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Microbiological and Sensory Quality Changes in Cabbage Casserole and Mixed Vegetable Salad with Mayonnaise during Storage

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ABSTRACT

The microbiological and sensory quality of cabbage casserole and mixed vegetable salad with mayonnaise was assessed after production, on the sell-by date and 7 d later. Samples were taken directly from five different plants, stored at 4°C and analyzed by three different laboratories. Sell-by periods were 8 to 14 d after the day of production. No *Bacillus cereus, Clostridium perfringens, Staphylococcus aureus* (salad), fecal streptococci or coliforms (casserole) were detected. Casseroles had median aerobic plate counts (APC) of 1.5×10^2, 3.3×10^2 and 4.5×10^3 cfu/g on different analysis times. Yeasts were detected in some casseroles on the sell-by dates. A few more had yeasts and/or molds a week later. Taste, odor, consistency and appearance scores showed a steady decrease during storage. Nine casseroles were deemed unfit for human consumption 7 d after the sell-by dates. Main defects were sliminess and acid, fermented taste and visible mold spots. Salads had a median APC of 5.2×10^3 cfu/g after production, which remained constant during storage. Salads from all companies contained lactobacilli and counts increased slightly during storage. Molds were encountered in samples of only one company and yeasts primarily of another. Median sensory scores decreased slightly during storage. One salad was deemed unfit on the sell-by date and six a week later. Main defects were musty and/or fermented taste and odor and watery consistency. Linear regression equations between taste and $\log_{10}$ microbial counts showed very low or no correlation. Also, the counts of sensorially unfit samples varied from low to high.

Casseroles and salads are common articles in Finnish meals. In 1981, consumption of commercial products was 12.0 and 4.5 million kg, respectively, *(2)* corresponding to annual per capita consumption of 2.5 and 0.9 kg. Liver casserole comprises about 50% of casserole trade. The second position is held by cabbage casserole with a total consumption of 2.1 million kg in 1981. In common commercial production, chopped cabbage and ground beef are cooked in bouillon in a pan. Precooked rice and spices are added. The mixture is divided into retail or catering units, placed in aluminum containers and fully cooked for 2 h in an oven at 170°C. The product is cooled by air flow to room temperature and covered. Final pH of the product is 5.5-5.9 and water activity (a_w) is 0.98. Recommended practice is to steam the casserole for 15 min in a water bath before serving. However, the product frequently is eaten without any further heating.

Mixed vegetable salad with mayonnaise comprises 40% of the salad trade in Finland. The salad is made of cubed pieces of ham (or cooked sausage), cooked potatoes, cooked carrots, cucumbers, pickles as well as peas, mayonnaise and some spices. Vinegar is added to adjust the pH to 4.5-4.9. Water activity is 0.98. The product is eaten without any heat treatment.

According to Finnish public health legislation, foods with a pH value above 4.5 and a_w above 0.88 are classified as perishable *(17)*. These foods must be stored under refrigeration or frozen. They must also carry a label indicating sell-by date and giving storage instructions. In recent years, regulatory agencies have shown intensified interest in quality and shelf-life of perishable foods. One of the reasons is that these foods comprise a significant portion of the complaints on food quality forwarded to public authorities.

The purpose of this study was to assess the microbiological and sensory quality of commercial cabbage casserole and mixed vegetable salad with mayonnaise after production, on the sell-by date, and 7 d after the sell-by date. The results could then be related to evaluation of the appropriateness of the sell-by periods set by manufacturers. It was also of interest to try to correlate

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microbiological counts to sensory quality of samples, and compare the results between three different analyzing laboratories.

MATERIALS AND METHODS

Samples

Retail packages of both cabbage casserole and mixed vegetable salad with mayonnaise were collected from five different processing plants, comprising a total of six companies, later referred to as companies A through F, in November 1981 and March 1982, respectively. The market coverage of these companies was 75 to 80% for both foods. The samples were taken on one particular day from one production run at each factory and rapidly transported under refrigeration to the three analysis laboratories: the Department of Food Hygiene of the College of Veterinary Medicine (a university food research laboratory), the Food Research Laboratory of the Technical Research Centre of Finland (a governmental food research laboratory) and the Food and Milk Inspection Laboratory of the City of Helsinki (a municipal food laboratory), later referred to as laboratories 1, 2 and 3. Analyses, using methods previously agreed upon as well as sensory description and grading were carried out on 1 d after production, on the sell-by date indicated on the label, and 7 d after the sell-by date. Before analysis the samples were stored in the laboratories at 4°C, the temperature recommended on the product labels.

Retail packages for casseroles were aluminum containers with a plastic cover and for salads closed plastic containers. Each unit contained 400 g of food except salad from company D, which had 200 g. At each analysis time two sample units were tested separately for microbial content and then combined into a single sample for sensory analysis in each laboratory.

Microbiological methods

Subsamples of 10 g were homogenized with 90 ml of 0.1% peptone water. Homogenate and serial 10-fold dilutions were used for microbiological analyses described in Table 1. Arithmetic mean of the results of duplicate samples was given as the laboratory result.

pH measurement

Ten-g portions of each sample were mixed with an equal amount of distilled water and the pH was determined using a pH-meter.

Sensory evaluation

Sensory quality of samples was evaluated by trained judges using the scoring method *(1)* and instructions characterizing product defects. Relative importance of the different quality properties was taken into account in the scoring scales which ranged from 0 to 10 for taste, 0 to 4 for odor and consistency and 0 to 2 for appearance. A taste score of 5 points or less on an individual score sheet meant that the judge considered the sample unacceptable for human consumption. When low scores were given, the reason had to be explained. Laboratory scores were arithmetic means of points given by each judge. The number of judges was 4-5 in the municipal laboratory and 9-12 in the research laboratories. The laboratory deemed a sample unfit for human consumption if at least two judges had considered it unacceptable. Cabbage casserole was assessed after heating in steam, as recommended on the labels, and mixed vegetable salad with mayonnaise after adjustment to room temperature.

Statistical analysis

Scatter diagrams and linear regression equations were computed to evaluate possible correlation between taste scores and microbial counts.

Ranking test described by Youden *(25)* was used to statistically assess the differences in laboratory performance at $p < 0.05$, two-tail test. The results of parallel samples from different laboratories were ranked in order of magnitude. The highest microbial count or sensory score was assigned the value one and the lowest the value three. For a tie the ranking values were split. Ranking was not done when all laboratories reported

TABLE 1. *Microbiological methods for analyzing cabbage casserole and mixed vegetable salad with mayonnaise.*

Organism	Food	Medium	Reference
Aerobic Plate Count	Casserole & salad	Plate Count agar (Difco)	*11*
Lactobacilli	Salad	Rogosa SL agar (Orion Diagnostica, Espoo, Finland) Anaerobic incubation at 30°C	*21*
Coliforms	Casserole	Violet Red Bile agar (Difco)	*11*
Fecal streptococci	Casserole & salad	Slanetz-Bartley agar (Orion Diagnostica)	*19*
Bacillus cereus	Casserole	Blood agar (Orion Diagnostica)	*18*
	Salad	*Bacillus cereus* Selective agar according to Mossel (Merck) + 50 μg polymyxin B sulfate/ml (Borroughs Wellcome Co, London, England)	*16*
Clostridium perfringens	Salad	Sulfite Cycloserine agar (base medium: SFP agar, Difco)	*11*
Sulfite reducing clostridia	Casserole	Iron Sulfite agar tubes (Oxoid)	*20*
Staphylococcus aureus	Salad	Baird-Parker agar (Difco)	*11*
Yeasts & molds	Casserole & salad	Sabourand Dextrose agar (Difco) + 100 μg oxytetracycline/ml (Sigma)	*13*

TABLE 2. *Microbial counts (log_{10} cfu/g) in cabbage casserole one day after production (I), on the sell-by date (II) and seven days after the sell-by date (III).*

Organism/ analysis time	Company/sell-by period (d) A/12	B/9	C/14	D/9	F/10	Overall median
Aerobic Plate Count						
I	2.07(1.74-2.70)[a]	2.17(2.15-2.18)	2.59(1.85-3.30)	ND(ND)	2.85(2.62-3.18)	2.18
II	2.30(1.48-3.30)	2.25(1.95-2.59)	2.94(2.00-3.52)	1.74(ND-3.81)	2.92(2.52-3.48)	2.52
III	4.27(1.40-7.53)	2.98(2.18-4.34)	6.19(1.54-8.82)	3.02(2.04-3.65)	5.47(2.73-7.30)	3.65
Coliforms						
I-III	ND (ND)[b]	ND (ND)	ND (ND)	ND (ND)	ND (ND)	ND
Fecal streptococci						
I-III	ND (ND)	ND (ND)	ND (ND)	ND (ND)	ND (ND)	ND
Bacillus cereus						
I-III	ND (ND)	ND (ND)	ND (ND)	ND (ND)	ND (ND)	ND
Sulfite reducing clostridia						
I-III	ND (ND)	ND (ND)	ND (ND)	ND (ND)	ND (ND)	ND
Yeasts						
I	ND (ND)	ND (ND)	ND (ND)	ND (ND)	ND (ND)	ND
II	2.31 (ND-3.54)	3.02 (ND-5.67)	ND (ND)	2.83 (ND-5.08)	ND (ND-2.45)	ND
III	3.05 (ND-4.46)	ND (ND)	2.40 (ND-3.81)	4.52 (2.85-5.86)	2.49 (ND-3.20)	2.56
Molds						
I	ND (ND)	ND (ND)	ND (ND)	ND (ND)	ND (ND)	ND
II	ND (ND)	ND (ND)	ND (ND)	ND (ND)	ND (ND)	ND
III	2.03 (ND-2.70)	3.21 (ND-6.23)	ND (ND)	2.13 (ND-3.00)	ND (ND)	ND

[a]Geometric mean and range of the results of the three laboratories.
[b]ND = Not detected; assigned 0.5 × detection limit for calculation of mean.

nondetectable microbial levels. Individual ranks were summed, yielding a ranking score for each laboratory and test.

RESULTS

Microbiology

Results of microbiological analyses of cabbage casserole and mixed vegetable salad with mayonnaise are presented in Tables 2 and 3, respectively. No *B. cereus, C. perfringens* nor *S. aureus* could be detected in any of the samples. Likewise the counts for coliforms and fecal streptococci were negative.

Casserole. Casseroles had a low aerobic plate count (APC) 1 d after production and on the sell-by date. The values on 7 d after the sell-by period varied considerably. However, 5 of 15 samples had counts exceeding 10^6 colony forming units (cfu/g), indicating a distinct increase in APC following set sell-by time periods. Yeasts, at levels exceeding 10^3 cfu/g were detected in three and six casserole samples on the sell-by date and a week later, respectively. Molds were detected in only three samples analyzed after the indicated shelf lives.

Salad. Salads showed a median APC count of slightly less than 10^4 cfu/g 1 d after production. This remained constant during storage. Lactobacilli were initially encountered in low numbers, with an overall median of 72 cfu/g. These increased by about one log_{10} by the sell-by date and remained constant during the following week. Yeasts, at levels exceeding 10^3 cfu/g, were observed only in the products of company A. Two of three samples from this company had a yeast count of 10^5 cfu/g on the sell-by date, and similarly a week later. Low levels of molds were detected in salads of company B.

pH

Initial pH values in salads varied from 4.50 to 4.91. No changes in pH were observed during storage.

Sensory evaluation

Casserole. All cabbage casserole samples received good sensory scores 1 d after processing (Table 4). Products of company A were, however, characterized as raw and slightly watery. On the sell-by date almost all sensory attributes indicated decreased quality, as expected. None of the casserole samples was deemed unfit for human consumption. Main product defects were musty taste and odor for company A, stale taste and odor for companies B and C, and surface darkening for company D. A week after the sell-by periods, samples from all companies were deemed unfit for human consumption by at least one of the three laboratories. Main defects were sliminess and acid, fermented taste as well as visible mold spots. Next to taste, the reduced sensory quality of casseroles was best observed in appearance.

Salad. Salads produced by company A had a loose consistency and a slight off-odor immediately after processing. Other salads received good sensory scores (Table 5), although, with the exception of company B, were re-

TABLE 3. *Microbial counts (log_{10} cfu/g) and pH values in mixed vegetable salad with mayonnaise one day after production (I), on the sell-by date (II) and seven days after the sell-by date (III).*

Determination/ analysis time	Company/sell-by period (d) A/8	B/13	C/10	D/12	E/12	Overall median
Aerobic Plate Count						
I	3.81(3.66-3.96)[a]	3.57(3.48-3.62)	3.47(3.30-3.60)	4.15(3.92-4.38)	3.94(3.72-4.23)	3.72
II	4.46(4.20-4.87)	2.82(2.48-3.30)	3.22(2.95-3.45)	4.36(3.76-5.18)	4.05(3.85-4.30)	3.85
III	4.40(3.30-5.62)	2.87(2.76-3.00)	3.03(2.93-3.20)	4.10(3.73-4.41)	4.34(3.97-4.64)	3.73
Lactobacilli						
I	2.06(ND-3.15)	1.62(ND-2.30)	1.03(ND-1.70)	2.01(ND-3.04)	2.48(ND-3.38)	1.86
II	3.67(3.20-3.94)	2.01(1.60-2.30)	1.16(ND-1.48)	3.11(2.30-3.58)	3.53(3.40-3.64)	3.20
III	3.02(1.81-4.89)	2.07(1.78-2.28)	ND(ND-1.30)	3.59(2.28-4.41)	3.40(2.92-3.71)	2.28
Fecal streptococci						
I-III	ND (ND)[b]	ND (ND)	ND (ND)	ND (ND)	ND (ND)	ND
Bacillus cereus						
I-III	ND (ND)	ND (ND)	ND (ND)	ND (ND)	ND (ND)	ND
Clostridium perfringens						
I-III	ND (ND)	ND (ND)	ND (ND)	ND (ND)	ND (ND)	ND
Staphylococcus aureus						
I-III	ND (ND)	ND (ND)	ND (ND)	ND (ND)	ND (ND)	ND
Yeasts						
I	2.72(2.15-3.08)	ND (ND)	2.03(ND-2.70)	ND (ND)	ND (ND)	ND
II	4.60(2.82-5.56)	ND (ND)	ND (ND)	ND (ND)	ND (ND)	ND
III	4.68(2.76-5.70)	ND (ND)	ND (ND)	ND (ND-2.54)	ND (ND-2.30)	ND
Molds						
I	ND (ND)	2.86(2.75-2.93)	ND (ND)	ND (ND)	ND (ND)	ND
II	ND (ND)	2.41(2.40-2.45)	ND (ND)	ND (ND)	ND (ND)	ND
III	ND (ND)	ND (ND-2.15)	ND (ND)	ND (ND)	ND (ND)	ND
pH						
I	4.66(4.60-4.77)	4.57(4.50-4.70)	4.64(4.60-4.72)	4.54(4.50-4.60)	4.82(4.75-4.91)	4.60
II	4.70(4.60-4.80)	4.61(4.55-4.72)	4.63(4.60-4.70)	4.57(4.50-4.66)	4.88(4.75-4.98)	4.66
III	4.63(4.50-4.78)	4.57(4.50-4.72)	4.57(4.50-4.72)	4.57(4.50-4.72)	4.88(4.80-4.98)	4.60

[a]Geometric mean and range of the results of the three laboratories.
[b]ND = Not detected; assigned 0.5 × detection limit for calculation of mean.

ported to contain excessive vinegar. On the sell-by date the taste and odor scores dropped from the initial values, whereas the appearance and consistency scores remained practically unchanged. Samples of company A were rancid and were regarded unfit for human consumption by one of the laboratories. Products of companies B, C and D had slightly stale taste and odor and those of B also had moldy odor. Products of company E were superior to others in taste, with no specific defects.

A week after the sell-by periods a marked decrease in mean values of all sensory attributes was observed in salads. One laboratory deemed products of all companies unfit for human consumption. Salad of company A was also regarded unfit by another laboratory. Main defects reported were musty and/or fermented taste and odor as well as watery consistency. Besides the lowered quality in taste and odor the appearance of some salads was very repelling a week after the sell-by dates.

Shelf-life

The sell-by periods for casseroles were 9 to 14 days and for salads 8 to 13 days after the day of production.

Correlation between microbiological counts and sensory quality

Casserole. Scatter diagrams and estimated regression lines of taste scores (Y) of casseroles as a function of $\log_{10}$ APC (X_1) or $\log_{10}$ yeast count (X_2) are presented in Fig. 1. The regression equations were $Y = 8.12 - 0.30\ X_1$ between taste and $\log_{10}$ APC and $Y = 7.87 - 0.28\ X_2$ between taste and $\log_{10}$ yeast count. The coefficients of correlation, r^2 were 0.23 and 0.06, respectively. Excluding data points with non-detectable microbe levels, r^2 values decreased to 0.17 and 0.03, respectively. The microbial counts of casseroles deemed sensorially unfit for human consumption were widely spread.

Salad. Scatter diagrams and estimated regression lines of taste scores (Y) of salads as a function of $\log_{10}$ APC (X_1), $\log_{10}$ lactobacilli count (X_2) or $\log_{10}$ yeast count (X_3) are presented in Fig. 2. The regression equations were $Y = 8.57 - 0.27\ X_1$ between taste and $\log_{10}$ APC, $Y = 8.53 - 0.40\ X_2$ between taste and $\log_{10}$ lactobacilli count and $Y = 7.96 - 0.18\ X_3$ between taste and $\log_{10}$ yeast count. The r^2 values were 0.02, 0.12 and 0.02, respectively. r^2 values for data-points excluding

TABLE 4. *Sensory evaluation scores for cabbage casserole one day after production (I), on the sell-by date (II) and seven days after the sell-by date (III).*

Quality property	Company/sell-by period (days)					Overall median (total unfit)
	A/12	B/9	C/14	D/9	F/10	
Appearance (0-2)[a]						
I	1.5(1.3-1.7)[b]	1.7(1.7-1.8)	1.4(1.2-1.5)	1.6(1.5-1.8)	1.5(1.4-1.6)	1.5
II	1.2(1.0-1.4)	1.4(1.2-1.6)	1.3(1.2-1.5)	1.6(1.5-1.7)	1.1(1.1-1.2)	1.3
III	1.2(1.1-1.3)	1.3(1.2-1.4)	0.7(0.5-1.0)	1.4(1.3-1.6)	1.2(1.0-1.3)	1.2
Consistency (0-4)						
I	2.9(2.8-3.1)	3.3(3.0-3.5)	3.1(3.0-3.2)	3.4(3.0-3.7)	3.1(2.7-3.5)	3.1
II	2.6(2.2-3.0)	2.7(2.4-2.9)	2.7(2.6-2.9)	3.4(3.3-3.5)	2.9(2.8-3.0)	2.9
III	2.6(2.4-2.8)	2.7(2.4-3.0)	2.2(1.8-2.5)	3.2(2.9-3.4)	2.7(2.4-3.2)	2.6
Odor (0-4)						
I	3.3(2.9-3.6)	3.4(2.9-3.9)	3.5(3.4-3.7)	3.6(3.2-4.0)	3.6(3.4-3.8)	3.5
II	2.7(2.3-3.3)	3.0(2.5-3.3)	3.1(2.9-3.3)	3.6(3.5-3.8)	3.0(2.6-3.8)	3.2
III	2.3(1.8-2.8)	2.4(2.4-2.5)	2.2(0.8-3.3)	3.2(3.1-3.3)	3.0(2.7-3.3)	2.7
Taste (0-10)						
I	7.5(6.7-8.2)	8.3(7.4-9.2)	8.3(8.1-8.4)	8.3(7.5-8.8)	8.1(7.8-8.3)	8.2
II	6.5(6.2-6.7)	7.4(7.0-7.9)	7.2(7.0-7.5)	7.8(7.6-8.0)	7.2(6.1-8.5)	7.2
III	5.9(5.0-6.6)	6.4(6.1-6.6)	5.2(1.7-7.6)	7.5(7.3-7.7)	7.0(6.3-8.3)	6.4
Unfit for human consumption[c]						
I	0[d]	0	0	0	0	(0)
II	0	0	0	0	0	(0)
III	2	3	2	1	1	(9)

[a]Scales used in scoring: 0 = minimum, maximum = 2, 4 or 10.
[b]Mean and the range of scores given by the three laboratories.
[c]See Materials and Methods for definition.
[d]Number of laboratories deeming sample unfit.

TABLE 5. *Sensory evaluation scores for mixed vegetable salad with mayonnaise one day after production (I), on the sell-by date (II) and seven days after the sell-by date (III).*

Quality property	Company/sell-by period (d)					Overall median (total unfit)
	A/8	B/13	C/10	D/12	E/12	
Appearance (0-2)[a]						
I	1.5(1.5-1.6)[b]	1.8(1.6-1.9)	1.8(1.7-2.0)	1.5(1.1-1.9)	1.8(1.7-1.9)	1.7
II	1.5(1.3-1.6)	1.8(1.7-1.8)	1.8(1.7-2.0)	1.4(1.2-1.5)	1.8(1.7-1.9)	1.7
III	1.2(1.0-1.4)	1.4(0.9-1.6)	1.6(1.3-1.7)	1.0(0.7-1.3)	1.5(1.4-1.8)	1.4
Consistency (0-4)						
I	3.2(3.2-3.2)	3.6(3.3-4.0)	3.6(3.2-4.0)	3.1(2.6-3.7)	3.7(3.5-3.9)	3.4
II	3.1(2.6-3.8)	3.5(3.4-3.7)	3.5(3.1-4.0)	3.0(2.8-3.2)	3.3(3.0-3.6)	3.3
III	2.7(2.4-2.9)	2.9(2.2-3.4)	3.1(2.4-3.7)	2.6(2.3-3.0)	3.2(3.0-3.3)	3.0
Odor (0-4)						
I	3.3(3.1-3.5)	3.7(3.4-4.0)	3.7(3.4-3.9)	3.4(3.1-3.5)	3.8(3.5-4.0)	3.5
II	2.9(2.7-3.2)	3.5(3.2-3.8)	3.4(3.2-3.8)	3.6(3.4-3.8)	3.6(3.3-3.9)	3.4
III	2.7(2.0-3.5)	3.0(2.4-3.6)	2.9(2.1-3.7)	3.0(2.5-3.5)	3.2(2.8-3.4)	3.0
Taste (0-10)						
I	7.1(6.6-7.6)	8.5(7.6-9.8)	8.5(7.7-9.6)	8.2(7.7-9.1)	8.6(7.9-9.6)	7.9
II	6.8(5.3-8.8)	7.8(6.9-8.9)	7.8(7.3-8.6)	7.8(7.3-8.2)	8.4(7.6-9.8)	7.7
III	5.9(3.9-7.6)	7.0(5.2-8.7)	6.6(3.8-8.5)	6.7(4.3-8.1)	7.6(6.1-8.6)	7.6
Unfit for human consumption[c]						
I	0[d]	0	0	0	0	(0)
II	1	0	0	0	0	(1)
III	2	1	1	1	1	(6)

[a]Scales used in scoring: 0 = minimum, maximum = 2, 4 or 10.
[b]Mean and the range of scores given by the three laboratories.
[c]See Materials and Methods for definition.
[d]Number of laboratories deeming sample unfit.

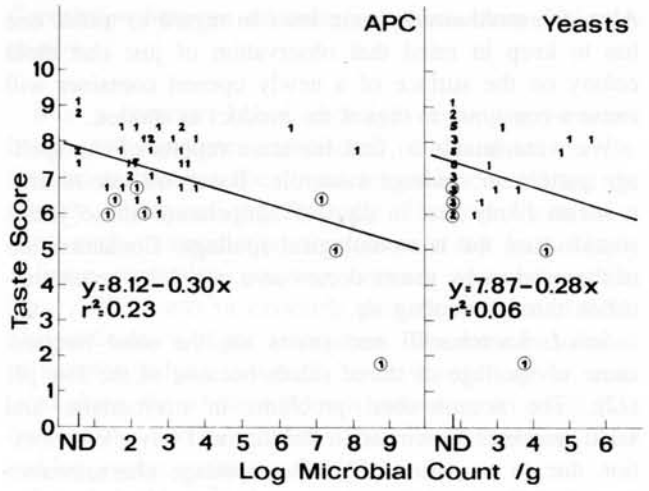

Figure 1. *Scatter diagrams and estimated regression lines between taste scores and log_{10} APC as well as log_{10} yeast counts in cabbage casserole stored at 4°C. Circled data points indicate samples deemed sensorially unfit for human consumption.*

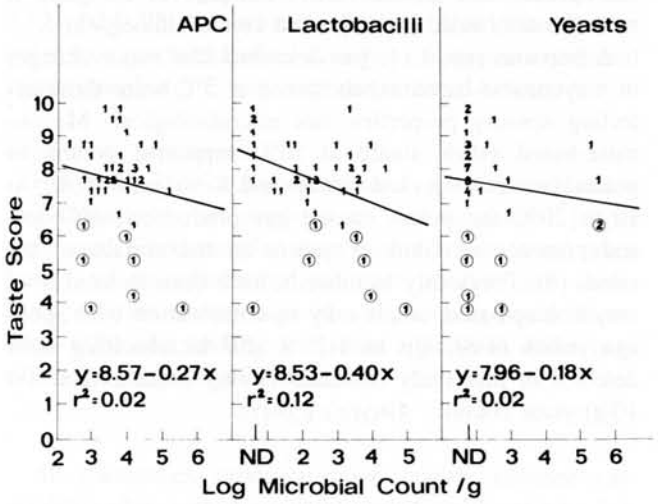

Figure 2. *Scatter diagrams and estimated regression lines between taste scores and log_{10} APC, log_{10} lactobacilli as well as log_{10} yeast counts in mixed vegetable salad with mayonnaise stored at 4°C. Circled data points indicate samples deemed sensorially unfit for human consumption.*

nondetectable microbial levels were 0.02, 0.08 and 0.08, respectively. The microbial counts of salads deemed sensorially unfit for human consumption were widely spread.

Comparison of laboratory performances

Ranking test procedure indicated that laboratory 3 had a tendency to report extreme values for samples analyzed (Tables 6 and 7). This was statistically significant in four of five microbiological tests and in five of eight sensory tests. Unexplainably, this laboratory tended to have the highest APC values for casserole but the lowest for salad. Furthermore, this laboratory reported consistently higher scores than the two other laboratories with regard to taste, odor and consistency. Laboratory 1 reported significantly lower odor scores for both the casserole and salad. Laboratory 2 was strictest in deeming the highest number of samples unfit for human consumption.

TABLE 6. *Comparison of laboratory performances in regard to microbiological determinations by the ranking test.*

Food/ determination	Laboratory/ranking scores[a] 1	2	3	No. of analyses included[b]
Casserole				
APC	36	33.5	20.5*	15
Yeasts	14.5	21.5	12	8
Salad				
APC	23.5	26.5	40*	15
Lacto-bacilli	24	27.5	38.5*	15
Yeasts	12.5	16.5	7*	6

[a]Low score indicates tendency to report high counts and high score low counts.
[b]Only results indicating detectable microbe levels in at least one laboratory were included; maximum 15.
* Significantly different at $p < 0.05$.

TABLE 7. *Comparison of laboratory performances in sensory evaluation by the ranking test.*

Food/ sensory quality	Laboratory/ranking scores[a] 1	2	3
Casserole			
Taste	31.5	31.5	15*
Odor	34*	28	16*
Consistency	32.5	25.5	20
Appearance	27.5	22	28.5
Salad			
Taste	36	39*	15*
Odor	38*	35.5	16.5*
Consistency	36	35	19*
Appearance	32	32.5	25.5

[a]Low score indicates tendency to report high sensory scores and vice versa; 13 casserole and 15 salad analyses were included.
* Significantly different at $p < 0.05$.

DISCUSSION

Microbiological quality

Casserole. Cabbage casseroles showed good microbiological quality during their sell-by period and even a week later. Only a few samples had excessive APC or yeast counts, indicating microbiological spoilage. No pathogens or indicator organisms tested for were detected, evidently due to the heat treatment the product undergoes during processing and the following refrigerated storage. A preliminary study of several different casserole dishes purchased from retail outlets in Finland in 1981 indicated high APC levels in 2 of 22 samples (National Board of Trade and Consumer Interests, unpublished data).

Salad. Mixed vegetable salad with mayonnaise also showed excellent microbiological quality except for the yeast or mold occurrence in products of company A and B, respectively. In other investigations of microbial flora of commercially prepared salads, low counts generally

have been reported when low pH has been encountered due to salad dressing, mayonnaise or vinegar *(5,7,10,23)*. Bacterial pathogens or fecal streptococci were not detected in the present study. Besides processing conditions in the plants this is due to the low pH and inhibitory or bactericidal effect of acetic acid present in the product and low storage temperature.

Sensory quality

Casserole. Casseroles kept their sensory attributes satisfactorily to the end of their sell-by period. Not a single sample was judged unfit for human consumption until shelf-life was exceeded. Sliminess and acid, fermented taste as well as visible mold spots were reasons for judging 9 (at least one sample of each company) of 15 samples unfit 7 d after the sell-by date.

Salad. Generally, salads maintained a high sensory quality. Median taste values were 7.7 and 7.6 on the sell-by dates and a week later, respectively. However one sample was judged unfit for human consumption on its sell-by date due to fermented odor and rancid taste. A week later 6 (at least one sample of each company) of 15 samples had such a musty and/or fermented taste and odor and watery consistency that they were considered unacceptable.

Shelf-life

Sell-by periods were 9 to 14 d for casseroles and 8 to 13 d for salads. These seemed to be validly set for all except one salad sample, where raw materials of inferior quality may have been used. However, before taking a final stand on the appropriateness of the set shelf-life, one has to know the amount of temperature abuse and fluctuation which is likely to happen during transport and retail outlet storage, and to consider the effect of these on the quality and shelf-life of the product. The labelled storage temperatures for casseroles and salads were 4°C, 2-6°C and less than 6°C. In our study, the products were stored at constant 4°C.

Six to 14 days sell-by periods at 1 - 5°C have been reported to be the commercial practice for mayonnaise-based salads in the United Kingdom *(4)*. On the other hand, up to 4 month shelf lives are used in Sweden for mayonnaise-based salads *(24)*. This is based on the use of the preservatives benzoic acid and sorbic acid and sometimes esters of p-hydroxy-benzoic acid. The conclusion of the Swedish study was that these labelled shelf lives were far too long even in cases where more than the permitted level of preservatives had been used. Moreover, the beneficial use of benzoic acid in low pH salads is questionable since, e.g., at pH 4.6 only 16% of the compound is in the undissociated, effective form.

Spoilage

Casserole. Observed defects of cabbage casserole samples described by the judges were due to yeast and mold spoilage. However, only two samples had a yeast count close to 10^6/g, the level usually considered to be associated with sensory spoilage of foods by yeasts *(14)*. Also, the mold counts were low. In regard to molds one has to keep in mind that observation of just one mold colony on the surface of a newly opened container will cause a consumer to regard the product as spoiled.

We were unable to find literature reports of the spoilage pattern in cabbage casserole. Based on our results, it seems likely that in case of temperature abuse yeasts would cause the microbiological spoilage. Contamination of the product by yeasts occurs as a post-bake recontamination through cooling air.

Salad. Lactobacilli and yeasts are the most frequent cause of spoilage of stored salads because of the low pH *(12)*. The nonmicrobial problems in mayonnaise and salad dressings are emulsion stability and flavor deterioration due to oxidation *(22)*. The spoilage characteristics described by the judges to mixed vegetable salad with mayonnaise refer to fermentation by yeasts and/or lactobacilli and, in the case of company B, to mold growth. Yeast numbers exceeded 10^5/g in two samples on the sell-by date and a week later. Samples of company B were the only salads having mold count, although low.

A previous report *(4)* has described that major changes in mayonnaise-based salads stored at 5°C were those affecting sensory properties, not microbiological. Mayonnaise-based salads stored at 10°C supported growth of yeasts *Saccharomyces dairensis* and *S. exiguus (4,8)*. At 10 to 20°C the yeasts caused gas production, off-odors and presence of films of yeasts on the surface of the salads *(8)*. Previously lactobacilli have been isolated from mayonnaise-based salads only in combination with spoilage yeasts *(4,8)*. Up to 1.2×10^4 lactobacilli/g were detected in this study in salads having nondetectable (< 10/g) yeast counts.

Risk of growth of pathogenic microorganisms

Casserole. In cabbage casserole, the nonsporeforming microbial pathogens are destroyed by heat treatment during processing. Good manufacturing practice, rapid cooling and low storage temperature will prevent germination of spores and multiplication of other possible pathogens introduced by post-process contamination. In case of moderate temperature abuse, spoilage by yeasts will most likely precede growth of any pathogens to the food poisoning level.

Salad. Smittle (*22*) concludes in his literature review of microbiology of mayonnaise and salad dressings: In terms of public hazard, a meat and vegetable salad with a pH of 5.3 or less appears to be safe, providing the acidulant is acetic acid, is mixed uniformly into the product, and is refrigerated at 7.2°C or below. However, in the case of temperature abuse above 20°C for several hours *Salmonella typhimurium* and *Staphylococcus aureus* have been shown to be capable of multiplying and the latter organism to be capable of producing enterotoxin *(9,15)*.

Correlation between microbiological counts and sensory quality

It is a common belief, especially among government bodies and consumer associations, that a direct correlation exists between the "total microbial count" and the sensory quality of the food *(3)*. However, with most foods such an association does not exist *(6)*. In this study a linear regression equation between taste scores and $\log_{10}$ APC counts in casserole gave an r^2 value of 0.23. This indicates a slight association. The microbial counts of samples judged sensorially unfit were, however, scattered along the whole APC axis indicating no correlation between the two parameters. The r^2 value between taste and $\log_{10}$ yeast count was 0.06.

In salads, the r^2 between taste scores and $\log_{10}$ APC count was 0.02, indicating lack of direct correlation. This was supported by wide scattering of APC numbers of sensorially unacceptable samples. The r^2 values between taste score and $\log_{10}$ lactobacilli or $\log_{10}$ yeast count were 0.12 and 0.02, respectively. Sensory deterioration without major microbiological changes of mayonnaise-based salads stored at 5°C also has been reported before *(4)*.

Laboratory comparison

Harmonized microbiological and sensory evaluation and characterization methods as well as trained judges were used. Food samples from each company were taken from one manufacturing run and divided into three. Transportation and storage of samples was equal. However, using the ranking test some significant differences among laboratories were detected.

CONCLUSIONS

All companies produced good quality cabbage casseroles and/or mixed vegetable salads with mayonnaise. The reason for one poor quality salad batch might have been the use of some raw materials of inferior quality. The microbiological and sensory attributes remained good or satisfactory to the stated sell-by dates. Even a week later many of the samples were regarded acceptable for human consumption. Major changes in casserole and salad stored at 4°C were those affecting sensory quality. The sell-by periods of 9 to 14 d for casserole and 8 to 13 d for salad seemed appropriate when products were stored at 4°C. Storing both casseroles and salads at refrigeration temperature is essential to prevent or retard microbiological spoilage of the products and to prevent the risk of multiplication and toxin production of possible food poisoning bacteria in them. Linear regression equations between taste and $\log_{10}$ microbial counts showed very low or no correlation.

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