's minimum variance method that is one of the demonstrated superior performance hierarchical methods (Punj and Stewart, 1983), was used. In Ward's method, the distance between two clusters is the sum of squares between the two clusters summed over all variables. At each step in the clustering procedure, the within-cluster sum of squares is minimized over all partitions obtainable by combining two clusters from the previous stage (Hair *et al.*, 1998). The results of this preliminary analysis (the resulting dendrogram and agglomeration schedule) were used to determine the number of clusters and a starting point for the employed in the second stage nonhierarchical *K*-means clustering method. This iterative partitioning method appears to outperform hierarchical methods if a nonrandom starting point is specified. In *K*-means method, cases are reassigned by moving them to the cluster whose centroid is closest to that case minimizing the variance within each cluster. Reassignment continues until every case is assigned to the cluster with the nearest centroid (Punj and Stewart, 1983).

## Results and Discussion

### *Aggregate Conjoint Models*

The survey data were analyzed by ordinary least squares regression that is incorporated in the ACA software. The part-worths for each single level of each attribute were estimated from the regression coefficients for respondents individually. The relative importance of each attribute was derived in ACA for each individual by obtaining the difference between the part-worths of the most preferred and the least preferred attribute levels and expressed in terms of percent (Churchill, 1999). These attribute relative importances were used to compare importances of different attributes of food safety improvement. The aggregate relative importance of an attribute was calculated by averaging individual respondents' importances of the attribute.

Table 1 illustrates chemical food safety improvement attributes and their relative importances obtained from aggregate ACA models for expert and farmer groups of respondents, columns 'Experts' (n = 11) and 'Farmers' (n = 47) respectively. These results reveal expert and farmer respondents' perceptions of chemical food safety improvement at the dairy farm level. Based on results of the preliminary analysis eight respondents were excluded from the final analysis, for details see later.

Table 1. Relative importance of attributes of chemical food safety improvement on the dairy farm (%)<sup>\*</sup>

	Farmers n=47	Experts n=11	All respondents n=58
Country of origin of compound feed/by-product feed manufacturers	6.36 <sup>a</sup> (12)	5.13 <sup>a</sup> (13)	6.13 (12)
Quality assurance system of compound feed manufacturers	9.24 <sup>a</sup> (3)	10.05 <sup>a</sup> (3)	9.39 (3)
Origin of forage	6.97 <sup>a</sup> (8)	7.89 <sup>a</sup> (5)	7.14 (8)
Quality assurance system of compound feed transporters	7.85 <sup>a</sup> (6)	6.90 <sup>a</sup> (9)	7.67 (7)
Identification of treated cows	10.78 <sup>a</sup> (1)	10.77 <sup>a</sup> (1)	10.78 (1)
Action in case of doubt about the withdrawal period	9.44 <sup>a</sup> (2)	10.06 <sup>a</sup> (2)	9.56 (2)
Maintenance of the equipment	5.73 <sup>a</sup> (13)	5.71 <sup>a</sup> (12)	5.73 (13)
Treatment plan	6.64 <sup>a</sup> (10)	7.05 <sup>a</sup> (8)	6.71 (10)
Water used for watering cows and production purposes	7.96 <sup>a</sup> (5)	7.56 <sup>a</sup> (6)	7.89 (4)
Reuse of water for cleaning and disinfection	6.88 <sup>a</sup> (9)	7.17 <sup>a</sup> (7)	6.93 (9)
Outdoor drinking system while grazing	7.99 <sup>a</sup> (4)	6.79 <sup>a</sup> (10)	7.76 (5)
Adequate cleaning and disinfection	6.62 <sup>a</sup> (11)	6.52 <sup>a</sup> (11)	6.60 (11)
Best farm practices performance	7.54 <sup>a</sup> (7)	8.40 <sup>a</sup> (4)	7.71 (6)
Total	100.00	100.00	100.00
Predictive accuracy, mean of the ACA model fit (R <sup>2</sup> )	0.830	0.814	0.827

<sup>\*</sup>n represents the number of respondents per group of respondents

<sup>a</sup>Means within a row bearing common subscript do **not** differ, measured at 5% significance level

Numbers in brackets are the rankings of average attributes' importances

In general, for the 13 attributes included in the chemical questionnaire both groups of respondents fairly agree on the most and least important attributes for food safety improvement. The farmer respondents as well as the expert respondents believe that:

- (a) 'identification of treated cows', 'actions in case of doubt on withdrawal period' and 'quality assurance system of compound feed manufacturers' are most important attributes;
- (b) 'maintenance of the equipment', 'country of origin of compound feed/by-product feed manufacturers' and 'adequate cleaning and disinfection' are least important attributes.

For all attributes, there were no significance differences detected between perceptions of expert and farmer respondents (independent t-Test,  $p \leq 0.05$ ). These findings indicate that compare to expert respondents farmer respondents do not consider the corresponding attributes as more or less important: both groups show comparable levels of attributes' importances.

The results of Table 1 also show that the average fit of the final estimated ACA models ( $R^2$ ) for both groups of respondents was rather good, 0.814 for expert and 0.830 for farmer respondents respectively. These results imply that the predictive validity of the estimated models is good. Besides, these results indicate that the respondents included in the final ACA models were highly and perfectly consistent in expressing their preferences. Based on the preliminary ACA results, the seven respondents, namely three expert and four farmer respondents, were removed from the ACA and, hence, were not included in further cluster analysis. For these respondents the holdout choices, included in the final section of ACA questionnaire, showed low consistency ( $R^2 < 0.6$ ) (Huber *et al.*, 1991). Furthermore, preliminary results of the cluster analysis (see the following section) allowed detecting one outlier among farmer respondents. This respondent was also deleted from the final ACA.

### *Identifying Respondent Groups*

By pooling expert and farmer respondents and using the two-stage cluster analysis procedure described above, four clusters were identified by Ward's method in the first stage (all consistent respondents were pooled). For each cluster, the center, which is simply the mean of the variables included in clustering, was specified as the starting point for the second stage. The results of Ward's hierarchical method identified one obvious outlier (Hair *et al.*, 1998) as having a unique unrealistic profile, which composed a separate group. This respondent was detected as potential outlier by preliminary analysis of the data as well (box plots and z-scores). In particular, the profile of the outlier included outmost values on importances of attributes 'identification of treated cows' (22.62%), 'reuse of water for cleaning and disinfection' (0 %) and 'outdoor drinking system while grazing' (0%). This respondent was eliminated from further analysis as unrepresentative. The remaining cases were submitted to K-means nonhierarchical analysis for refinement of the clusters.

Compared to clusters identified by hierarchical procedure, the four-group solution obtained by nonhierarchical method showed groups of almost equal size. Also, the cluster profiles matched rather well. That is, hierarchical and nonhierarchical methods resulted in first group of 32 versus 31 observations respectively (29 matches), in the second group of 12 versus 12 (11 matches), in the third group of 9 versus 10 (8 matches). The observations in the fourth group were absolutely identical. Independent t-Test was performed to compare the four corresponding cluster centers for the clusters obtained by hierarchical and nonhierarchical methods. There was no significant difference between the means of all clustering variables of the corresponding clusters obtained by these two methods (independent t-Test,  $p \geq 0.05$ ).

The correspondence and stability of the four cluster solutions between the hierarchical and nonhierarchical methods confirms the result subject to theoretical and practical acceptance (Hair *et al.*, 1998). Chemical food safety improvement attributes and their relative importances for the four respondent groups are provided in Table 2.

Examination of relative importances of chemical food safety improvement attributes for each group indicates that respondents value the attributes rather different. Analysis of variance technique (or ANOVA) was employed to distinguish differences in attribute importances between identified groups of respondents. Results showed that eight out of thirteen attributes significantly differ between groups ( $F$ -ratio,  $p \leq 0.05$ ). For those attributes where a statistically significant difference was found, *post hoc* tests (Gabriel, Hochberg and Games-Howel) were performed to find out which groups differ.

Table 2. Relative importance of attributes of chemical food safety improvement on the dairy farm by group (%)<sup>\*</sup>

	Group 1 n=31	Group 2 n=12	Group 3 n=10	Group 4 n=5
Country of origin of compound feed/by-product feed manufacturers	6.53	4.69	5.92	7.54
Quality assurance system of compound feed manufacturers	8.61 <sup>a</sup>	9.37 <sup>b</sup>	9.08 <sup>c</sup>	14.87 <sup>abc</sup>
Origin of forage	7.27	7.70	6.21	6.90
Quality assurance system of compound feed transporters	7.61	8.77 <sup>a</sup>	7.64	5.46 <sup>a</sup>
Identification of treated cows	11.15	10.12	9.52	12.55
Action in case of doubt about the withdrawal period	8.79 <sup>a</sup>	8.85 <sup>b</sup>	13.77 <sup>abc</sup>	7.64 <sup>c</sup>
Maintenance of the equipment	5.26	5.61	6.28	7.79
Treatment plan	6.77 <sup>a</sup>	8.56 <sup>b</sup>	6.60 <sup>c</sup>	2.15 <sup>abc</sup>
Water used for watering cows and production purposes	7.84	9.21 <sup>a</sup>	6.62 <sup>a</sup>	7.55
Reuse of water for cleaning and disinfection	7.94 <sup>al</sup>	6.22	5.88 <sup>l</sup>	4.51 <sup>a</sup>
Outdoor drinking system while grazing	7.07 <sup>a</sup>	9.17 <sup>a</sup>	6.31	11.58
Adequate cleaning and disinfection	6.75	6.11	6.91	6.22
Best farm practices performance	8.41 <sup>a</sup>	5.62 <sup>ab</sup>	9.26 <sup>bc</sup>	5.24 <sup>c</sup>
Total	100.00	100.00	100.00	100.00
Mean of the ACA model fit ( $R^2$ )	0.820	0.818	0.865	0.823

<sup>\*</sup> n represents the number of respondents per group

<sup>a,b,c</sup> Means within a row bearing common superscript differ, measured at 5% significance level

<sup>l</sup> Means within a row bearing common superscript differ, measured at 10% significance level

From results of Table 2, it appears that preferences of group 1 respondents, representing 53 % of the respondents, are rather consistent with aggregate preference results (see Table 1, column ‘All respondents’).

Group 2 is comprised of respondents who worry most about attributes relating to water use practices and animal feed. It can be seen that, compared with respondents from other groups, they perceive ‘water used for watering cows and production purposes’ (9.21%) and ‘quality assurance system of compound feed transporters’ (8.77%) as more important attributes. Yet, respondents from group 2 believe that the attributes ‘outdoor drinking system while grazing’ (9.17%) and ‘quality assurance system of compound feed manufacturers’ (9.37%) are of high importance.

Respondents in group 3 are most concerned with animal treatment and hygiene. The attributes relating to animal treatment such as ‘action in case of doubt about the withdrawal period’, ‘identification of treated cows’ and ‘treatment plan’ include 29.89% of the total importance of 13 considered attributes. At the same time, compared with respondents from the other groups, respondents in this group consider ‘best farm practices performance’ (9.26%) as more important.

Group 4 respondents have a relatively strong preference for ‘quality assurance system of compound feed manufacturers’; this attribute has a relative importance of 14.87%. It may be also seen that, compared with respondents from other groups, they perceive ‘outdoor drinking system while grazing’ (11.58%), and ‘maintenance of equipment’ (7.79%) as more important. However, respondents in this group are relatively unconcerned with ‘treatment plan’ (2.15%). Compared with respondents from the other groups, they also have lower preference for ‘action in case of doubt about the withdrawal period’ (7.64%). These results indicate that members of group 4 place less importance on animal treatment related attributes and put a bit more importance on real inputs used for cows, namely inputs of feed, inputs of medicines and inputs of water.

A comparison of the aggregate relative importances of food safety improvement attributes and relative importances of food safety improvement attributes for the four groups (Table 2) is important in terms of the interpretation of respondents’ perceptions. An examination of the individual groups indicates that the aggregate preference results reflect only perceptions of chemical food safety improvement of respondents from group 1. Furthermore, these results indicate that groups are best identified not by the background of the respondents (experts or farmers), but rather by their perceptions. In particular, different perceptions with respect to the considered chemical hazards (antibiotics and dioxin) were the reason for differences between groups. It would seem that the respondents from group 3 perceive additional prevention of antibiotics as more important. While it seems that respondents from group 2 believe that



prevention of dioxin contamination is more important. Overall, however, ‘identification of treated cows’ is one of the most important attributes regardless of the group examined.

### *Validation of the Cluster Solution*

A second nonhierarchical *K*-means clustering method with non-specified starting point was employed to perform a validity check for stability of the cluster solution (Hair *et al.*, 1998). The clusters for both four-group solutions were rather comparable, varying in size at the most by 12 observations, and cluster profiles were similar. Namely, the second *K*-means method resulted in the first group of 19 respondents (16 matches), in the second group of 19 (12 matches), in the third group of 10 (7 matches) and in the fourth group of 7 (5 matches).

There was no significant difference between the means of all clustering variables of the corresponding clusters obtained by these two methods (independent t-Test,  $p \geq 0.05$ ).

### **Concluding Remarks**

This paper determines the most important attributes for chemical food safety improvement at the dairy farm. Farmers’ perceptions were elicited and compared with those from experts. The following concluding remarks can be made about the current research:

- Results of two aggregate ACA models did not show significant differences in perceptions of importance of attributes to improve food safety between the groups of farmer and expert respondents. So, farmers and experts seem to have the same perceptions.
- The results of cluster analysis yielded four distinct groups composed of both farmers’ and experts’ respondents. So, there is not a common perception of farmers and experts on how food safety with respect to chemical hazards is best improved.
- The findings of this research are useful for identifying the directions in which more effort is to be made to improve food safety on the dairy farm.
- The findings also help advisors to define their message for farmers to get a higher awareness of the most important attributes of food safety improvement and to ensure a higher level of food safety in farm production.
- An additional study is necessary to explore further factors, which predetermine the identified difference in perceptions of food safety improvement between groups of farmers.
- An additional study is necessary to analyze microbiological hazards and compare those results with those from the current study to come to an integrated view on whole-farm food safety improvement. Together with an economic analysis of costs, it is possible to determine the least-cost interventions to improve food safety for milk at the dairy farm.

### **Endnotes**

<sup>1</sup>A complete copy of the survey is available from the authors upon request.

### **References**

- Churchill, G. A. (1999). *Marketing Research. Methodological Foundations*. The Dryden Press, Fort Worth, TX.
- Commission of the European Communities. (2000). *White Paper on Food Safety*. COM-1999 719 Final. Brussels, Belgium. Online. Available: [http://europa.eu.int/comm/dgs/health\\_consumer/library/pub/pub06\\_en.pdf](http://europa.eu.int/comm/dgs/health_consumer/library/pub/pub06_en.pdf).
- Gould, B. W., M. Smukowski and J. R. Bishop (2000). HACCP and the dairy industry: an overview of international and U.S. experiences. In L. J. Unnevehr (eds.), *The Economics of HACCP: Costs and Benefits*. Eagan Press, St. Paul, Minnesota, 365-384.
- Green, P. A. and V. Srinivasan (1990). Conjoint analysis in marketing: New developments with implications for research and practice. *Journal of Marketing* (54): 3-19.
- Hair, J. F., R. E. Anderson, R. E. Tatham and W. C. Black (1998). *Multivariate Data Analysis*. Prentice-Hall, Inc., Upper Saddle River, New Jersey.
- Huber, J. C., D. R. Wittink, F. J. A. and R. L. Miller (1991). An Empirical Comparison of ACA and Full Profile Judgments. In M. Metegrano (eds.), *Proceedings of Sawtooth Software Conference, 1991*, Ketchum, ID. Sawtooth Software, 189-202.
- Manalo, A. B. (1990). Assessing the importance of apple attributes: an agricultural application of conjoint analysis. *Agricultural and Resource Economics Review* 19 (2): 118-124.
- Punj, G. and D. W. Stewart (1983). Cluster Analysis in Marketing Research: Review and Suggestions for Application. *Journal of Marketing Research* 20: 134-148.

- Valeeva, N. I., M. P. M. Meuwissen, A. G. J. Oude Lansink and R. B. M. Huirne (2004). Improving Food Safety within the Dairy Chain: an Application of Conjoint Analysis. *Submitted for publication to Journal of Dairy Science*.
- Wittink, D. R. and T. Bergestuen (1999). Forecasting with conjoint analysis. In J. S. Armstrong (eds.), *Principles of Forecasting: A Handbook for Researchers and Practitioners*. Kluwer Academic Publishers, Norwell, MA, 145-168.
- Wittink, D. R., M. Vries and W. Burhenne (1994). Commercial use of conjoint analysis in Europe: Results and critical reflections. *International Journal of Research in Marketing* (11): 41-52.