

2016-12

Microbiological quality of ready-to-eat fresh vegetables and their link to food safety environment and handling practices in restaurants

Faour-Klingbeil, D

<http://hdl.handle.net/10026.1/5125>

10.1016/j.lwt.2016.07.051

LWT - Food Science and Technology

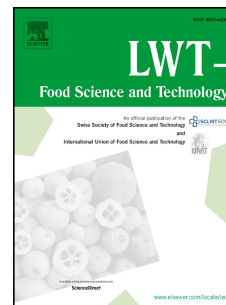
Elsevier Ltd.

All content in PEARL is protected by copyright law. Author manuscripts are made available in accordance with publisher policies. Please cite only the published version using the details provided on the item record or document. In the absence of an open licence (e.g. Creative Commons), permissions for further reuse of content should be sought from the publisher or author.

Accepted Manuscript

Microbiological quality of ready-to-eat fresh vegetables and their link to food safety environment and handling practices in restaurants

Dima Faour-Klingbeil, Ewen C.D. Todd, Victor Kuri



PII: S0023-6438(16)30462-5

DOI: [10.1016/j.lwt.2016.07.051](https://doi.org/10.1016/j.lwt.2016.07.051)

Reference: YFSTL 5625

To appear in: *LWT - Food Science and Technology*

Received Date: 4 May 2016

Revised Date: 18 July 2016

Accepted Date: 21 July 2016

Please cite this article as: Faour-Klingbeil, D., Todd, E.C.D., Kuri, V., Microbiological quality of ready-to-eat fresh vegetables and their link to food safety environment and handling practices in restaurants, *LWT - Food Science and Technology* (2016), doi: 10.1016/j.lwt.2016.07.051.

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

© 2016. This manuscript version is made available under the CC-BY-NC-ND 4.0 license

<http://creativecommons.org/licenses/by-nc-nd/4.0/>

Contact at University of Plymouth:
v.kuri@plymouth.ac.uk

Microbiological quality of ready-to-eat fresh vegetables and their link to food safety environment and handling practices in restaurants

Dima Faour-Klingbeil^{a*}, Ewen C. D. Todd^b, Victor Kuri^a

^aSchool of Biological Sciences, Plymouth University, UK

^bVisiting Professor, Department of Nutrition and Food Science, American University of Beirut, Lebanon, and Ewen Todd Consulting, Okemos, Michigan, USA

*Correspondence author: dima.faour@gmail.com

ABSTRACT

1 The increased consumption of ready-to-eat salads outside homes as a result of a fast
2 paced lifestyle, awareness on their nutritional attributes and enhanced processing
3 technology is well documented. This study aimed to determine the microbiological
4 quality of fresh-cut salads vegetables in small and medium sized foodservice
5 establishments (SMEs) and to identify risk factors and handling practices through
6 observational assessment in order to investigate if an association between
7 microbiological quality and visual assessment (inspection) scores can be established.
8 A total of 118 samples fresh-cut vegetable salads were collected from 50 inspected
9 locations and analysed microbiologically, in addition to 49 swabs of knives and cutting
10 boards. There was no statistically significant correlation between visual assessment
11 scores and bacteriological counts on vegetables or cutting boards. Nonetheless, the
12 consistent relationship between inspection ratings on cross-contamination and cleaning
13 components and *Listeria* spp. levels was statistically significant. This study
14 demonstrated that overall visual assessment scores would not directly reflect the safety
15 of salad vegetables and that the significance of microbiological assessment should be
16 considered in relation to individual inspection components. It is necessary to place

17 effective control measures on cleaning standards and risk of cross-contamination to
18 improve the microbiological safety of fresh salad vegetables in SMEs.

19

20 **1. INTRODUCTION**

21 Fresh vegetables are rich sources of water-soluble vitamins and other nutrients
22 essentials to improve the nutritional status and decrease the risk of cardiovascular
23 disease (Su & Arab, 2006). However, when they are not carefully prepared, they can be
24 subjected to pathogenic contamination and become hazardous to health particularly
25 when eaten raw (WHO, 2008).

26 Outbreak investigations often indicate that food service establishments (FSE) greatly
27 contribute to foodborne illnesses involving fresh produce (Jones & Angulo, 2006;
28 Sodha et al., 2011). Multiple studies revealed that food workers were frequently
29 engaged in unsafe food handling (Clayton & Griffith, 2004; Manning, 1994; Rajagopal
30 & Strohbehn, 2013; Sneed, Strohbehn, & Gilmore, 2004) and that microbial
31 contamination of ready-to-eat (RTE) foods typically occurred in FSEs with food
32 handlers as asymptomatic carriers of pathogenic microorganisms or with poor personal
33 hygiene being involved (McEvoy et al., 2004; Todd et al., 2008). Equipment or surfaces
34 that have not been effectively cleaned or remained wet between cleaning and use also
35 serve as direct routes for contamination of ready to eat foods (Evans et al., 2004; Gill et
36 al., 2001), besides inappropriate storage temperatures, and insufficient cooking (Jones
37 et al., 2008; WHO, 2007).

38 Less information is available on the relative health risks attributed to handling practices
39 and preparation procedures of raw salad vegetables in SMEs, while other RTE foods
40 and meats have attracted more attention.

41 Inspection tools are essential for capturing information on the general hygiene standards
42 and food handlers' practices Although private or local authorities' inspections are an

43 effective mechanism to assure compliance to food safety standards, there is no a clear
44 indication of a correlation between risk of foodborne illnesses and inspection scores.
45 There have been many cases when restaurants scored high on inspections and were still
46 having critical violation in food safety(Jones et al., 2004). The significance of
47 association of microbiological quality of RTE vegetables to hygiene inspection scores
48 has not been fully investigated and not sufficiently addressed by researchers. Earlier
49 attempts to establish direct relationship between the results on microbiological analysis
50 of food and visual inspections have not been successful and were mostly based on foods
51 of animal origins(Powell & Attwell, 1995; Tebbutt & Southwell, 1989; Wyatt & Guy,
52 1980).

53 This study aimed at conducting observational assessment of the fresh produce handling
54 processes from the receiving stage until display and service to identify risk factors that
55 may be associated with the microbial safety of fresh produce in SMEs which will
56 provide further insights to devise effective preventive measures.

57

58 **2. MATERIAL AND METHODS**

59 **2.1 Observational survey**

60 A convenience sample of fifty SMEs located in Beirut were observationally assessed for
61 hygiene standards and handling practices of food handlers during the salad vegetable
62 preparation. The survey checklist comprised 6 constructs of 2-7 components for analysis
63 in which the good hygienic practices (GHP) and other prerequisites proposed by the
64 Codex Alimentarius (CAC/RCP 1, 1969) were considered for the visual assessment
65 (Table 1). Additional components in relation to salad preparation practices were also
66 included. The criteria for each component were defined to specify limits for
67 classification. (Supplementary materials).

68 A reliability analysis test was performed to measure the internal consistency in the
69 survey questionnaire. Cronbach's Alpha was 0.928 which indicates a high level of
70 internal consistency for our scale.

71 **2.2 Additional information**

72 Additional 8 questions on handling practices of fresh vegetables during receiving,
73 washing and storage were posed to food handlers (n=80) via face-to-face interviews that
74 were conducted in our earlier study on food safety knowledge, attitudes and practices
75 (Faour-Klingbeil et al., 2015). The questions were ranked on a five points rating scale
76 (never = 1, rarely = 2, sometime = 3, often = 4 and always =5).

77 To ensure consistency and unbiased data records, the data collection and visual
78 assessment were carried out by one of the authors (Dima Faour-Klingbeil).

79

80 **2.3 Collection of RTE fresh-cut salads vegetables samples**

81 **2.3.1 Management of samples**

82 A total of 118 samples of various fresh cut RTE salad vegetables (lettuce, parsley,
83 arugula, coriander, cucumber, tomato and radish) prepared in 50 restaurants were
84 collected after washing and cutting/chopping. On average, 3 types of vegetables were
85 sampled from each restaurant, being subjected to availability and preparation plans at
86 times of visits. They were placed in a sterile bag by food handlers at the end of the
87 preparation process by means of utensils or tools typically used when bringing them
88 into display or storage containers, taking care that they would not touch the inside of the
89 bags.

90 **2.3.2 Swabs of cutting boards and knives**

91 Before cutting/chopping vegetables, surfaces of cleaned cutting boards and knives
92 (normally cleaned by assigned cleaners in well-established restaurants, or food workers

93 in less developed restaurants) were swabbed by moistened cotton-tip in buffered
94 peptone water (BPW) (Bio-rad laboratories Ltd, Hemel Hempstead, UK) in three
95 different directions: left to right, top to bottom, and diagonal over a 50 cm² area for
96 cutting boards and a length of ca. 10cm on knives. The swabs were placed in tubes of 5
97 ml buffered peptone water for subsequent analysis.

98

99 **2.3.3 Microbiological analysis of samples**

100 Samples of salad vegetables were analysed for the presence of pathogens and hygiene
101 indicators organisms commonly isolated from RTE fresh vegetables, i.e., *S. aureus*,
102 *Salmonella* spp., *Listeria* spp., *L. monocytogenes*, in addition to total viable counts
103 (APC), *E. coli* and TCs (Nguz et al., 2005; Sagoo et al., 2001). For microbiological
104 analysis, all the media used were obtained from Bio-Rad Laboratories Ltd., Hemel
105 Hempstead, UK unless otherwise mentioned and samples were analysed according to
106 ISO 16140. Briefly, 10 g of the samples was weighed into sterile stomacher bags and
107 homogenized with 90 ml sterile peptone buffered water (BPW) for 2 min at medium
108 speed. Aliquots of 0.1 ml of appropriate dilutions were spread in duplicates on suitable
109 media. APC were enumerated on plate-count agar, as for *E. coli* and TC, 1 ml was
110 dispensed into petri dishes for enumeration by pouring technique using RAPID'*E. coli* 2
111 agar. The plates were incubated at 37°C for 48 h. *Coagulase-positive Staphylococci*
112 were enumerated on RAPID'*Staph* Agar supplemented with egg yolk. For the detection
113 of *S. aureus*, typical presumptive colonies with clear halo resulting from proteolysis of
114 egg yolk were further tested using a latex agglutination test (Pastorex *Staph* Plus). For
115 the isolation of *Salmonella* spp., selective enrichment was performed in Rappaport-
116 Vassiliadis-soya broth to be incubated at 41.5°C. After 24 h of incubation, a 0.1 ml
117 sample was plated on RAPID'*Salmonella* agar and plates were incubated at 37°C for

118 24h (\pm 2h). While for *L. monocytogenes*, Fraser ½ broth was used in the selective
119 enrichment and after incubation for 1 h at 20°C, 0.1 ml of the homogenate was
120 transferred onto RAPID'*L. monocytogenes* agar plates to be incubated at 37°C for 24–
121 48h. *Listeria* spp. were enumerated and typical *L. monocytogenes* colonies were
122 afterwards selectively identified and by *Listeria* strips (bioMérieux, Marcy l'Etoile,
123 France). *Salmonella* spp. colonies were identified biochemically by the lysine iron agar
124 and tryptic sugar iron agar slants biotyping technique. Additional confirmation for
125 positive *Salmonella* spp. colonies and for *E. coli* was done by the API 20E bacterial
126 identification test strip.

127 The counts were reported as means of colony-forming units (CFU) per g and were
128 converted into Log CFU/g.

129 Additionally, for statistical purposes, *Listeria* spp were ranked into 3 levels (Above 100
130 CFU/g, Below 100 CFU/g, and Not detected).

131 **2.3.4 Swab tests**

132 The swabs in 5 ml tube of BPW were vortexed vigorously for 1 min. Tenfold serial
133 dilutions were spread-plated onto duplicate plates of PCA, RAPID'*Staph* agar
134 supplemented with egg yolk and RAPID'*E. coli* 2 agar.(Sneed, Strohbahn, Gilmore, et
135 al., 2004). Counts were expressed as log CFU/swabbed area.

136

137 **3. DATA HANDLING AND STATISTICAL ANALYSIS**

138 All data were analysed using the IBM SPSS Statistics (SPSS) version 22.

139 Observational assessment of each of the 26 components was rated on three units scale
140 (adequate=3, incomplete=2, inadequate=1). The sum of the total awarded units on
141 adequacy level (visual assessment scores) was converted to 100 points.

142 Frequency of levels in compliance (adequacy level) for each visually inspected
143 component was obtained. Bacterial levels differences among different compliance levels
144 were compared using One-way ANOVA, and independent t-test was performed to
145 compare results between two groups.

146 The association between bacterial counts and overall visual assessment scores was
147 assessed by Pearson correlation and multiple linear regression analysis; binomial
148 regression was performed for *S. aureus*.

149 The percentage variances in bacterial counts (Log CFU/g) explained by individual
150 inspection components were determined by correlation ratio ETA^2 (η^2 ratio). In the case
151 *Listeria* and *S. aureus*, Spearman's rho and cross-tabulations Somer'd tests were also
152 applied.

153

154 **4. RESULTS**

155 **4.1 Overall results on food handlers 'practices and hygiene conditions on premises**

156 Results of the visual inspections of FSEs and food handlers' practices during the
157 preparation of fresh salads vegetables indicated structural inadequacies and insufficient
158 fulfilment of hygiene prerequisites with a mean score on overall adequacy level of 55.5
159 \pm 19.0 over 100 possible points (Figure 1), with the majority of locations being below
160 scores of 50-70. Over half (54%) of the food premises failed to fulfil the basic hygienic
161 requirements for clean floors, equipment and food contact surfaces, while a third had
162 limitations in the structural conditions (Figure 2). Recorded incompliances included
163 open drains, gaps and holes on windows and walls and evidence of pests (cockroaches)
164 at the time of the survey. Furthermore, 22% had not a completely well maintained
165 premise. More than a half (52%) of the FSEs had space limitations compromising the
166 preparation of food safely, whereas only 22% of premises had taken measures to

167 separate areas for the preparation of raw meats and RTE foods. It was notable that the
168 inappropriate sanitation measures were not applied in 60% of the premises (Figure 2).
169 Only 8% of FSEs had cleaning schedules, and showed evidence of temperature
170 monitoring records of salads display and cold storage.

171 In addition, a large percentage of food businesses (64%) lacked hand washing sinks; or
172 designated sinks for washing fresh fruits and vegetables were either absent (32%) or if
173 fitted, it was not clean and used for others purposes such as washing hands or
174 implements used with raw meat and cooked foods (40%). More concerning, gloves were
175 used correctly and appropriately during the salad preparation in just a fifth (20%) of the
176 premises.

177 Risks of cross-contamination were detected in 48% of the premises, for example by the
178 presence of heavily chipped or unclean cutting boards, unfamiliarity of food handlers
179 with the concept of color-coding or separate use of utensils and cutting boards for raw
180 meat and fresh vegetables. There was misuse of colour-coded cutting boards in 18% of
181 FSE's where colour-coded cutting boards were used for several types of food. The
182 component "frozen foods are thawed properly" was not observed in 74% of the
183 premises visited, yet it was inadequately performed in 14% of the locations where
184 frozen fish or chicken soaked in water were noted at the time of the visit.

185 **4.2 Handling practices and the process of salads vegetables preparation**

186 Fresh vegetables were received during the mornings (7-9 a.m.) in plastic crates transported
187 on open trucks or in vans. The great majority (95%) reported that they received fresh
188 produce in uncooled vehicles (Table 2). In some cases, the person in charge or business
189 owner purchased the daily needs from the central market or nearby groceries. More than
190 two thirds of the respondents reported sourcing the fresh produce from the same

191 supplier (68.4%), and washing the vegetables before cutting (77%). In general,
192 preparation started early, particularly with bundles of parsley which were finely
193 chopped for serving later in the day in traditional salads and appetizers. Parsley leaves
194 were chopped before washing in 34% of FSEs, which is consistent with the typical
195 preparation sequence at homes (Figure 3), aiming to keep the texture of the leaves
196 longer, as they would becoming soggy if they are washed ahead of time. About a third
197 of the food businesses did not sanitize fresh vegetables, and used only water to wash
198 them. However, a large proportion (84%) reported that the wash water was neither
199 treated nor filtered. With long-standing shortages of potable water in Lebanon,
200 restaurants, and homes, purchase water, often of uncertain quality and source, which is
201 then stored in tanks. Out of the 56% using sanitizers, 21% used sodium
202 dichloroisocyanurate (NaDCC) and more than a third (45%) applied a post-sanitization
203 water rinse to remove the remaining taste or odour, respectively. It was noted during
204 inspection discussions and observations that automated systems regulating the
205 concentrations of chemical sanitizers in addition to water filters were in place, in some
206 corporate-managed restaurants. On other places (24 %), incorrect dilutions of sanitiser
207 was observed, typically as haphazard mixing of vinegar or NaDCC tablets in water. The
208 majority reported that fresh produce was kept in cold storage, whereas this was actually
209 only observed in 38% of the premises, with inadequate alternatives including stairways,
210 kitchen floors of spaces in crowded production areas.

211 **4.3 The microbiological quality of fresh salads vegetables**

212 Results on microbiological analysis of fresh-cut salad vegetables are presented in (Table
213 3 and 4).

214 The mean APC levels ranged from 2.90 to 7.38 Log CFU/g, with counts above
215 10^7 CFU/g recorded for 17% of the samples. The prevalence rate was substantially high

216 in TCs (79.6%, 94/118). TCs were found between 1.72 - 6.40 Log CFU/g, of which
217 38% were >4 Log CFU/g. Whereas, *E.coli* was isolated from 31.3% (37/118), with
218 bacterial loads ranging from less than 1.00 to 7.15 Log CFU/g, and the incidence rate
219 was 64.8% of the positive samples (24/37) for counts higher than 100 CFU/g.

220 More than two thirds (41.5%) of the samples were found to contain *S. aureus*. In
221 addition, *Listeria* spp. were isolated from 70.6% of the samples. The overall incidence
222 level was 53% for counts above 100 CFU/g, with an average of 3.24 Log CFU/g. *L.*
223 *monocytogenes* had a prevalence rate of 3.7 % mainly in arugula, parsley and lettuce,
224 whereas *Salmonella* was detected in 0.9%, (lettuce).

225 Results on recovered microorganisms from contact surfaces (cutting boards and knives)
226 are presented in Table 5. The microbial levels varied from below detection limits (10
227 CFU/swabbed area) to generally high levels. *E.coli* was isolated from 30.6% (15/49) of
228 contact surfaces (knives and cutting boards); of those, the mean values were found
229 between 2.70 - 7.02 Log CFU/swabbed area, whereas the incidence rate in TCs was
230 higher (53.0%, 26/49) with levels between 4.88 - 8.40 Log CFU/swabbed area. There
231 was no statistically significant correlation between the microbial counts recovered from
232 contact surfaces and the ratings on the adequacy level of sanitation of work surfaces
233 ($p>0.05$).

234 Overall, the analysis of data shows no statistical significant differences and inconsistent
235 trends in bacterial counts of different visual assessment rankings for each individual
236 inspection component ($p>0.05$). For instance, higher counts of TCs were observed on
237 lettuce and parsley obtained from premises with inadequate sanitary conditions and
238 unsafe handling practices, however this was not the case with cucumbers (Table 6).
239 Also, the frequency in the distribution of bacterial levels on lettuce and parsley in
240 relation to hygiene scores shows that high concentration levels were grouped at lower

241 scores (Figure 4). Likewise, the mean levels of coagulase-positive *Staphylococcus* spp.
242 were higher on all vegetables prepared on premises lacking handwashing sinks (Figure
243 5).

244 There was no correlation between total visual assessment scores and bacterial levels
245 ($p>0.05$). However, independent t-test still reveals a significant difference ($t=-2.198$, 81,
246 $p=0.03$), between inspection scores for premises with *Listeria* counts above 100 CFU/g
247 (53.44 ± 18.39) and those where the organism was not detected (64.48 ± 26.12). When
248 Eta correlation and non-parametric tests were further performed for this organism, no
249 significant correlations of microbial results with all individual inspection component
250 ($p>0.05$) were shown, while correlation tests and cross tabulations somer'd test
251 revealed a significantly low and moderate association of *Listeria* levels with the
252 inspection components related to cross contamination, handling practices, zoning and
253 availability of handwashing sinks ($p<0.05$) (Figure 6). This association level was
254 consistent with linear regression establishing that *Listeria* spp levels may be predicted
255 by the visual assessment scores ($F_{1,103}=11,614$, $p=0.001$, but the score accounted for
256 only 10.5% (R^2) of the explained variability in *Listeria* levels in vegetables. Given the
257 small value of R^2 , the prediction model using the visual assessment scores is not
258 accurate. However and more interestingly, as we considered each inspected component
259 individually, Eta² coefficients showed higher percentage in variations in *Listeria* spp.
260 counts (30-34%) which were explained and attributed to cross contamination and
261 cleaning operations components ($p<0.05$).

262 5. DISCUSSION

263 5.1 Food safety practices and microbial quality of fresh salads vegetables

264 A number of food safety practices concerns were identified in this study. The general
265 lack of cleaning and sanitization procedures combined with a clear evidence of cross-
266 contamination opportunities were generally reflected in the overall unsatisfactory
267 quality of RTE vegetables. The majority of SMEs seemed to be unaware of the
268 significance of applying control measures when handling vegetables and of the
269 fundamental requirements for separate handwashing and vegetables washing sinks. APC
270 were above the specified limits for RTEs, 7 Log CFU/g, in 17% of the analysed
271 samples. when APC count is $>10^6$ CFU/g, it may not necessarily relate to food safety
272 hazards; in many of these cases, there is a predominant microorganism from an
273 environmental source (PHLS, 2000) such as the processing stages involving handling,
274 cutting, slicing and improper storage as well as display conditions (Abadias et al.,
275 2012); Nguz et al. (2005) showed that chlorine treated fresh-cut organic mixed
276 vegetables were still found to harbour high levels of TCs (5.9 Log CFU/g) and it was
277 proposed that high loads of coliforms in RTE vegetables at retails levels is directly
278 influenced by intense use of untreated manure during pre-harvest, and extensive
279 handling during postharvest (Aycicek et al., 2006). In our earlier study, TCs \geq 5 Log
280 CFU/g were isolated from more than two third of the fresh vegetables (69%) coming
281 from locations with alarming deficits at harvest and post-harvest washing, storage and
282 distribution stages (Faour-Klingbeil et al., 2016).

283 According to the EC legal food safety criteria and the UK Public Health Laboratory
284 Service (PHLS) microbiological guidelines for RTE foods sampled at the point of sale,
285 for category 5 fresh vegetables (HPA, 2009; PHLS, 2000), our study results on
286 microbial contamination levels of more than half of the RTE salad vegetables were
287 unsatisfactory due to *E. coli* and *Listeria* spp. counts that exceeded the criteria limits

288 $>10^2$ CFU/g indicating poor hygienic practices and sanitary conditions (Gilbert et al.,
289 2000).

290 *Listeria* spp. are rarely implicated in illnesses involving produce, however, they may
291 indicate a significant failure of hygiene standards in the preparation and /or storage of
292 fresh vegetables(Gilbert et al., 2000) which in turn are considered hazardous for
293 *L.monocytogenes* contamination (Ponniah et al., 2010). Presence of *L.monocytogenes*
294 and *Salmonella* spp. were traced back to samples obtained from restaurant that had no
295 handwashing sinks, fresh vegetable washing sinks, or adequate preparation and storage
296 areas or surfaces and the corresponding visual assessment score recorded 32 over 100
297 possible points.

298 The lacking of handwashing sinks explained the fact that proper handwashing before
299 and after use of gloves were not commonly observed, although many other factors could
300 interfere as well. High frequency of *S. aureus* indicates poor hygiene practices of food
301 handlers, the latter being known to be carriers of this pathogen (Todd et al., 2008) and
302 may contribute in direct contamination of RTE fresh vegetables and contact surfaces via
303 the hands (Todd et al., 2008).

304 **5.2 Food contact surfaces**

305 The PHLS recommended guidelines for cleaned contact surfaces specified levels of
306 total viable microorganisms less than 80 CFU/cm² as satisfactory, 80-10³CFU/cm² is
307 borderline, and over 10³CFU/cm² is unsatisfactory been associated with poor hygiene
308 practices (Herbert et al., 1990). PCA counts $\geq 10^3$ CFU/cm² was recorded for 33/49
309 swabbed surface. The overall incidence rate of *E.coli* was 15/49 with counts ≥ 1
310 CFU/cm², whereas *E. coli* counts $\geq 10^3$ CFU/cm² were recorded for 10/49 of swabs. TCs
311 and *Staphylococcus* spp. were found in 26/49 and 39/49 of swabs with counts
312 $\geq 10^3$ CFU/cm². In this regard, the high microbial population size on contact surfaces

313 offered an additional assumption for the actual contamination observed on the washed
314 salad items, particularly that sanitization and cleaning operations were lacking in a great
315 majority of locations. Sneed, Strohbahn, Gilmore, et al. (2004) indicated that inadequate
316 sanitation and recontamination problems were actually related to high aerobic plate
317 counts recovered from cutting boards. Non-sanitized and scratched cutting surfaces,
318 combined in some cases with misuse of sanitizers dilution, are an appropriate
319 environment for harbouring pathogens that have the propensity to form biofilm on
320 surfaces (Pui et al., 2011) and resist washing processes (Ravishankar et al., 2010).

321 As RTE fresh vegetables were obtained after washing, the existing microbiological
322 characteristics do raise further doubts as to the implication of water quality. It is well
323 recognized that natural resources and water supply in Lebanon endures a high risk of
324 chemical and microbial pollution (Houry & El Jeblawi, 2007; Jurdi, 1992), at the same
325 time, it is substantiated that washing with water of unsatisfactory microbial quality can
326 serve as a vehicle for dispersion of microorganisms (Holvoet et al., 2013) and was the
327 primary cause for the homogenous spread of *Salmonella* Enteritidis to fresh-cut
328 vegetables during processing (Perez-Rodriguez et al., 2014). The quality of water used
329 for washing or in post-sanitization rinsing process in SMEs should be addressed in
330 future studies as a critical element to maintain fresh vegetables safety specially when
331 more restaurants nowadays rely on purchasing water of unknown sources, usually
332 coming in tankers collected from spring water but may or may not be chlorinated, to
333 compensate for the shortage in water supply..

334 **5.3 Association of microbial counts to visual assessment scores and inspection** 335 **components**

336 Our data revealed an inconsistent association between the bacterial counts and visual
337 assessment scores of handling practices and hygiene conditions. As we also studied the

338 possibility of association to each single inspection component, the microbiological
339 quality of salad vegetables did not show any direct correlation with each individual
340 inspected component. It was found that the cell counts were either corresponding or
341 conflicting in trend across ranking on adequacy level and types of produce. The
342 complexity of the interfering factors during sampling of RTE fresh vegetables from
343 different operational conditions (e.g., environment and storage temperature, receiving
344 and pre-receiving conditions of fresh vegetables, preparation stages of fresh cut
345 vegetables, sampling methods) challenges the possibility to detect a clear cut trend and
346 association. Add to this, large number of samples might be needed to investigate such a
347 trend. Our findings are in accordance with a study by Powell and Attwell (1995) where
348 a link between the total viable counts and *S.aureus* on turkey and ham and the
349 compliance rate to different inspection components was not established. Findings of
350 earlier studies did not as well confirm such an association with the microbiological
351 quality of foods of meat origin (Tebbutt & Southwell, 1989; Wyatt & Guy, 1980). Kuri
352 et al. (1996) found that microbial indicators in meats, including pathogen prevalence,
353 were not correlated to total hygiene scores of meat retailers, nor to temperature of
354 samples, but they were related to type of retailer or origin of product.

355 We actually noted higher population size of hygiene indicators on some samples
356 prepared under inadequate hygiene conditions, although a statistically significant
357 correlation with the inspection scores failed. According to our results, it may be
358 reasonable to consider that low visual assessment scores on the hygiene standards and
359 handling practices probably indicate unsatisfactory microbial quality and likelihood for
360 risks of salad vegetables contamination with *L.monocytogenes*, however, this
361 association was only significant in relation to individual components related to cross-
362 contamination and effective cleaning. The total visual assessment score can be affected

363 by a number of possible combinations of ranking levels of the 26 variables; a low
364 inspection score might not necessarily indicate low ratings of all the critical components
365 that have direct impact on the microbiological quality of vegetables. Hence, inspections
366 should focus upon factors most likely to be responsible for foodborne infection or high
367 microbial levels associated with RTE vegetables.

368

369 **6. CONCLUSION**

370 Links between the visual assessment scores on the overall food safety performance and
371 the microbiological quality of RTE fresh vegetables are not simple to establish and were
372 not clearly correlated. The total visual assessment scores per se would not directly
373 indicate the microbiological safety of RTE vegetables in restaurants. However,
374 variations in microbial counts and a significant correlation of high *Listeria* levels with
375 the inadequate cleaning performances and cross-contamination preventive measures
376 were recorded, which imply that shortfalls in those particular practices may possibly
377 indicate pathogenic contamination of fresh vegetables.

378 Also, this study found high microbial loads in RTE vegetables that could serve as an
379 indicator for the need to promote awareness on the critical areas commonly identified in
380 SMEs and as guidance for local authorities to target those that may mostly affect the
381 safety of fresh vegetables. It underscored the considerable requisite for improvement in
382 sanitary and good hygienic practices and for vigilant cleaning and sanitation procedures
383 to reduce or eliminate contamination and cross-contamination risks that may occur at
384 pre-farm gate and throughout the supply chain stages. Therefore, applications of critical
385 control points for the preparation of fresh salad vegetables and personnel training on the
386 hazards associated with their preparation are fundamentals to improve the food safety of
387 fresh produce particularly when prepared in small working facilities in SMEs.

388 7. ACKNOWLEDGEMENTS

389 The authors gratefully acknowledge the support provided by the Department of
390 Nutrition and Food Science, American University of Beirut for partially funding this
391 research work through a grant from the Lebanese National Council for Scientific
392 Research (CNRS) #102598.

393

8. REFERENCES

- Abadias, M., Alegre, I., Oliveira, M., Altisent, R., & Viñas, I. (2012). Growth potential of *Escherichia coli* O157:H7 on fresh-cut fruits (melon and pineapple) and vegetables (carrot and escarole) stored under different conditions. *Food Control*, 27(1), 37-44. doi: <http://dx.doi.org/10.1016/j.foodcont.2012.02.032>
- Aycicek, H., Oguz, U., & Karci, K. (2006). Determination of total aerobic and indicator bacteria on some raw eaten vegetables from wholesalers in Ankara, Turkey. *International Journal of Hygiene and Environmental Health*, 209(2), 197-201. doi: 10.1016/j.ijheh.2005.07.006
- CAC/RCP 1(1969). Recommended international code of practice general principles of food hygiene (Revision 4 - 2003). Retrieved from: <http://www.mhlw.go.jp/english/topics/importedfoods/guideline/dl/04.pdf>
- Clayton, D., & Griffith, C. (2004). Observation of food safety practices in catering using notational analysis. *British Food Journal*, 106, 211– 227.
- Evans, J. A., Russell, S. L., James C., & Corry, J. E. L. (2004). Microbial contamination of food refrigeration equipment *Journal of Food Engineering*, 62, 225-232.
- Faour-Klingbeil, D., Kuri, V., & Todd, E. (2015). Investigating a link of two different types of food business management to the food safety knowledge, attitudes and practices of food handlers in Beirut, Lebanon. *Food Control*, 55, 166-175.
- Faour-Klingbeil, D., Murtada, M., Kuri, V., & Todd, E. (2016). Understanding the routes of contamination of ready-to-eat vegetables in the Middle East. *Food Control*, 62, 125-133. doi: <http://dx.doi.org/10.1016/j.foodcont.2015.10.024>
- Gilbert, R., de Louvois, J., Donovan, T., Little, C., Nye, K., Ribeiro, C., Bolton, F. (2000). Guidelines for the microbiological quality of some ready-to-eat foods sampled at the point of sale. PHLS Advisory Committee for Food and Dairy Products. *Communicable Disease and Public Health*, 3(3), 163-167.
- Gill, C. O., Bryant, J., & Badoni, M. (2001). Effects of hot water pasteurizing treatments on the microbiological condition of manufacturing beef used for hamburger patty manufacture. *International Journal of Food Microbiology*, 63(3), 243-256.
- Herbert, M., Donovan, T., & Manger, P. (1990). A study of the microbial contamination of working surfaces in a variety of food premises using the traditional swabbing technique and commercial contact slides . In Ashford (Ed.).
- Holvoet, K., Sampers, I., Callens, B., Dewulf, J., & Uyttendaele, M. (2013). Moderate Prevalence of Antimicrobial Resistance in *Escherichia coli* Isolates from Lettuce, Irrigation Water, and Soil. *Applied and Environmental Microbiology* 79(21), 6677–6683.
- Houri, A., & El Jeblawi, S. W. (2007). Water quality assessment of Lebanese coastal rivers during dry season and pollution load into the Mediterranean Sea. *Journal of Water and Health*, 5(4).
- HPA. (2009). Guidelines for Assessing the microbiological safety of ready-to-eat foods. *Health Protection Agency*. .
- Jones, S. L., Parry, S. M., O'Brien, S. J., & Palmer, S. R. (2008). Are staff management practices and inspection risk ratings associated with foodborne disease outbreaks in the catering industry in England and Wales? *Journal of Food Protection*, 71(3), 550-557.
- Jones, T. F., & Angulo, F. J. (2006). Eating in restaurants: a risk factor for foodborne disease? *Clin Infect Dis*, 43(10), 1324-1328. doi: 10.1086/508540

- 443 Jones, T. F., Pavlin, B., LaFleur, B., Ingram, L., & Schaffner, W. (2004). Restaurant
444 inspection Scores and foodborne disease. *Emerging Infectious Diseases* 10(4),
445 688-692.
- 446 Jurdi, M. (1992). A national study on the quality of potable water in Lebanon.
447 *Proceedings of the national workshop of the status of water in Lebanon, United*
448 *Nations International Children's Emergency Fund (UNICEF). Beirut, Lebanon*
449 pp. 145-173 (in Arabic).
- 450 Kuri, V., Madden, R. H., & Collins, M. A. (1996). Hygienic quality of raw pork and
451 chorizo (raw pork sausage) on retail sale in Mexico City. *Journal of Food*
452 *Protection* 59 (2), 141-145.
- 453 Manning, C. K. (1994). Food safety knowledge and attitudes of workers from
454 institutional and temporary foodservice operations. *Journal of the American*
455 *Dietetic Association*, 94(8), 895-897. doi: [http://dx.doi.org/10.1016/0002-](http://dx.doi.org/10.1016/0002-8223(94)92372-8)
456 [8223\(94\)92372-8](http://dx.doi.org/10.1016/0002-8223(94)92372-8)
- 457 McEvoy, J. M., Sheridan, J. J., Blair, I. S., & McDowell, D. A. (2004). Microbiological
458 contamination of beef carcasses in relation to hygiene assessment based on
459 criteria used in EU Decision 2001/47/EC. *International Journal of Food*
460 *Microbiology*, 92, 217-225.
- 461 Nguz, K., Shindano, J., Samapundo, S., & Huyghebaert, A. (2005). Microbiological
462 evaluation of fresh-cut organic vegetables produced in Zambia. *Food Control*,
463 16(7), 623-628. doi: <http://dx.doi.org/10.1016/j.foodcont.2004.07.001>
- 464 Perez-Rodriguez, F., Saiz-Abajo, M. J., Garcia-Gimeno, R. M., Moreno, A., Gonzalez,
465 D., & Vitas, A. I. (2014). Quantitative assessment of the Salmonella distribution
466 on fresh-cut leafy vegetables due to cross-contamination occurred in an
467 industrial process simulated at laboratory scale. *International Journal of Food*
468 *Microbiology*, 184, 86-91. doi: 10.1016/j.ijfoodmicro.2014.05.013
- 469 PHLS. (2000). Microbiological guidelines for some ready-to-eat foods sampled at the
470 point of sale. . *Communicable Disease and Public Health*, 3, 163-167.
- 471 Ponniah, J., Robin, T., Paie, M., Radu, S., Ghazali, F., Kqueen, C., Malakar, P. (2010).
472 *Listeria monocytogenes* in raw salad vegetables sold at retail level in Malaysia.
473 *Food Control*, 21, 774-778.
- 474 Powell, C., & Attwell, R. W. (1995). A comparative study of food retail premises by
475 means of visual inspection and microbiological quality of food. *Epidemiology*
476 *and Infection*, 114, 143-151.
- 477 Pui , C. F., Wong, W. C., Chai, L. C., Lee, H. Y., Tang, J. Y. H., Noorlis, A., Son, R.
478 (2011). Biofilm formation by *Salmonella* Typhi and *Salmonella* Typhimurium
479 on plastic cutting board and its transfer to dragon fruit. *International Food*
480 *Research Journal*, 18, 31-38.
- 481 Rajagopal, L., & Strohbehn, C. H. (2013). Observational assessment of glove use
482 behaviors among foodservice workers in a university dining setting: Testing a
483 visual intervention tool. *Food Protection Trends*, 33(5), 315-324.
- 484 Ravishankar, S., Zhu, L., & Jaroni, D. (2010). Assessing the cross contamination and
485 transfer rates of *Salmonella enterica* from chicken to lettuce under different
486 food-handling scenarios. *Food Microbiology*, 27(6), 791-794. doi:
487 <http://dx.doi.org/10.1016/j.fm.2010.04.011>
- 488 Sagoo, S. K., Little, C. L., & Mitchell, R. T. (2001). The microbiological examination
489 of ready-to-eat organic vegetables from retail establishments in the United
490 Kingdom. *Letters in Applied Microbiology*, 33(6), 434-439.

- 491 Sneed, J., Strohbahn, C., & Gilmore, S. (2004). Food safety practices and readiness to
492 implement HACCP programs in assisted-living facilities in Iowa. *Journal of*
493 *American Dietetic Association* 104(11), 1678-1683.
- 494 Sneed, J., Strohbahn, C., Gilmore, S., & Mendonca, A. (2004). Microbiological
495 evaluation of foodservice contact surfaces in Iowa assisted-living facilities.
496 *Journal of American Dietetic Associatio.*, 104(11), 1722-1724.
- 497 Sodha, S. V., Lynch, M., Wannemuehler, K., Leeper, M., Malavet, M., Schaffzin, J.,
498 Braden, C. (2011). Multistate outbreak of Escherichia coli O157:H7 infections
499 associated with a national fast-food chain, 2006: a study incorporating
500 epidemiological and food source traceback results. *Epidemiology and Infection*,
501 139(2), 309-316. doi: 10.1017/S0950268810000920
- 502 Su, L. J., & Arab, L. (2006). Salad and raw vegetable consumption and nutritional status
503 in the adult US population: results from the Third National Health and Nutrition
504 Examination Survey. *Journal of American Dietetic Association*, 106(9), 1394-
505 1404. doi: 10.1016/j.jada.2006.06.004
- 506 Tebbutt, G., & Southwell, J. (1989). Comparative study of visual inspections and
507 microbiological sampling in premises manufacturing and selling high-risk foods.
508 *Epidemiology and Infection* 103, 475-486.
- 509 Todd, E. C., Greig, J. D., Bartleson, C. A., & Michaels, B. S. (2008). Outbreaks where
510 food workers have been implicated in the spread of foodborne disease. Part 5.
511 Sources of contamination and pathogen excretion from infected persons. *Journal*
512 *of Food Protection*, 71, 2582-2595.
- 513 WHO. (2007). Food safety and foodborne illness. Retrieved from
514 WHO. (2008). Microbiological hazards in fresh fruits and vegetables. *WHO report*
515 *:Microbiological Risk assessment series.*
- 516 Wyatt, C., & Guy, V. (1980). Relationship of microbial quality of retail meat samples
517 and sanitary conditions. *Journal of Food Protection* 43, 385-389.

518

Table 1. The six different constructs comprised in the visual assessment survey in SMEs

Inspection constructs	Individual Inspection Components
Construct 1: Structural compliance	<ul style="list-style-type: none"> • General maintenance conditions and evidence of pest in the production environment • Zoning (separation of fresh produce from raw meat and poultry) • All major pieces of equipment such fridges, freezers ovens, hot holding equipment, cold holding equipment are fitted with working temperature monitoring gauges • Availability of proper handwashing sink
Construct 2: Personal Hygiene	<ul style="list-style-type: none"> • Wearing hair cap • Appropriately clean personnel protective clothing
Construct 3: Sanitation	<ul style="list-style-type: none"> • Clean floors, walls, overall facilities and implements • Waste containers are covered, kept clean • Sanitisers for work surfaces readily available for use during food preparation • Containers used to drain vegetables are kept clean
Construct 4: Evidence of procedures and management system control	<ul style="list-style-type: none"> • Records keeping for verification of temperature monitoring and system audits (during cooking, cooling, storing) • Cleaning system and schedule • Where a chemical sanitiser is used , there are records to show levels are maintained
Construct 5: Contamination and Cross contamination control measures	<ul style="list-style-type: none"> • Staff cleaning tools are stored in appropriate manner and not at risk of contaminating food or equipment during preparation • Staff personal belongings are stored in appropriate manner and not at risk of contaminating food or equipment during preparation? • Received fresh vegetable are stored in protected areas • Washing sink designated for fresh produce only • Unprocessed raw vegetables are prepared so that contamination and cross- contamination does not occur (separate cutting boards and utensils) • Visitors or unauthorized staff are granted protective clothing upon entry • Entry for authorized personnel only
Construct 6: Safe and hygienic handling practices	<ul style="list-style-type: none"> • Appropriate use of gloves and handwashing • Frozen food is properly thawed • Vegetable sanitizers are made up correctly • Food on hold is covered

Table 2 Frequency of self-reported handling practices of fresh vegetables in foodservice establishments

Process	Frequency of handling practices N (%)				
	Always	Often	Sometimes	Rarely	Never
Are fresh vegetables delivered from one supplier/source?	52(68).	17 (22)	5 (7)	1 (1)	1 (1)
Are fresh leafy vegetables or/and pre-cut vegetables delivered cooled?	2 (3)	0 (0)	2 (3)	0 (0)	72 (94)
Is the washing water used for fresh vegetables and fruits chlorinated?	13(17)	0 (0)	0 (0)	0 (0)	64(83)
Do you wash the vegetables before cutting?	51 (77)	1 (1)	1 (1)	0 (0)	13 (20)
If applicable: how often you record the temperature of the display salad bar?	12 (35)	0 (0)	0 (0)	0 (0)	22 (65)
The received fresh vegetables are kept in the cold storage room/fridge	67 (93)	0 (0)	1 (1)	0 (0)	4 (6)
The washed and cut vegetables for salads and garnishes are held at room temperature before preparation/service	17 (26)	0 (0)	2 (3)	0 (0)	47 (71)

Table 3. Microbial loads of different fresh salads vegetables

Produce	N	PCA[†]	Coliforms[†]
Lettuce	30	5.50 ± 1.55	3.89 ± 2.19
Parsley	34	5.42 ± 1.32	4.48 ± 2.16
Cucumber	18	4.60 ± 2.01	3.52 ± 2.10
Radish	9	5.09 ± 2.20	1.72 ± 2.68
Mint	11	3.92 ± 2.74	3.93 ± 2.75
Coriander	1	7.38 ± 0.00	6.40 ± 0.00
Aragula	5	3.99 ± 2.44	3.30 ± 3.06
Tomato	3	2.90 ± 2.57	2.13 ± 2.20
Lettuce	4	5.35 ± 1.59	3.20 ± 1.49
Iceberg	3	4.54 ± 0.77	1.46 ± 2.53

[†]Values are mean Log CFU/g ± standard deviation.
The minimum detection limit was 10 CFU/g.

Table 4. Mean levels of *E. coli* and coagulase-positive *Staphylococcus* spp. on salads vegetables

Produce	N	<i>E. Coli</i>	<i>Staphylococcus</i> spp.
		Log CFU/g \pm SD (min-max)	Log CFU/g \pm SD (min-max)
Lettuce	30	0.92 \pm 1.80 (<1.00 -7.15)	2.89 \pm 2.28 (<1.00 – 7.76)
Parsley	34	0.70 \pm 1.50 (<1.00 - 5.40)	2.93 \pm 1.87 (<1.00 – 6.16)
Cucumber	18	1.30 \pm 1.43 (<1.00 - 3.40)	2.01 \pm 1.99 (<1.00 – 5.45)
Radish	9	0.35 \pm 0.88 (<1.00 -2.65)	2.84 \pm 2.37 (<1.00 – 6.48)
Mint	11	1.36 \pm 1.78 (<1.00 - 4.91)	2.69 \pm 2.08 (<1.00 – 5.62)
Coriander	1	1.30 \pm 0.91 (<1.00 - 1.30)	4.04
Aragula	5	0.92 \pm 1.45 (<1.00 - 3.30)	2.76 \pm 1.67 (<1.00 – 4.15)
Tomato	3	<1.00	2.00 \pm 2.00 (<1.00 – 4.00)
lettuce	4	<1.00	4.47 \pm 1.73 (2.30 – 6.00)
Iceberg	3	0.33 \pm 0.58 (<1.00 – 1.00)	1.83 \pm 1.58 (<1.00 – 2.78)

The minimum detection limit was 10 CFU/g.

Table 5. Bacterial counts recovered from two contact surfaces

Contact surface	N	Mean log CFU/swabbed area (min-max)			
		PCA	<i>Staphylococcus</i> spp	<i>E.coli</i>	Total coliforms
Chopping board†	29	4.99 (<1.00-8.40)	4.42 (<1.00-8.40)	1.19 (<1.00-6.02)	2.62 (<1.00-8.40)
Knife*	20	5.62 (<1.00-8.40)	4.62 (<1.00-7.98)	1.13 (<1.00-5.95)	4.31 (<1.00-8.40)

†Cutting board swabbed area of 50 cm²

*Knife (no defined area – ca.10-20 cm²)

Table 6. Distribution of the mean Log CFU/g of bacterial loads on fresh produce according to adequacy level of control measures

Microorganism	Rating†	N	Prevention of cross-contamination	Sanitation	Protected, clean storage of fresh produce	
			Mean ± SD	Mean ± SD	N	Mean ± SD
<u>Coliforms</u>						
Lettuce	Adequate	9	3.84 ± 3.09	3.67 ± 2.93	11	3.81 ± 2.59
	Inadequate	17	3.86 ± 1.68	4.20 ± 1.98	13	4.42 ± 1.68
Parsley	Adequate	10	3.80 ± 2.20	3.97 ± 2.23	14	3.95 ± 1.94
	Inadequate	20	4.68 ± 2.19	5.35 ± 2.39	13	4.46 ± 2.69
Cucumber	Adequate	6	4.15 ± 2.42	3.92 ± 2.48	7	3.84 ± 2.35
	Inadequate	9	3.79 ± 1.82	3.47 ± 1.99	7	3.61 ± 2.06
<u>E.Coli</u>						
Lettuce	Adequate	9	1.46 ± 2.50	1.18 ± 2.17	11	1.19 ± 2.31
	Inadequate	17	0.85 ± 1.54	1.23 ± 1.77	13	0.85 ± 1.56
Parsley	Adequate	10	0.54 ± 0.97	0.79 ± 1.55	14	1.15 ± 2.05
	Inadequate	20	0.65 ± 1.48	0.81 ± 1.83	13	0.63 ± 1.15
Cucumber	Adequate	6	1.96 ± 1.47	1.79 ± 1.47	7	1.68 ± 1.53
	Inadequate	9	1.29 ± 1.43	0.91 ± 1.47	7	1.36 ± 1.53
<u>PCA</u>						
Lettuce	Adequate	9	6.14 ± 1.71	6.10 ± 1.54	11	5.41 ± 1.63
	Inadequate	17	5.21 ± 1.40	5.07 ± 1.32	13	5.41 ± 1.63
Parsley	Adequate	10	5.51 ± 1.51	5.48 ± 1.29	14	5.31 ± 1.28
	Inadequate	20	5.49 ± 1.21	5.30 ± 1.29	13	5.42 ± 1.55
Cucumber	Adequate	6	5.87 ± 1.22	4.36 ± 2.72	7	5.84 ± 1.11
	Inadequate	9	4.09 ± 1.82	4.84 ± 1.11	7	3.87 ± 1.96
<u>Staphylococcus</u>						
Lettuce	Adequate	9	2.83 ± 1.73	3.36 ± 2.13	11	3.20 ± 1.91
	Inadequate	17	2.67 ± 2.43	2.53 ± 2.55	13	2.84 ± 2.90
Parsley	Adequate	10	2.85 ± 2.17	3.16 ± 1.87	14	3.18 ± 1.89
	Inadequate	20	2.95 ± 1.78	2.26 ± 1.97	13	2.13 ± 2.08
Cucumber	Adequate	6	1.80 ± 2.02	1.56 ± 1.82	7	1.91 ± 1.87
	Inadequate	9	2.53 ± 2.12	3.24 ± 1.97	7	2.86 ± 2.12

†"Incomplete" ranking was omitted for easier presentation of data

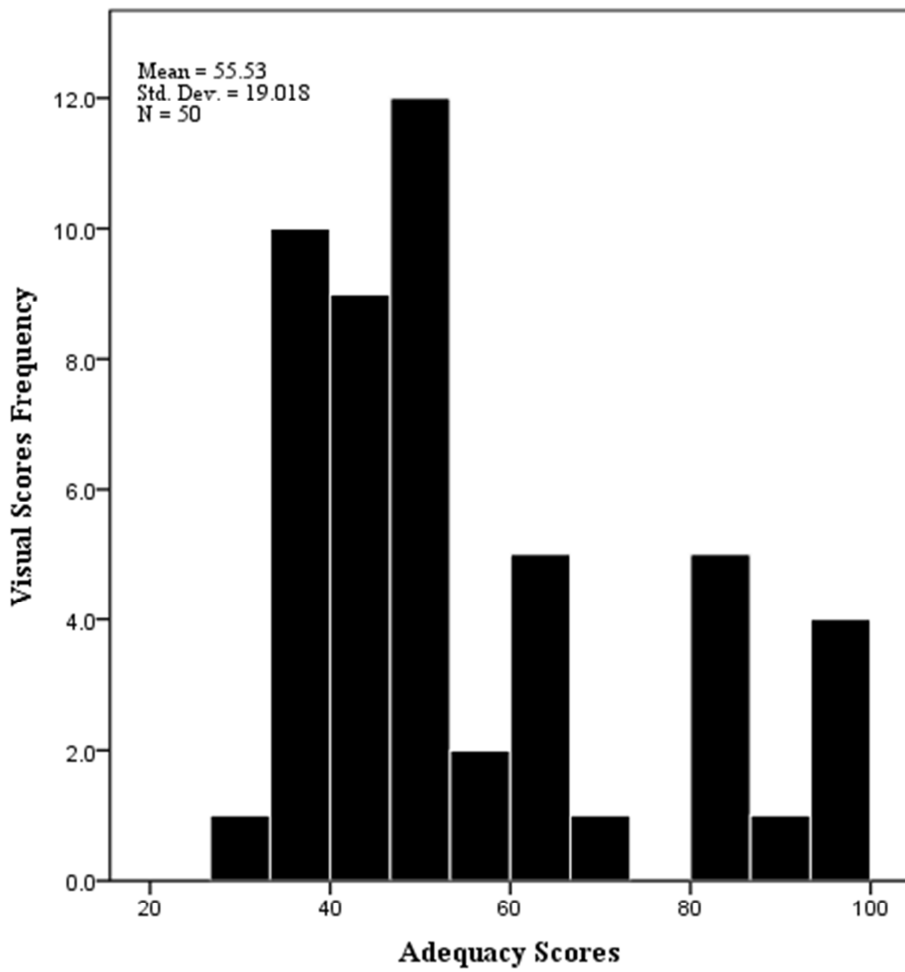


Figure 1. The distribution of total score obtained from the overall visual assessment of hygiene conditions and handling practices.

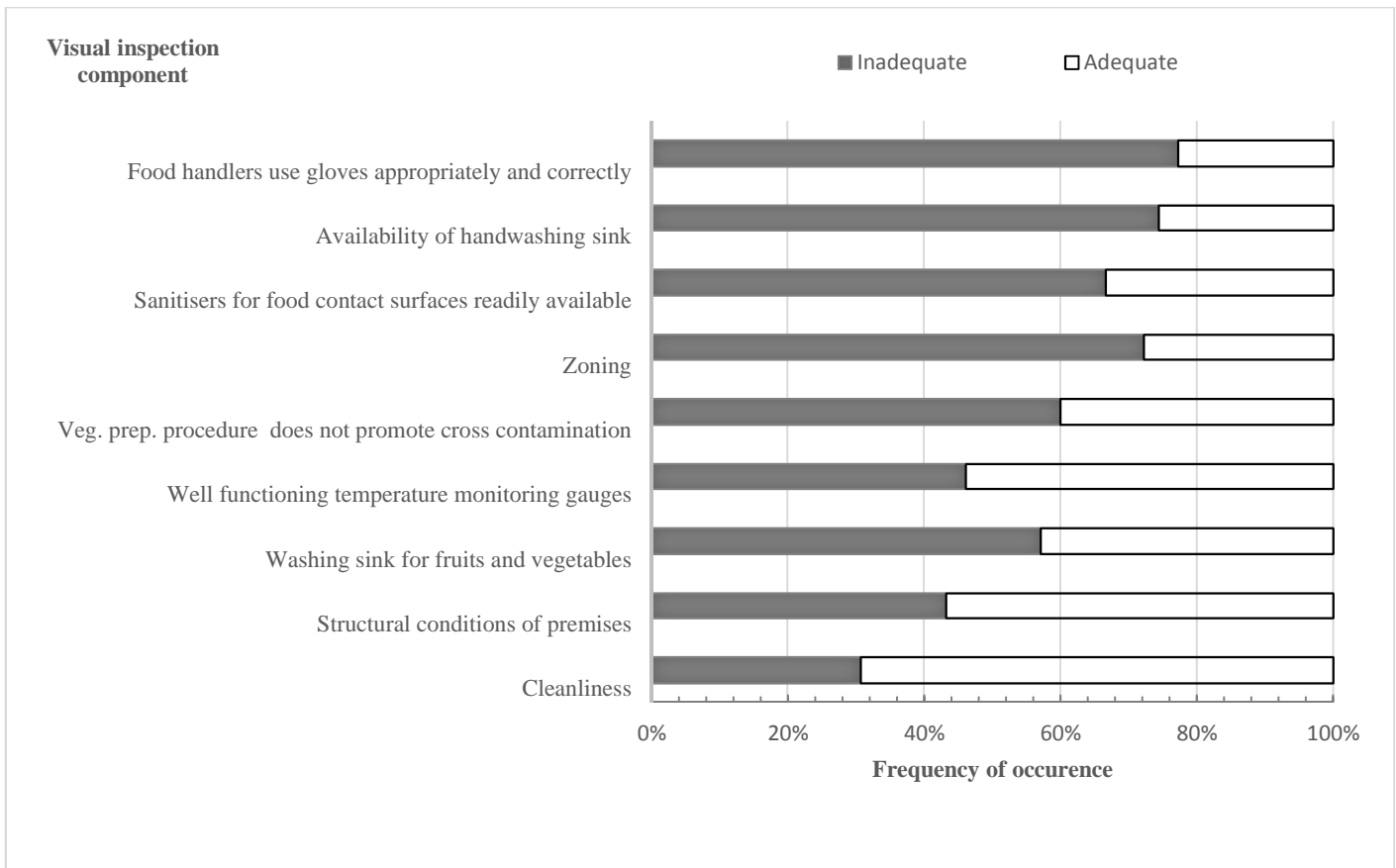


Figure 2. Distribution of food businesses' compliance with basic hygiene requirements and control measures

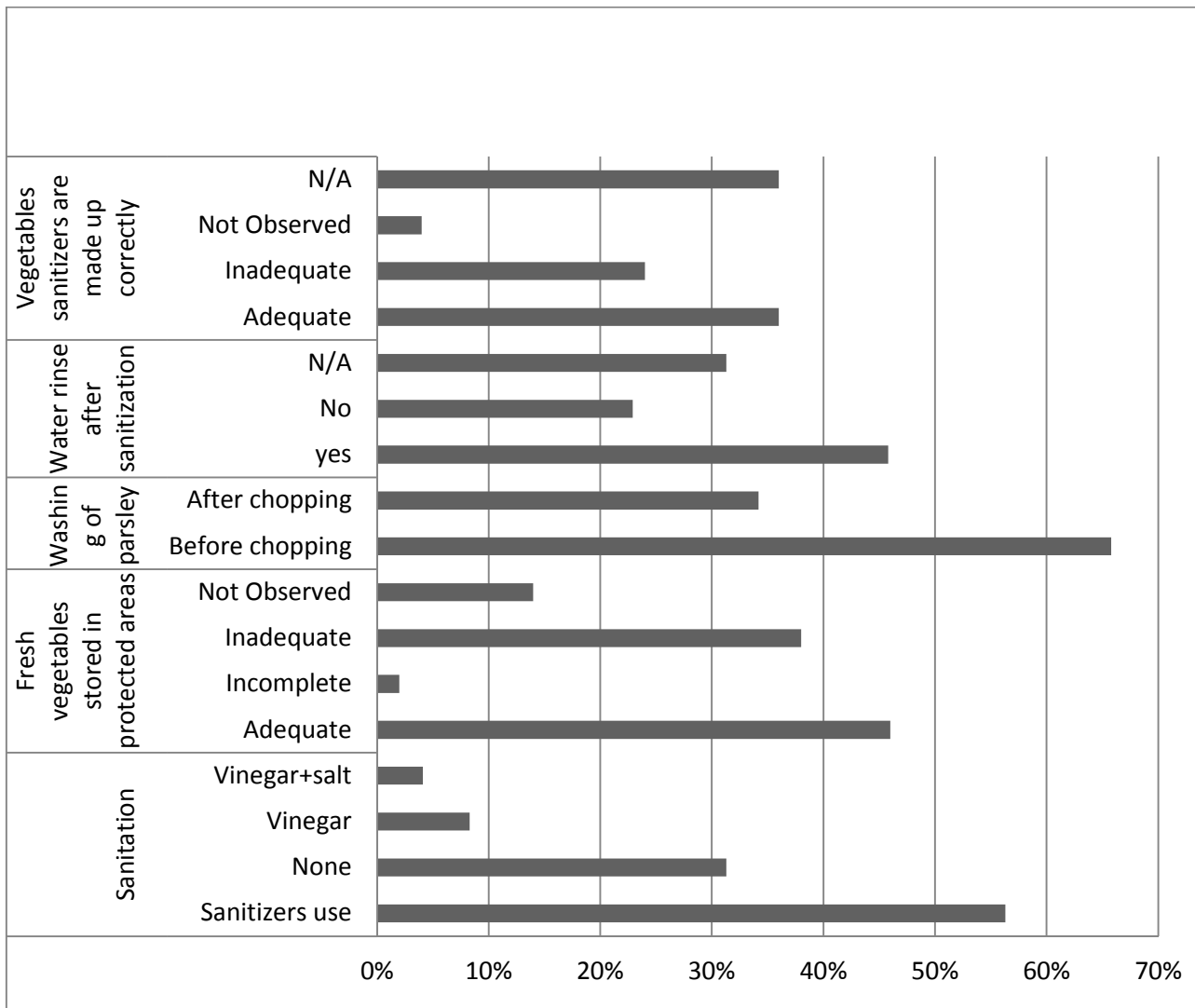


Figure 3. Distribution of food businesses' adequacy level in relation to washing and storing practices of fresh salads vegetables

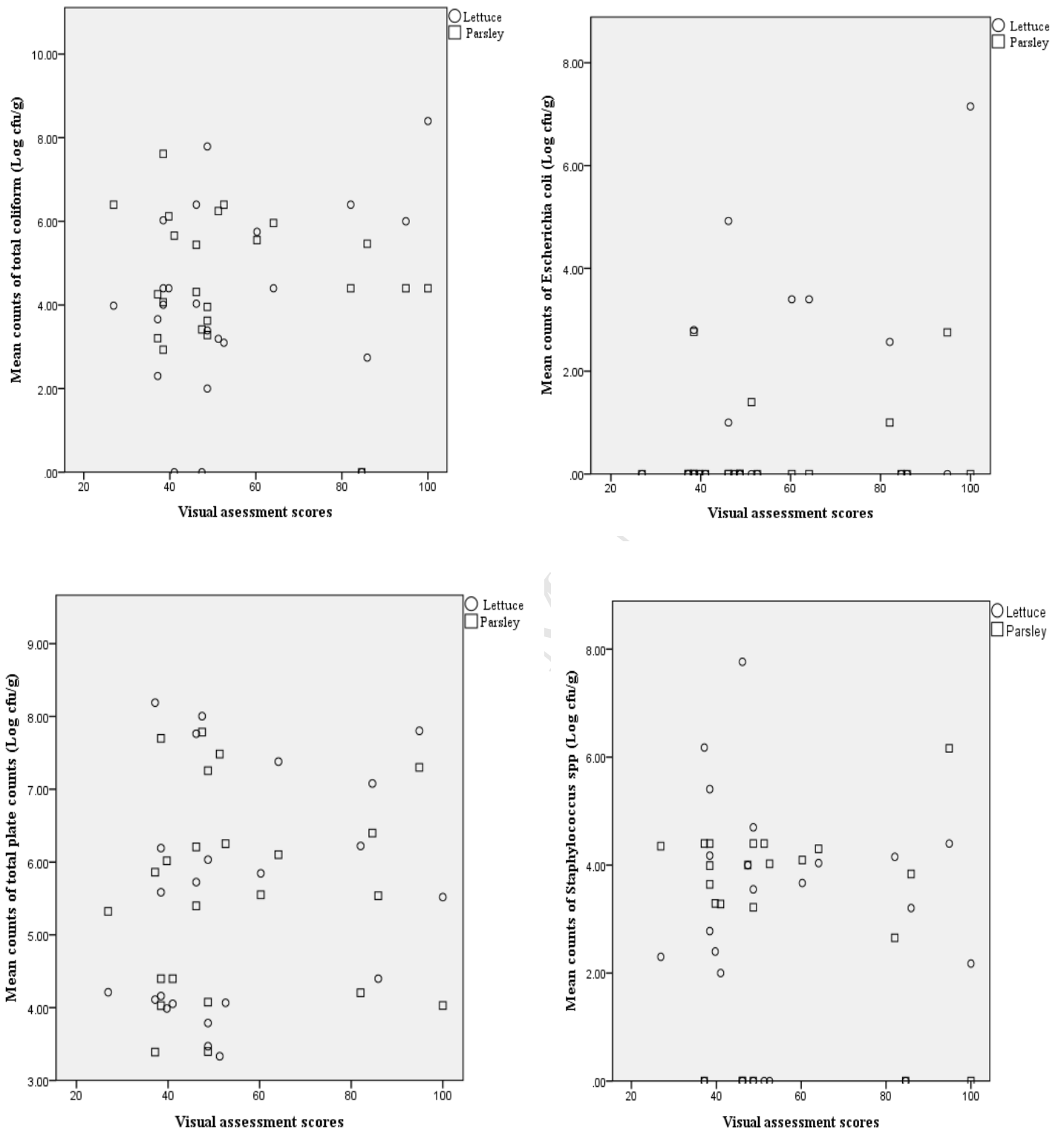


Figure 4. The distribution of microorganism levels on fresh vegetables in relation to the different values of visual assessment scores obtained on all inspected components

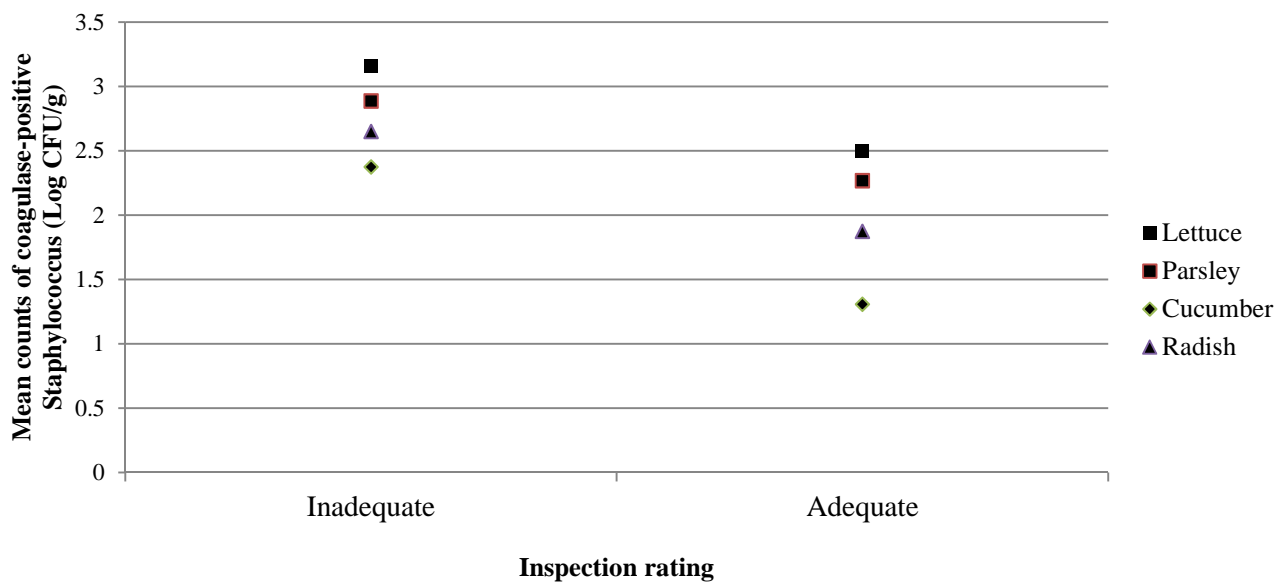


Figure 5 Distribution of mean levels of *Staphylococcus* spp. in relation to component "Availability of handwashing facilities"

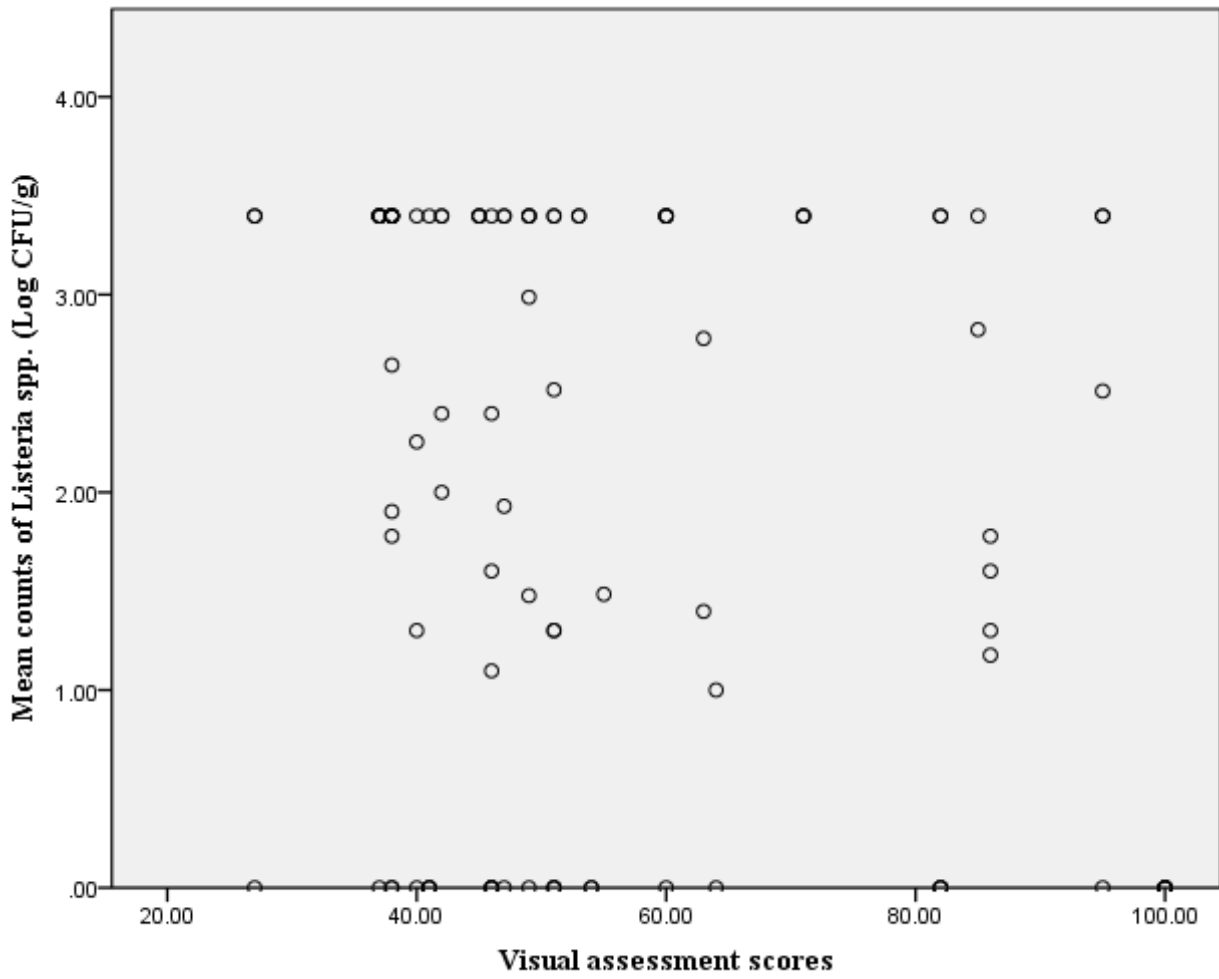


Figure 6. Distribution of Listeria spp. in relation to the visual assessment scores on all inspected components during salad vegetables preparation.

**The association of microbiological quality and handling practices of ready-to-eat fresh salad vegetables with food safety environment in restaurants:
Case study in Lebanon**

Highlights

1. Microbial loads on salads vegetables, hygienic conditions/practices were assessed.
2. Association of microbiological quality with visual assessment scores was tested.
3. *Listeria monocytogenes* and *Salmonella* spp. were detected.
4. There was no significant relationship with the total visual assessment scores
5. Correlation of cross-contamination components to *Listeria* levels was significant
6. Poor cleaning can possibly be linked to *Listeria* levels in salads vegetables.