Food Control 45 (2014) 76–80

Contents lists available at ScienceDirect

Food Control

journal homepage: www.elsevier.com/locate/foodcont

What consumers expect from food control and what they get – A case study of the microbial quality of sushi bars in Denmark

J.J. Leisner [a,*], T.B. Lund [b], E.A. Frandsen [c], N.B.E. Andersen [a], L. Fredslund [a], V.P.T. Nguyen [a], T. Kristiansen [c]

[a] Department of Veterinary Disease Biology, Faculty of Health and Medical Sciences, University of Copenhagen, Denmark
[b] Department of Food and Resource Economics – IFRO, Faculty of Science, University of Copenhagen, Copenhagen, Denmark
[c] Gefion Gymnasium, Copenhagen, Denmark

ARTICLE INFO

Article history:
Received 25 November 2013
Received in revised form
2 April 2014
Accepted 8 April 2014
Available online 4 May 2014

Keywords:
Own control
Microbiological quality
Fish products
Food inspection
Consumer evaluation

ABSTRACT

Sushi is a traditional Japanese food, also popular in Europe, consisting of acidified rice and raw fish. This study investigated the correlation between monitoring of hygienic levels and compliance with establishment-managed controls by public food inspectors and observed microbial levels of two types of sushi products, Maki salmon and Nigeri salmon, sold by Danish outlets. Danish consumers' knowledge of the specific tests carried out by food inspectors was also examined. The total microbial contents of the products ranged from 4.1 to 7.5 log CFU/g and contents of *Escherichia coli* and *Staphylococcus* spp. ranged from <1 to 2.3 and <2 to 3.0 log CFU/g, respectively. There was in general no correlation between the publicly accessible rankings by the food inspectors and the microbiological contents of the products. Underlying reasons might be that the regulatory monitoring of compliance with control programs does not readily include two important parameters, personal hygiene and initial microbial quality of products. Microbiological examination of sushi products does not constitute a part of routine monitoring of hygienic levels, a fact that by use of a questionnaire study was found not to be widely known among consumers.

1. Introduction

The traditional Japanese food, sushi, prepared from raw and cooked fish and soured rice has become very popular in many European countries, including Denmark. A recent German study showed that sushi prepared by sushi bars had relatively high aerobic plate count levels as well as counts of *Escherichia coli* and *Staphylococcus aureus*. This could be a result of processing conditions and/or cooling and hygiene conditions during storage and preparation (Atanassova, Reich, & Klein, 2008). The authors concluded that the consumers should be aware of the risk associated with such products, which should be eaten immediately or kept properly refrigerated and eaten no later than the "best before" date.

The objectives of the present study were, firstly to compare the microbial standard of similar Danish sushi products with products from other countries and, secondly to examine the extent to which food authorities detect potential deviations from compliance with own control programs by sushi bars. Thirdly, knowledge among Danish consumers of the control programs carried out by food inspectors was also examined with a special focus on knowledge about microbial monitoring.

The Danish Veterinary and Food administration introduced the so-called Smiley system in 2001 (Kjeldgaard, Stormly, & Leisner, 2010; Nielsen, 2006; www.findsmiley.dk/en-US/Forside.htm) that resembles the restaurant hygiene grade cards in North America and the "scores on doors" schemes in the UK (Jin & Leslie, 2003; Worsfold & Worsfold, 2007). This system results in public records from unannounced visits by food inspectors. The inspector evaluations include visual observations; on the spot measurements of temperatures in incubators and in food products and inspection of data recorded under the shops own control programs. Usually microbiological examinations of foods are not a part of the evaluation. We have in this study used the web-based Smiley records to examine the extent to which the Smiley evaluations of the food

* Corresponding author. Department of Veterinary Disease Biology, Faculty of Health and Medical Sciences, University of Copenhagen, Grønnegårdsvej 15, DK 1870 Frederiksberg C., Denmark. Tel.: +45 35332768.
E-mail address: jjl@sund.ku.dk (J.J. Leisner).

http://dx.doi.org/10.1016/j.foodcont.2014.04.017
0956-7135/

authorities agree with the microbiological counts of fresh sushi sold by a range of sushi bars in the Danish capital, Copenhagen.

Since results from inspections are made publicly accessible consumers can, at least in theory, evaluate sushi bars based on their Smiley rating. Indeed, practically all Danish consumers are acquainted with the Smiley system, and the level of general trust in it is high (Stürup & Nielsen, 2009). A majority of Danish consumers who have encountered a restaurant with a poor rating also rejected eating there (Stürup & Piper, 2007). However, it is unknown whether Danish consumers are aware that microbiological examinations are not a standard part of the Smiley evaluation. For this reason we also surveyed consumer's knowledge of the specific tests carried out by inspectors.

2. Materials and methods

A total of 20 shops were evaluated including both outlets with positive and negative smiley rankings. We ranked the shops according to smiley evaluations done within a half year before and a half year after our samplings (Table 1). The number of smiley evaluations varied widely from shop to shop, ranging from 1 to 4 smiley rankings during the year. The underlying reason for the different numbers of regulatory inspections appeared to be partly correlated with the smiley rankings obtained immediately before and during the year. Thus, if a poor smiley evaluation was obtained at a specific visit more visits would follow in a relatively short period of time. In some cases, however, shops also were inspected a number of times even if the outcome in all cases was a positive smiley evaluation. We therefore assume that for at least such shops the actual number of visits were to some extent random. The outlets were located within different geographical areas of Copenhagen including the central business district (one outlet), Østerbro (two), Vesterbro (five), Nørrebro (one), Frederiksberg (seven) and Valby (three). One package of Nigeri salmon and Maki salmon were purchased and each shop was visited twice. Explanation on the Smiley symbols is as follows:

☺: the inspector had no remarks; 😐: certain rules must be obeyed; ☹: an injunction or prohibitory order has been given to the outlet; ☹: the outlet has received an administrative fine, been reported to the police or approval has been withdrawn.

We evaluated the microbiological qualities by homogenizing of aliquots of 10 g of fresh sushi products (including both rice and ingredients) in 0.1% peptone saline with a Seward Stomacher 400 Lab Blender (U.K.) for 30 s. The numbers of aerobic bacteria, *E. coli* and *Staphylococcus* spp. were determined after serial dilution in 0.1% peptone saline by pour plating 1 ml in, respectively, plate count agar (Oxoid) incubated aerobically at 25 °C for 3 d, 1 ml in Rapid *E. coli* agar (Biorad) incubated aerobically at 37 °C for 2 d and surface spreading 100 μl on Baird Parker agar (Oxoid) incubated aerobically at 37 °C for 2 d.

In Denmark Iron Agar and/or Long & Hammer agar is routinely used for determination of aerobic count and specific spoilage organisms in fish and fish products (NMKL 184). In this study we decided to use PCA for determination of the aerobic count as it has been used in several studies concerning microbial quality of sushi (*e.g.* Adams et al., 1994; Anon, 2000; Atanassova et al., 2008). *E. coli* and *Staphylococcus* spp. counts constituted measurements of hygiene in relation to faecal contamination and handling, respectively. Number of samples is indicated in Table 1. All bacteriological analyses were conducted within 2 h of purchase and samples were kept refrigerated under transport and subsequent storage. We have not included analysis of *Listeria monocytogenes* although there are limits for presence of this pathogen according to current legislation (Anon, 2006). This is due to the short shelf life of sushi in general prevent extended growth of this organism. In addition, *Vibrio* spp. such as *Vibrio vulnificus* and *Vibrio alginolyticus* could also be considered as potential pathogens in relation to sushi and indeed are important for Japanese sushi products (Anon, 2011). They are, however, seldom found in Australian or European sushi products (Anon, 2008; Atanassova et al., 2008) and we therefore also omitted analyses of contents of *Vibrio* spp. in this study.

We surveyed consumer usage of the Smiley ratings and knowledge about specific tests conducted by Smiley inspectors by means of a questionnaire that was distributed to three different student groups in the period April 2013 to May 2013. The first group consisted of students at a high school in Copenhagen (The Gefion Gymnasium, $n = 80$), the second group comprised veterinary undergraduate students ($n = 115$), and the third group food engineer

Table 1
Listing of smiley rankings with microbial analyses of sushi products.

Smiley ranking	Product type	No. of samples[d]	Mean APC (log CFU/g)[e]	Mean *E. coli* (log CFU/g)[f]	Mean *Staphylococcus* spp. (log CFU/g)[f]
1[a] ☺	Maki	14 (7)	5.5 (4.2–6.5)	N/A (0%)	N/A (0%)
	Nigeri	14 (7)	5.4 (4.3–6.2)	N/A (0%)	N/A (0%)
2[b] ☺	Maki	10 (5)	5.7 (4.9–6.8)	2.3 (40%)	2.9 (20%)
	Nigeri	10 (5)	5.3 (4.1–7.5)	1.4 (20%)	2.6 (20%)
3[c] ☺☺☺☹	Maki	16 (8)	5.7 (4.8–7.2)	2.0 (31.3%)	2.5 (6.3%)
	Nigeri	16 (8)	5.6 (4.8–6.6)	1.6 (37.5%)	3.0 (6.3%)

[a] These shops only received ☺ in 1 to four visits within the time period (less than half a year before and after microbiological samplings). In addition only ☺ was received if the time period included one to three additional smiley rankings (before and after the half year limit).

[b] These shops only received ☺ in 1 to four visits within the time period (less than half a year before and after microbiological samplings). However, ☺, 😐 or ☹ was received if the time period included one to three additional smiley rankings (before and after the half year limit).

[c] These shops received at least one of these rankings: ☺, 😐 or ☹ in 1 to four visits within the time period (less than half a year before and after microbiological samplings).

[d] Numbers in parentheses are numbers of outlets.

[e] Geometric average. Numbers in parentheses are the APC range.

[f] Geometric average of positive samples. Numbers in parentheses are the percentage of positive samples.

Table 2
Descriptive statistics, Smiley awareness, and score on knowledge scale in the three surveyed groups.

	High school students ($n = 80$)	Veterinary students ($n = 116$)	Food engineer students ($n = 44$)
Gender			
Woman	67.5% (54)	86.1% (99)	70.5% (31)
Man	32.5% (26)	13.9% (16)	29.5% (13)
Age			
Mean (in years)	17.2	22.9	24.2
St.dv.	0.91	2.49	3.85
Awareness of Smiley system			
Yes	93.8% (75)	95.7% (110)	100% (43)
No	6.2% (5)	4.3% (5)	0% (0)
Knowledge scale[a]			
Mean	2.49	3.22	3.61
St.dv.	1.07	0.83	0.81

[a] Scale was constructed on basis of five questions probing on the evaluations included in the Danish Smiley examination (1. 'Self-policing control system': correct; 2. 'Microbial count': false; 3. 'Temperature': correct; 4. 'Sensory quality': false; 5. 'Firm accounting': correct). In the case of a correct response the score 1 was assigned (if incorrect 0) producing a measure with the range 0–5.

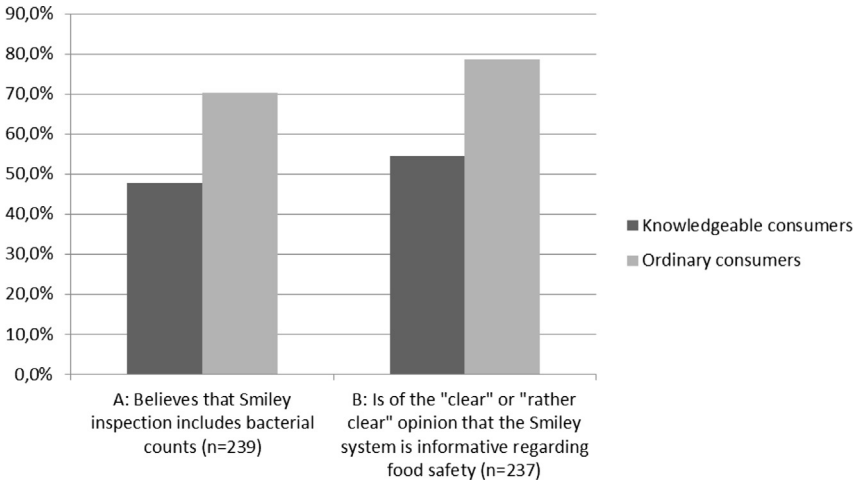

Fig. 1. Prevalence of belief in that inspection includes bacterial count and trust in that the Smiley system is informative – in percent among knowledgeable and ordinary consumers.

undergraduate students ($n = 44$) at the University of Copenhagen (see socio-demographic details in Table 2). Obviously, students cannot by regarded as representative of the entire population. However, a recent population-wide survey shows that students and the youngest age segment do not differ from the general population regarding awareness of and trust in the Smiley system (Anon, 2009b). The sample employed in this study does not deviate from this, 96% of which were aware of the Smiley system, suggesting that the student population surveyed here by and all resembles the wider Danish public.

Arguably the high school students and veterinary undergraduate students can be regarded as ordinary consumers, since they do not have special knowledge about food safety or the Danish food inspection system. The latter group does, however, follow a course in these topics immediately after the time for our survey. Later in their study, veterinary students have the possibility for specializing within the areas of food safety and food microbiology and will at that time subsequently acquire an in-depth knowledge on the subject. The food engineer undergraduate students can, on the other hand, be expected to have more detailed knowledge due to their initial interest in these topics although their first major course in food microbiology was scheduled immediately after this survey. The credibility of this assumption is backed up by data. A knowledge scale was constructed on basis of five questions posed to the respondents about the kinds of evaluations that are included in Smiley inspections (see note to Table 2 for details). The food engineers scored clearly and significantly higher (at the 0.05 significance level) than the veterinary students and high school students, also when controlling for age and gender differences (in an ordinal logistic regression – analysis not shown). Therefore, in the analysis that follows, the food engineer students are treated as a knowledgeable group, while the two latter groups are collapsed and treated as ordinary consumers.

3. Results and discussion

The average total aerobic bacterial counts and *E. coli* counts were similar to those obtained by others for fresh sushi products in Europe (Atanassova et al., 2008; Suppin, Rippel-Rachlé, & Smulders, 2007) (Table 1). Number of samples graded as microbiological unacceptable according to ANZFA (2001) and PHLS microbiological guidelines (2000), with a cut off value of 6 log cfu/g, were 31% for maki samples and 19%, for nigeri samples, respectively. These values were higher than found for Australian, American and Hong

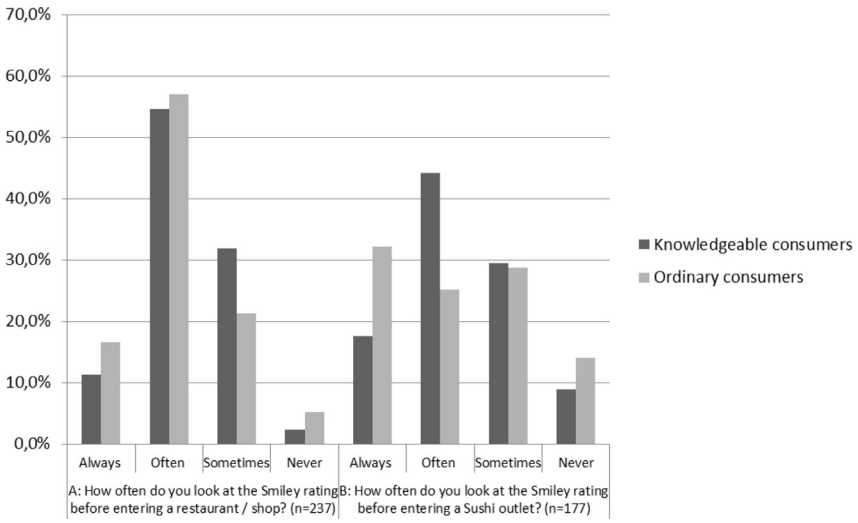

Fig. 2. Usage of Smiley ratings at restaurants in general and at Sushi restaurants/outlets – in percent among knowledgeable and ordinary consumers.

Kong screening studies (Adams et al., 1994; Anon, 2000, 2008, 2009a).

The average counts for positive samples of *Staphylococcus* spp. (Table 1) were similar to the results reported by Suppin et al. (2007) but substantial lower than reported by Atanassova et al. (2008). In the latter study frequencies of 100% for *Staphylococcus* spp. and average counts of 4.1 log CFU/g for freshly prepared Nigeri salmon and Maki salmon were observed.

It is clear that the variation in total microbial counts in the present study was not correlated with the smiley rankings; *i.e.* the evaluation by food inspectors of the shop's control programs and hygienic standards of the distinct outlets were not supported by the microbiological counts of the products. Too few results was obtained for the average *Staphylococcus* spp. counts to reach a conclusion whereas a higher frequency of samples positive for *E. coli* was observed for outlets including lower smiley rankings.

The smiley rankings in Table 1 represent between one and up to four evaluations by food inspectors within a half year before and a half year after our samplings. We also compared the counts with the last smiley ranking obtained for the shops before our samplings. These smiley evaluations were, however, with two exceptions all positive which indicates an even more pronounced lack of correlation between total counts and the score obtained by the food inspectors. Similarly, there was no correlation between *E. coli* and *Staphylococcus* spp. counts and smiley rankings. An explanation of these findings can to some degree be explained based on how the regulatory inspections are performed. Firstly, the number of visits during a given time period is subject to variation as described under Materials and Methods. This will result in that the duration of time between a particular microbiological sampling and smiley rankings given within half a year before or after the sampling will differ between shops. This will add to an overall poor correlation between counts and smiley rankings.

A second and less trivial explanation would be whether the topics of the regulatory inspection are necessarily the most relevant in regard to the microbial quality. Thus a total of 24 negative smiley evaluations (both within half a year before and after our samplings as well as one to three additional smiley rankings immediate outside this time period) for the shops included in this study were distributed as follows: Storage temperature abuse of sushi products or ingredients (8 cases; with on the spot temperature measurements of products ranging from 3.5 to 12.6 °C (Table S1)), violation of storage or heat treatment of other products than sushi (3 cases), poor hygiene on the shop premises (5 cases), unsatisfactory pH control of acidified rice ingredients (3 cases), poor documentation of shop based control (7 cases), unsatisfactory freezing for parasite control (3 cases), misleading naming of ingredients (3 cases), illegal import of ingredient (1 case) and lacking of public display of previous negative smiley rankings (3 cases). As one shop might on a specific occasion have more than one deviation leading to a negative smiley evaluation the total number of deviations adds up to 36. Of these deviations only storage temperature abuse of sushi products, pH control of rice and to some degree poor hygiene on premises – a total of 16 deviations – can be perceived to have an effect on the microbial quality of sushi products.

Thus, one of the general points of inspection by the food authorities include on the spot measurements of the temperature of incubators and/or the fish ingredient that constitute an important part of the final product. Temperature violations might on the other hand be expected since keeping sushi under refrigerated conditions affects the sensory quality of the product as the rice become crunchy and the ingredients lose their flavor (Anon., 2008). Even so, the majority of visits by the inspectors showed no violations of storage temperature. It can be deduced that the increased bacteriological counts in some samples from such shops are most likely not due to temperature abuse but instead to other conditions such as poor hygiene or initial microbial quality of the products. It is not clear whether prolonged storage at refrigeration temperature may be an issue, however, the loss of sensory quality as noted above indicates that this might not in general be the case. That poor hygiene can be a contributing factor is indicated by the findings of *E. coli* and *Staphylococcus* spp. in some samples, albeit in low numbers. Indeed an outbreak in U.S. with enterotoxigenic *E. coli* linked to sushi was deduced to be most likely due to poor food-handling and food hygienic practices (Jain et al., 2008). Finally, variation in microbial quality of raw materials might be an issue. It should be noted in this context that some of the maki products contained raw vegetables as an ingredient which might have added to the overall microbial count.

In conclusion it appears that regulatory control of sushi outlets is based more on temperature control and control of the pH of the rice ingredient than on two additional microbiologically important criteria, hygiene and, perhaps, initial quality. For this reason the resulting smiley ranking may not always give the public an accurate impression of the microbiological quality of sushi. This potential oversight is relevant to study further in agreement with the recommendations laid down by Feng (2012) regarding efforts to ensure sushi products of a satisfactorily safety and quality.

It is in this context of interest that the survey data showed a discrepancy between the practical evaluations done by inspectors and the knowledge of the Smiley scheme among ordinary consumers. Thus, 70.3% of the ordinary consumers (high school students and veterinary students), compared to 47.7% of the knowledgeable group (food engineer students), were of the opinion that an inspection includes microbiological testing (Fig. 1A) although this is very rarely or never the case. This should be seen in light of the circumstance that a substantial proportion of the ordinary consumers believed that the Smiley system is informative with respect to food safety (Fig. 1B) and that they read the Smiley rating "always" or "often" when going to a restaurant/shop (Fig. 2A). Also among the subgroup of consumers reporting that they purchase or eat food from a Sushi restaurant or outlet ($N = 177$) many responded that they "always" or "often" read the Smiley rating before entering the premises (Fig. 2B). These results points towards that the food authorities also need to evaluate whether the public has an appropriate understanding of the information that can be gathered from Smiley evaluations.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.foodcont.2014.04.017.

References

Adams, A. M., Leja, L. L., Jinneman, K., Beeh, J., Yuen, G. A., & Wekell, M. M. (1994). Anisakid parasites, *Staphylococcus aureus* and *Bacillus cereus* in sushi and sashimi from Seattle area restaurants. *Journal of Food Protection, 57*, 311–317.

Anon. (2000). *Sushi & sashimi in Hong Kong. Risk Assessment studies*. Report No. 2. HKSAR, P.R. China: Food and Environmental Hygiene Department.

Anon. (2006). Commission regulation (EC) No 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs. *Official Journal of the European Union*. L 338/1.

Anon. (2008). *Report on food handling practices and microbiological quality of sushi in Australia*. NSW Food Authority http://www.dh.sa.gov.au/pehs/Food/0901-Microbiological-quality-of-sushi.pdf Accessed 30.03.12.

Anon. (2009a). *Microbiological quality of sushi. Snapshot Survey on the Microbiological Quality of Sushi Sold in NSW*. http://www.foodauthority.nsw.gov.au/_Documents/science/sushi_survey_2009_report.pdf Accessed 30.03.12.

Anon. (2009b). *Fødevarestyrelsen. Effektmåling af smiley-ordningen. Forbrugere*. Online – uge 49 2008. Job nr. D27359 http://www.findsmiley.dk/NR/rdonlyres/05E0D71F-E588-4CD1-AC48-BE42116AC7CA/0/Smiley_analyse_tabeller_december_2008.pdf.

Anon. (2011). *Risk assessment of Vibrio parahaemolyticus in seafood*. World Health Organization. Food and Agricultural Organization of the United Nations.

ANZFA (Australia New Zealand Food Authority). (2001). *Guidelines for the microbiological examination of ready-to-eat foods*. http://www.foodstandards.gov.au/_srcfiles/Guidelines%20for%20Micro%20exam.pdf Accessed 30.03.12.

Atanassova, V., Reich, F., & Klein, G. (2008). Microbiological quality of sushi from sushi bars and retailers. *Journal of Food Protection, 71*, 860–864.

Feng, C. H.-I. (2012). The tale of sushi: history and regulations. *Comprehensive Reviews in Food Science and Food Safety, 11*, 205–220.

Jain, S., Chen, L., Dechet, A., Hertz, A. T., Brus, D. L., Hanley, K., & et al. (2008). An outbreak of enterotoxigenic *Escherichia coli* associated with sushi restaurants in Nevada, 2004. *Clinical Infectious Diseases, 47*, 1–7.

Jin, G. Z., & Leslie, P. (2003). The effect of information on product quality: evidence from restaurant hygiene grade cards. *The Quarterly Journal of Economics, 118*, 409–451.

Kjeldgaard, K. J., Stormly, M. L., & Leisner, J. J. (2010). Relation between microbial levels of ready-to-eat foods and the monitoring of compliance with HACCP-based own control programs in small Danish food outlets. *Food Control, 21*, 1453–1457.

Nielsen, A. (2006). Contesting competence – change in the Danish food safety system. *Appetite, 47*, 143–151.

NMKL No 184. (2006). *Aerobic count and specific spoilage organisms in fish and fish products*. P.O.Box 750, Sentrum, N-0106 Oslo, Norway: Nordic Committee on Food Analysis, c/o Norwegian Veterinary Institute.

PHLS (Public Health Laboratory Service). (2000). Guidelines for the microbiological quality of some ready-to-eat foods sampled at the point of sale. *Communicable Diseases and Public Health, 3*, 163–167.

Stürup, A., & Nielsen, C. E. (2009). *kommentarrapport. Onlineundersøgelse blandt forbrugere. Smiley-ordningens effekt 2008. Fødevarestyrelsen*. http://www.findsmiley.dk/NR/rdonlyres/CD40810D-68DB-470A-ACEE-2CE66712D182/0/Smiley_effektmaaling_forbrugere_2008.pdf.

Stürup, A., & Piper, N. (2007). *Kommentarrapport. Onlineundersøgelse blandt forbrugere. Smiley-ordningens effekt 2007. Fødevarestyrelsen*. http://www.findsmiley.dk/NR/rdonlyres/AA1C3D44-42E9-45F2-A4F0-1D23654F1BDC/0/2007_Rapport_smiley_effektmaaling_forbrugere.pdf.

Suppin, D., Rippel-Rachlé, B., & Smulders, F. J. M. (2007). Screening the microbiological condition of sushi from Viennese restaurants. *Wiener Tierärztliche Monatsschrift, 94*, 40–47.

Worsfold, D., & Worsfold, P. M. (2007). Evaluating food hygiene inspection schemes: "scores on doors" in the UK. *International Journal of Consumer Studies, 31*, 582–588.