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**Vending machines: food safety and quality assessment  
focused on food handlers and the variables involved in  
the industry**

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## Abstract

The purpose of this paper was to analyse the quality and safety parameters of food products sold in vending machines. A hygienic-sanitary assessment was conducted on 338 vending machines located on the island of Gran Canaria. Hygiene Assessment System (HAS) surveys, food handler examinations and microbiological (processed food and water) and physicochemical (water) controls were applied, permitting evaluation through the identification of the main risks and/or hazards of the hygienic-sanitary quality of the products sold in vending machines.

Despite the positive results obtained from the HAS surveys applied to all the vending machines, achieving a total mean score of  $87.6 \pm 7.5$  out of 100, the microbiological analysis showed that 5.7% of the 105 food samples were contaminated with *Listeria monocytogenes*, while *Salmonella* spp., *Escherichia coli* and *Staphylococcus aureus* were below the legally permitted limits. The lack of vehicles able to transport perishable food at correct temperatures ( $< 8^{\circ}\text{C}$ ) and the fact that some refrigerated vending machines were not at an ideal cooling temperature may have contributed to these values.

The assessment tools used in this study revealed hygienic deficiencies in the transportation and microbiological quality of the products, despite the favourable results obtained in the HAS surveys and food handler examinations, indicating that this relationship should be the subject of further study to improve its usefulness in the field of Hazard Analysis and Critical Control Points.

**Keywords:** vending machines; microbiology; food safety; food quality; HAS surveys; food handlers.

51

52 **1. Introduction**

53 In recent decades there has been a significant increase in the development of the  
54 vending machine industry. Japan is the world leader and in the United States of America  
55 this sector has a value of 30 billion American Dollars per year (Lin *et al.*, 2011), in the  
56 United Kingdom reaching approximately 1,700 million British Pounds (Mintel, 2009).

57 Spain is a European power in the use of vending machines with a consolidated  
58 industry and highly integrated use. There are 560,000 vending machines across Spain,  
59 that is, one machine for every 80 inhabitants, while Japan the industry leader, has 5.5  
60 million vending machines, one for every 23 people (MTV, 2008).

61 With the rapid growth of this industry, there has been concern to ensure  
62 consumers about the safety of food sold in vending machines. In the late eighties and  
63 early nineties, some authors (Anonymous, 1987; ICMSFIUMS, 1988; Snyder, 1991)  
64 considered that the Hazard Analysis and Critical Control Points (HACCP) system was  
65 the most appropriate method to monitor vending machine operators to ensure consumer  
66 safety, offering a high level of food safety based on food risk prevention. A few years  
67 later, Hunter (1992) suggested that all vending machine companies should control the  
68 quality and safety of their operations, preferably using the same HACCP system.

69 Under the HACCP system, food business operators ensure that all stages of  
70 production, processing and distribution of food under their control satisfy the relevant  
71 hygiene requirements laid down in Regulation (EC) No. 853/2004. Successful  
72 implementation of the procedures based on HACCP principles requires the full  
73 cooperation and commitment of food business employees. To this end, employees  
74 should undergo training (Egan *et al.*, 2007; Jevsnik *et al.*, 2008). An important factor to

take into consideration is that in the food business, the owner or manager is solely responsible for the management of human resources. Owners or managers who are trained in management, tend to give more value to training and actively encourage their employees to participate in further training development (Worsfold, 2005).

Several studies (Howes *et al.*, 1996; Greig *et al.*, 2007) have reported food mishandling as the main cause of foodborne disease and a factor strongly associated with outbreaks. Among the practices of food handlers which are often associated with foodborne outbreaks are: inadequate hand hygiene, inadequate hygiene of equipment and utensils, maintenance of ready-to-eat food at room temperature, preparation of meals in advance, insufficient cooking temperature and inadequate thawing (Greig *et al.*, 2007; Chan & Chan, 2008; Food and Drug Administration, 2009). Therefore, these professionals may be responsible for up to 97% of foodborne disease outbreaks (Egan *et al.*, 2007). Food handlers participate in the final stage of the prevention of foodborne diseases; they must take significant steps to reduce the number of pathogenic microorganisms to the minimum level (Medeiros *et al.*, 2004). In line with this, McIntyre *et al.* (2013) pointed out that educating food handlers to prevent foodborne illness is an important objective for industries and governments.

Food safety is of vital importance to consumers, the food industry and the economy. According to Raspor (2004), the number of annual cases of salmonellosis and campylobacteriosis in Europe is likely to exceed five million; this means that the economic and human losses from foodborne diseases can no longer be ignored. Based on these premises, we must address the potential dangers, especially those of a microbiological nature which can affect different food types in the vending machines.

98           It is important to take into consideration that food and drink present in machines  
99   are commonly found pre-packaged and must not be in contact with any surface of the  
100   machine. The microbiota of the food and drinks should be the same as in the food  
101   served by traditional methods. However, vending machines, once loaded, are left  
102   unattended for long periods of time, which can mean an increased microbiological risk.

103           Taking the example of drink vending machines, they are refilled, cleaned and  
104   maintained by the operating companies. The frequency of cleaning varies depending on  
105   the machine type, frequency of use, and location. Inside the machine there are a number  
106   of areas where it is possible to accumulate moistened dust which needs to be cleaned to  
107   prevent the possibility of microbial growth and the occurrence of dust clumps in  
108   beverages (Hall *et al.*, 2007).

109           Regarding the Spanish legislation on vending machines, it is important to say  
110   that until March 2010 it was required that the machines featured an authorization or  
111   approval by the Autonomous Community in which they were located and activated.  
112   However, now it is only necessary that they satisfy the applicable technical regulations.  
113   This was established by Law 1/2010 of March 1, amending the Law 7/1996 of 15  
114   January on retail trade, in line with the provisions of Directive 2006/123/EC, standard  
115   community developed under the auspices of the Establishing Treaty of the European  
116   Community.

117           Since studies on the hygienic and sanitary conditions, including microbiological  
118   analysis, about the food and drink sold in vending machines are very scarce (Hunter &  
119   Burge, 1986; Hunter, 1992, Hunter & Barrell, 1999, Hall *et al.* 2012), the aim of this  
120   paper was to assess the quality and the hygienic conditions of the products sold in  
121   vending machines, through physicochemical and microbiological water analysis,

122 microbiological food analysis, a hygienic-sanitary survey and a food handler knowledge  
123 examination, applying the results of these relationships to the management of HACCP  
124 in the vending industry.

125

## 126 **2. Materials and Methods**

### 127 *2.1 Vending machines:*

128 For this work we have considered the island of Gran Canaria in a comprehensive  
129 manner, with particular emphasis on the University of Las Palmas de Gran Canaria  
130 (ULPGC) campuses located on this island. The ULPGC has 23,931 students enrolled on  
131 various degree programmes distributed across 4 campuses on Gran Canaria (ULPGC,  
132 2013).

133 The study was carried out on 338 vending machines (111 hot drink vending  
134 machines; 82 cold drink vending machines; 74 snack vending machines and 71  
135 refrigerated vending machines dispensing solid food products) located in the town of  
136 Las Palmas de Gran Canaria, Spain, including 100% of the machines in ULPGC  
137 buildings, i.e. 70 units.

138

### 139 *2.2 Assessment of the adequacy of the vending machines:*

140 The adequacy of the vending machines was obtained employing information  
141 from different procedures. The first source was two Hygiene Assessment System (HAS)  
142 surveys, one applied to vending machines and another to the food replenishment route.  
143 The second source was the hygiene knowledge of the route managers, employing a

144 written test, and the third was the analysis of the quality of the food by microbiological  
145 counts, physicochemical evaluation and temperature measurements.

146

#### 147 2.2.1 HAS surveys:

148 In order to assess the state of adequacy of the vending machines and the food  
149 distribution route to those machines in terms of the hygienic and sanitary requirements  
150 of the legislation in force at the time of baseline (Regulation (EC) 853/2004), two HAS  
151 surveys were developed, taking into consideration previous studies where this kind of  
152 survey was applied (Millán & Sanjuán, 2005; Garcia Pinillos & Jukes, 2008;  
153 Carrascosa, 2010; Pérez, 2012; Raposo *et al.*, 2013). Each question in the survey was  
154 given a score according to the degree of compliance of the machines and the operations  
155 of the food replacement route using a predetermined scale.

156 The score given to each category of the health inspection rating was based on  
157 current regulations, the current scientific knowledge of hygiene and food technology  
158 and professional experience during visits to machines while monitoring the operator  
159 responsible for the replenishment of food in the machines, giving higher scores to  
160 operations posing greater risk. The surveys designed were based not only on the basis of  
161 hygienic-sanitary conditions, but also took into account the operation state of the  
162 machines and whether the products expended retained their best organoleptic properties  
163 and quality; for example, if a soft drink was dispensed at an acceptably cool temperature  
164 or whether biscuits were expended with a crunchy texture, rather than a mushy one.

165 For these two surveys, we considered a value of 75 out of 100 as the excluding  
166 minimum, below which the implementation of a HACCP system for serious deficiency  
167 in any of the areas represented by the headings in the survey cannot be carried out, and



168 it would be essential to take immediate measures to reduce the risk to public health, in  
169 addition to the weak points obtained by the surveys.

170 To complete the questions relating to the temperature of the food in the  
171 machines, measurements were made with a laser thermometer (Testo, Lenzkirch,  
172 Germany. Model 826-T2).

173

#### 174 2.2.2 Food handlers' hygiene knowledge:

175 To assess the knowledge of the food handlers about hygiene practices and  
176 attitudes related to the safety of the food produced in the company as well as that  
177 expended by the machines, two examination tests based on the scientific literature  
178 (Carrascosa, 2010; Garayoa *et al*, 2011) were designed. These examination tests  
179 consisted of 25 closed questions with three possible answers, one being correct. To  
180 pass, each food handler had to answer at least 19 questions correctly, equivalent to 75%  
181 correct. Participants were all the workers involved in any stage of processing and  
182 transport / replenishment of food in the machines. The two examination tests applied  
183 were different; there was a specific examination test for food processors and one for  
184 route managers, including questions more directed to the function they were carrying  
185 out in the company.

186 Coinciding with the visit to the company, the aforementioned examination tests  
187 were applied to the nine food processors and also to the twelve route managers. All food  
188 handlers had 35 minutes to perform the respective examination tests.

189

#### 190 2.2.3 Route manager/vending machine association

191 After completing all the HAS surveys corresponding to vending machines and  
192 route managers, a statistical correlation analysis was conducted to discern whether the  
193 extensive hygiene knowledge of the route managers was directly reflected in the  
194 hygienic conditions of the vending machines, they were responsible for.

195

#### 196 2.2.4 Food control

197 For twenty four months, 105 representative samples of all kinds of food  
198 processed in the vending company's kitchen were randomly collected from several  
199 vending machines situated in Las Palmas de Gran Canaria in sterile screw-capped wide  
200 mouthed plastic containers, at least 100 g of each sample, and then kept in a carrier box  
201 containing ice packs until delivery to the Bromatology Laboratory of the Veterinary  
202 Faculty, ULPGC within a maximum of six hours from collection. Food samples were  
203 processed in the laboratory within 12 hours of reception.

204 The microbiological analysis focused on pathogenic and potential-pathogenic  
205 microorganism markers (*Listeria monocytogenes*, *Salmonella* spp., *Escherichia coli*,  
206 *Staphylococcus aureus*). It also included spoilage-microorganisms and hygienic  
207 markers: aerobic.

208 For the microbial analysis, a representative product sample of 25 g of sample was  
209 considered. Decimal dilutions in peptone water solution (0.85% NaCl with 0.1% peptone;  
210 Cultimed, Barcelona, Spain) were used for microbial enumeration. Appropriate dilutions  
211 were transferred to the different media: Total viable counts bacteria were determined in plate  
212 count agar (PCA, Cultimed, Barcelona, Spain), incubated at 31°C for 72 h.; *S. aureus* was  
213 determined in Agar Baird Parker + RFR (bioMérieux, Marcy-I'Etoile, France) (ISO 6888-2),  
214 incubated at 37°C for 24-48 hours, and the identification of *E. coli* was realised by Coli ID

215 agar (bioMérieux, Marcy-I'Etoile, France) (AFNOR, BIO 12/19 - 12/06), incubated at 37°C  
 216 for 24-48 hours.

217 For *Listeria monocytogenes* identification, the VIDAS® LMO2 method was used,  
 218 the confirmation by spreading in Ottaviani-Agosti Agar and API Rapidec Mono  
 219 (bioMérieux, Marcy-I'Etoile, France) (AFNOR, BIO 12/11-03/04). While for *Salmonella*  
 220 spp. the method used was VIDAS® Easy SLM (bioMérieux, Marcy-I'Etoile, France)  
 221 (AFNOR BIO12/16-09/05), the confirmation in ChromIDTM *Salmonella*, incubated at 37°C  
 222 for 24 hours and for confirmation, the biochemistry test API 20 E. All samples were  
 223 analysed in duplicate.

224

225 2.2.5 Water (contained in hot drinks machines) physicochemical and microbiological  
 226 analysis:

227 Over twenty-four months, 34 samples of water placed in the hot drinks machines  
 228 were randomly collected from several vending machines situated on Las Palmas de  
 229 Gran Canaria for subsequent microbiological and physicochemical analysis at the  
 230 Bromatology Laboratory of Veterinary Faculty, ULPGC.

231 In the sampling, two sterile bottles were used, with a total volume of 400 ml. All  
 232 samples were kept at a temperature below 5°C during transport to the laboratory, for  
 233 less than two hours from collection to reception in the laboratory.

234 Microbiological analyses were performed using the membrane filtration  
 235 technique according to ISO protocols, for the detection of *E. coli* (ISO 9308-1:2002,  
 236 2002); *P. aeruginosa* (ISO 16266:2008, 2008b); *Enterococcus* spp. (ISO 7899-2:2003,  
 237 2003); and heterotrophic plate count (HPC) at 22 and 37°C (ISO 6222:2001, 2001).  
 238 Water samples of 250 mL each were filtered through a hydrophilic mixed cellulose ester  
 239 membrane (International PBI Spa, 2054045) of pore size 0.45 µm in diameter for all

organisms. The membranes were placed in each Petri dish filled with a specific medium: Tergitol TTC (Oxoid Corporation, 502948) for *E. coli*, *Pseudomonas* Agar Base/CN-Agar (Oxoid Corporation, 502946) for *P. aeruginosa*, and Slanetz and Bartley (Oxoid Corporation, PO5018A) for *Enterococcus* spp. The pour-plate method was used for the enumeration of HPC, and a sterile Petri dish was filled with 1 mL of a water sample. Amounts of 15 mL-20 mL of a Water Plate Count Agar Medium (Oxoid Corporation, CM1012B) were added. Petri dishes were incubated at 42°C for 24 h, at 37°C for 48 h, at 37°C for 48 h, and at 22-37°C for 24-72 h, for each medium and temperature, respectively. *P. aeruginosa* was confirmed using an oxidase test, a fluorescence test and cetrimide agar, followed by 24 h of incubation at 42°C.

The results were interpreted according to the current regulations for bottled water (Spanish Royal Decree (SRD) 1074/2002, by which the process of development, distribution and sale of bottled drinking water is regulated; amended by SRD 1744/2003), which states that *E. coli*, *Enterococcus* spp., *P. aeruginosa* should not be detectable in 250 ml samples of water and total coliforms in 100 ml samples of water, while HPC, at 22°C, and 37°C, should not exceed 100/ml, and 20/ml CFU, respectively.

Physicochemical analysis included the parameters: 1 – conductivity, proceeded in accordance with the standard UNE-EN 27888-1993 and was determined by a conductivity electrometry test (Crison Instruments, Allella, Spain. Basic Model 30) at 20°C, the result being expressed in  $\mu\text{S}/\text{cm}$ ; 2 – hardness, which was obtained using a kit (Total Hardness Test - Merck, Darmstadt, Germany), the result being expressed in mg/L; 3 – free residual chlorine, which was determined using a kit (Pool Tester) and pills (Lovibond, Salisbury, UK. Model DPD No 1 Rapid), the result being expressed in ppm; 4 – pH, which was determined with a pH meter (Crison Instrument, Allella, Spain. GLP-Model 22) and in pH measurements, the values were obtained at 20°C; 5 –

turbidity, measured by a turbidity meter (Hanna Instruments, Eibar, Spain. Model HI 93703) and the results were expressed in NTU.

### 2.3 Statistical analysis:

The data analysis of this work was carried out with the statistical software package SPSS 20.0 (SPSS, Chicago, IL, USA) for MAC OS X (Apple Computers, Cupertino, CA, USA).

For the assessment of the group of items common to all the vending machines, which corresponds to the general aspects of assessment common to all machines, they were classified as coming from university campuses or not. In each group, numerical variables were summarised in medians and interquartile ranges and the categorical in frequencies and percentages. Since there was no difference between groups, specific items, which varied according to whether it was a hot drink, cold drink, snack or solid products in refrigerated machine were analysed together for all machines. Spearman correlations of this average with the average grade of the route manager, and the total of the personal assessment, assessment of the vehicle and location were then obtained.

Percentages were compared as appropriate with the chi-square test or Fisher's exact test, means with the t-test and medians with the Wilcoxon test for independent data. A hypothesis test was considered statistically significant if the corresponding p-value was less than 0.05.

For the physicochemical parameters of water contained in hot drinks machines we proceeded to calculate means and standard deviations for the different determinations of the physicochemical parameters.

### 3. Results and Discussion

#### *Assessment of the adequacy of the vending machines*

##### *3.1 Vending machines HAS survey*

Table 1 shows the results concerning the aspects common to the different types of vending machines, which are those that reflect the technical-sanitary conditions of the machines. These results reveal a frankly positive assessment of the aspects common to all types of vending machines, since the 50th percentile (P50) of the total obtained valuation (V\_Total) for machines located in ULPGC buildings was 37 points and in the remaining locations where the machines were located was 38 points, with a maximum score of 40.

The results of the V7, V8, V9 and V11 variables showed in Table 1 are presented by frequencies and percentages for easier analysis. This is because all the vending machines obtained the maximum possible score or zero points.

Once a statistically significant difference between the machines situated in ULPGC buildings and the others was not found, the results regarding the specific aspects of each type of machine evaluated were analysed jointly.

##### *3.1.1 Hot drink machines*

Analysing the specific aspects of the 111 hot drinks evaluated, a satisfactory result was verified, where the V\_Total of the P50 lies at 53 points and the 75th percentile (P75) lies at 56.5 points, the maximum score being 60 (Table 2).

### 3.1.2 Cold drink machines

These results, shown in Table 3 indicate that specific aspects of cold drink machines had a high score, as reflected in the 48 points of the V\_Total corresponding to the P50 when the maximum score was 60. Notably, 75% of this type of machine obtained the maximum score in the variables V2, V3, V4, and V7, verifying that there was a correct replacement of food in the machines, thus permitting maximum compliance with the *first in - first out* (FIFO) criterion, which states that products with a closer expiry date should be the first to be expended from the machine. The fact that 75% of cold drink machines had their packaging in perfect integrity and cleanliness is a good indicator of the hygienic-sanitary conditions of the products displayed in these machines, this fact being supported by the good assessment of the remaining variables, especially considering that the glass, external panels and product collection area were also found to be in a state of maximum cleanliness.

### 3.1.3 Snack vending machines

The results expressed in Table 4 reveal the fairly good hygienic-sanitary state of this type of machine, considering their specific aspects. It should be noted that the maximum score was obtained for seven of the eight variables considered on the P75, and that the V\_Total in this percentile was 55 points out of 60.

### 3.1.4 Refrigerated vending machines dispensing solid food products

339 Finally, Table 5 shows the results for the specific aspects of refrigerated vending  
340 machines dispensing solid food products.

341 In general, as shown by the V\_Total of 52 points at P50 and 54 points at P75,  
342 these machines obtained high scores for the specific aspects under assessment, although  
343 in a few cases the temperature of expended food exceeded the critical limit of a cooling  
344 temperature of 8°C (Jevsnik *et al.*, 2013), which could pose a potential risk to  
345 consumers. On the other hand, a low valuation of variable V3 was verified, meaning  
346 that labelling needed to be improved, making it more suitable, complementing the  
347 information on some products and making it visible to consumers who wished to  
348 purchase a product in such machines.

349

350 Of the 338 machines which were evaluated with the HAS survey, 324 obtained  
351 an overall score of  $\geq 75$ , corresponding to 96% of all assessed machines. The mean total  
352 valuation (common aspects + specific aspects) was  $87.6 \pm 7.5$ .

353

### 354 3.2 Food replenishment route in vending machines HAS survey

355

356 Based on the analysis of the results shown in Table 6, regarding the route of  
357 food replenishment in vending machines, it is important to highlight the good score  
358 obtained in the groups Replenishing Staff and Machine Location, as shown by the P50  
359 of 35.5 and 17 points (out points 40 and 20 respectively). Regarding the Vehicles and  
360 Transportation group, their total obtained valuation (VVT\_Total) was significantly  
361 lower (P50 out of 23 points), positively highlighting the VVT1 variable. An  
362 improvement in these results would be obtained by increasing the number of isothermal  
363 and/or refrigerated vehicles (50%) for the different food replenishment routes. Thus, the



risk of breaking the cold chain in the transportation of perishable foods which need to be transported at refrigerated temperatures would be avoided.

During the period in which this study was conducted there were 12 route managers responsible for replenishing the food in the vending machines analysed. Of the 12 managers who carried out the food replenishment in the vending machines HAS survey, 7 obtained an overall score of  $\geq 75$ , corresponding to 58% of the total number of route managers evaluated. The mean total valuation (Groups: Replenished Staff + Machines Location) was  $75.3 \pm 10.1$ . As 5 managers received an overall score  $< 75$ , it was not possible to correlate them with the location of the machines which they were in charge of, considering that each manager topped up several machines in different areas.

In the literature reviewed for this work, no studies were found where HAS surveys were used to perform a hygienic-sanitary assessment in the vending industry. However, several authors (Garcia Pinillos & Jukes, 2008; Carrascosa, 2010; Pérez, 2012) have used and adapted this assessment tool in their investigations, obtaining final scores lower than those reached in the present paper.

Comparing the results of the HAS surveys conducted in the present work with those obtained in the above studies, it can be concluded that the hygienic-sanitary state of the vending machines was assessed in a very acceptable way, although the food replenishment route carried out by different route managers had the highest rate of exclusion.

### *3.3 Route managers' hygienic knowledge*

388 As a group, the route managers (12) obtained a minimum score of 75% correct  
389 answers on the food handlers' examination test; the average mark for this test was  $22 \pm$   
390 1.35, out of a maximum of 25 points. According to the results, it can be seen that  
391 despite the hygiene knowledge possessed by these managers, this fact did not imply a  
392 high assessment of the state of the food replenishment route for the machines which  
393 they are responsible for. The best explanation for this fact is related to the variable  
394 VVT1 where the P50 was 0. The fact that the vehicle used to carry out the route most of  
395 the time was not isothermal and/or refrigerated, even though it is not a direct  
396 responsibility of the route manager, could help improve the rating if the company had  
397 adequate resources. Comparing the results of the remaining sections of the two HAS  
398 surveys used in this work; it can be observed that the knowledge of the managers and  
399 high hygienic-sanitary state of the vending machines and the route for which they are  
400 responsible are related.

401 Other studies conducted in the food sector have also used a food handlers'  
402 examination test to assess the hygienic knowledge of food handlers, obtaining  $\geq 90\%$   
403 correct answers (Garayoa *et al.*, 2011) and  $> 80\%$  (Carrascosa, 2010).

404 The results obtained in the present paper show that the food handlers (route  
405 managers) evaluated have a high level of hygiene knowledge compared to the studies  
406 referred to above.

407

#### 408 3.4 Route manager/vending machine association

409

410 Spearman correlations established between the hygienic-sanitary evaluation of  
411 different vending machines and the route managers who were responsible for the food  
412 replenishment route for the machines are presented in Table 7.

413 From the analysis of these results is not possible to draw any statistically  
 414 significant correlation between the hygienic-sanitary state of the machines and the route  
 415 managers' hygienic knowledge/hygienic-sanitary conditions of the food replenishment  
 416 route ( $p > 0.05$ ).

417 Figure 1 shows the absence of any correlation between the total evaluation of  
 418 vending machines (common aspects + specific aspects) and the total evaluation of the  
 419 route manager (VPR + VVT + VUM) ( $p = 0.159$ ).

420 One possible reason which makes it impossible to establish any kind of route  
 421 manager/vending machine correlation could be the fact that the number of managers  
 422 was limited. To overcome this barrier it would be necessary to distribute the total  
 423 number of machines between more route managers, which would cause significant  
 424 expense to the company, as it would need to hire more staff.

425

### 426 *3.5 Microbiological evaluation of processed foods in the vending company*

427

428 The microbiological study of the 105 food samples processed by the vending  
 429 company and supplied in the machines, detected that 5.7% (6 samples) failed to comply  
 430 with the microbiological criteria laid down by Regulation (EC) No. 2073 / 2005 of the  
 431 Commission of 15 November 2005 on microbiological criteria for foodstuffs, as  
 432 specified for *L. monocytogenes*. These six samples included: three of tuna paste and  
 433 corn, one of watercress paste, one of vegetables and one breast of chicken sandwich.  
 434 These data can be justified by the characteristics of the products, which are favourable  
 435 to the development of *L. monocytogenes*, especially the high aw and the presence of  
 436 mayonnaise related to the high degree of handling, so ultimately they are easier to  
 437 contaminate. Similarly, *L. monocytogenes*, which has been associated with outbreaks in

Europe, was found in sandwiches (Wilson, 1996; Dawson *et al.*, 2006; Little *et al.*, 2008; Little *et al.*, 2009; Pesavento *et al.*, 2010). One possibility to reduce the likelihood of the development of *L. monocytogenes* would be to package it in a modified atmosphere (Sørheim *et al.*, 2004) or through the addition of nitrites (Kouakou *et al.*, 2009).

The average total aerobic mesophilic count, was  $18 \times 10^3$  CFU/g  $\pm$   $15 \times 10^3$  CFU/g, meaning that all samples analysed were presented in accordance with the criteria established by SRD 3484/2000, which lays down the health rules for the production, distribution and sale of prepared meals. Although this SRD is repealed in paragraphs 11 and 12 of Article 6 and Annex by SRD 135/2010, meaning that there are repealed provisions relating to microbiological criteria for foodstuffs, it was considered important to perform the aerobic mesophilic count and compare it with the criteria established by the SRD as a parameter of quality for prepared foods.

The other microbiological analyses in the present study obtained results which met the criteria established by SRD 3484/2000 in all cases.

In a similar way to our work, *L. monocytogenes* was identified in sandwiches in a study conducted in the United Kingdom (Little *et al.*, 2009), and in a sampling of sandwiches in vending machines (HPA, 2007). The authors of these two studies have commented on the importance of good food handling practices and temperature control as essential factors to prevent the development of diseases such as listeriosis, attributing the possible cause of the presence of *L. monocytogenes* in the food analysed to non-compliance with these requirements. In the present study, the handling practices where the sandwiches were prepared was not audited and may be because *L. monocytogenes* grows well in refrigeration and a shortened shelf-life would avoid the appearance of *L. monocytogenes*.

The absence of *Salmonella* spp., *E. coli* and *S. aureus* counts in the analysed samples are in agreement with the results of a similar study conducted on prepared foods (Pérez *et al.*, 2011).

### 3.6 Evaluation of food processors' hygienic knowledge

All the food processors (9) obtained at least 75% correct answers in the food handlers' examination test which was carried out, with an average score of  $21.4 \pm 1.24$ , out of a maximum of 25 points. These results indicate the high level of knowledge they had, similar to that demonstrated by route managers. This high level of hygiene knowledge could explain the generally acceptable results of the microbiological food assessment noted above, except for the six cases with *L. monocytogenes*. These cases, could be attributed to a loss of proper temperature control in the food, since poor handling practices are not indicated by the results of the food handlers' examination test. On the other hand, we can also assume that the transfer of knowledge and the implementation of hygienic knowledge of the food handlers in the kitchen, is questionable due to the presence of *L. monocytogenes*, which could be due to a failure in hygiene during processing

### 3.7 Evaluation of microbiological and physicochemical parameters of water contained in hot drinks machines

Microorganisms were not detected in any of the samples (34) that were taken to carry out microbiological analysis of the water to be used for hot drinks, demonstrating its high microbiological quality and compliance with the criteria established by SRD

1074/2002, by which the processing, distribution and sale of bottled drinking water is regulated; amended by SRD 1744/2003, establishing the sanitary criteria of water quality for human consumption.

Table 8 contains the results of the physicochemical evaluation of water expressed as means ( $\bar{x}$ ) and standard deviations ( $\sigma$ ) with the respective reference values according to SRD 1074/2002, by which the processing, distribution and sale of bottled drinking water is regulated; amended by SRD 1744/2003 and FACSA (2013). The results in Table 8 show the compliance of all parameters analysed with the reference values of the current regulations such as the SRD 1074/2002, by which the processing, distribution and sale of bottled drinking water is regulated; amended by SRD 1744/2003 and FACSA (2013). The fact that it was very soft water, with average values of hardness of  $68.95 \text{ mg/l} \pm 26.26 \text{ mg/l}$ , presupposes a low concentration of calcium, magnesium, strontium and barium ions. In the current legislation there are no criteria in relation to the hardness of the water.

According to the physicochemical and microbiological evaluation it can be stated that the water supplied to the hot drink machines is suitable, which has an important influence on the quality of the final product dispensed by such machines.

The results of the present study reveal the high quality of the water which was contained in the vending machines compared to other studies (Schillinger & Du Vall Knorr, 2004).

#### 4. Conclusions

This study provides important data about the relationship between the hygienic-sanitary state of vending machines and the quality/safety of the products expended by

512 them, taking into account the importance of the hygiene knowledge of the intervening  
513 food handlers.

514 The HAS surveys and food handlers examination tests have proven to be an  
515 excellent tool for assessing HACCP prerequisites. In this case, discovering deficiencies  
516 in the transportation of food and possible hygiene deficiencies found during the  
517 processing of products produced by the vending company. Therefore, we believe  
518 vending companies should focus their efforts on ensuring the hygiene of their products  
519 by reducing risks, rather than trying to extend their shelf-life, which could contribute to  
520 increasing these very risks.

521 Further studies focused on the relationship between the hygienic-sanitary state of  
522 vending machines and the hygienic knowledge of food handlers should provide more  
523 raw data about the importance of the influence of hygiene knowledge and its  
524 applicability by food handlers in the quality and safety of the products expended to the  
525 consumer.

526

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528

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532

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**Table 1. Common aspects of all types of vending machines – HAS survey.**

	ULPGC buildings						p
	Yes (n = 70)			No (n = 268)			
	Percentile			Percentile			
	P25	P50	P75	P25	P50	P75	
V1	5	5	5	5	5	5	NS
V2	5	5	5	5	5	5	NS
V3	5	5	5	5	5	5	NS
V4	4	5	5	5	5	5	NS
V5	5	5	5	5	5	5	NS
V6	5	5	5	5	5	5	NS
V10	3	3	4	3	3	4	NS
V_Total	35	37	38	36	38	39	0.057

Item	Total N = 338	ULPGC buildings		p
		Yes	No	
		N = 70	N = 268	
V7, n (%)	326 (96.4)	70 (100)	256 (95.5)	0.071
V8, n (%)	338 (100)	70 (100)	268 (100)	NS
V9, n (%)	136 (40.2)	22 (31.4)	114 (42.5)	0.091
V11, n (%)	337 (99.7)	70 (100)	267 (99.6)	NS

V1= Provided with operation indicator and visible thermometer (refrigerated foods) - maximum score = 5

V2= Correctly identified. Outer label with address of the operator - maximum score = 5

V3= Absence of reserves (expired products stored in the machine) - maximum score = 5

V4= Acceptable general external cleanliness - maximum score = 5

V5= Correct internal lighting of the machines - maximum score = 5

V6= Replenished foodstuffs according to expiry dates or best-before dates - maximum score = 5

V7= Machine with change. Check purse - maximum score = 1

V8= Reset all those products which for different reasons are not in conditions for consumption - maximum score = 1

V9= Effective and non unhealthy methods of cleanliness and hygiene - maximum score = 2

V10= Failures are not detected in the cleaning, disinfection, disinsectization and deratization plan - maximum score = 4

V11= Use of authorized products and materials - maximum score = 2

V\_Total= Total score obtained from V1 to V11 - maximum score = 40

NS= No statistical significance

**Table 2. Specific aspects of hot drink vending machines – HAS survey.**

Variable	Percentile		
	25%	50%	75%
V1	5.0	5	5.0
V2	5.0	5	5.0
V3	5.0	5	5.0
V4	3.0	4	4.5
V5	4.0	4	5.0
V6	3.0	4	5.0
V7	3.0	4	5.0
V8	3.0	4	5.0
V9	4.0	4	5.0
V10	3.0	4	5.0
V11	5.0	5	5.0
V12	5.0	5	5.0
V_Total	49.5	53	56.5

Data are expressed as median (interquartile ranges)

V1= Ingredients with correct organoleptic characteristics. Rancid milk, sugar or caked tea - maximum score = 5

V2= Chocolate without evidence of insects (weevils) - maximum score = 5

V3= Mixed with drinking water (SRD 140/2003) - maximum score = 5

V4= Proper general interior cleaning - maximum score = 5

V5= Cleaning between containers - maximum score = 5

V6= Cleaning of funnels and beaters - maximum score = 5

V7= Cleanliness of the coffee making apparatus - maximum score = 5

V8= Cleaning of trays - maximum score = 5

V9= Cleaning of sugar pivot and cup fall - maximum score = 5

V10= Swept and cleaned waste bin - maximum score = 5

V11= The mixtures are homogeneous and there is no sediment or suspension of undissolved particles - maximum score = 5

V12= Suitable beverage temperatures for support material used - maximum score = 5

V\_Total= Total score obtained from V1 to V12 - maximum score = 60

**Table 3. Specific aspects of cold drink vending machines – HAS survey.**

N = 82	Percentile		
Variable	25%	50%	75%
V1	5.00	7	8.00
V2	4.00	5	5.00
V3	4.00	5	5.00
V4	10.00	10	10.00
V5	6.00	7	8.00
V6	6.00	7	9.00
V7	9.25	10	10.00
V_Total	43.00	48	51.75

Data are expressed as median (interquartile ranges)

V1= Suitable temperature of 5°C - maximum score = 10

V2= Cleaning of glass and external panels – maximum score = 5

V3= Cleaning of product collection area - maximum score = 5

V4= Packaging complete and clean - maximum score = 10

V5= Cleaning of condenser grids - maximum score = 10

V6= Evaporator - maximum score = 10

V7= FIFO criterion is met - maximum score = 10

V\_Total= Total score obtained from V1 to V7 - maximum score = 60



**Table 4. Specific aspects of the snack vending machines – HAS survey.**

N = 74	Percentile		
Variable	25%	50%	75%
V1	6.25	10	10
V2	10.00	10	10
V3	5.00	5	5
V4	4.00	6	7
V5	5.00	5	5
V6	4.00	5	5
V7	4.00	5	5
V8	10.00	10	10
V_Total	47.00	52	55

Data are expressed as median (interquartile ranges)

V1= FIFO criterion is met for placement in the spirals - maximum score = 10

V2= Complete, clean, airtight packaging - maximum score = 10

V3= Identified product. All selections have labels - maximum score = 5

V4= Visible information about each product, especially expiry date labelling - maximum score = 10

V5= Cleaning of condenser grids - maximum score = 5

V6= Cleaning of product collection area - maximum score = 5

V7= Cleaning of glass panels - maximum score = 5

V8= Appropriate air conditioning temperature - maximum score = 10

V\_Total= Total valuation obtained from V1 to V8 - maximum score = 60

**Table 5. Specific aspects of the refrigerated vending machines dispensing solid food products – HAS survey.**

N = 71		Percentile		
Variable		25%	50%	75%
V1		10	10.0	10
V2		10	10.0	10
V3		5	5.0	5
V4		6	9.0	11
V5		3	4.5	5
V6		10	10.0	10
V_Total		49	52.0	54

Data are expressed as median (interquartile ranges)

V1= Original packaging material for food use - maximum score = 10

V2= Complete, clean, airtight packaging - maximum score = 10

V3= Correct labelling - maximum score = 10

V4= Cooling temperature of the machine does not exceed 8° C - maximum score = 15

V5= Cleaning of condenser grids - maximum score = 5

V6= Placement/exposure tidy and hygienic - maximum score = 10

V\_Total= Total score obtained from V1 to V6 - maximum score = 60

**Table 6. Route of food replenishment in vending machines – HAS survey.**

Group	Variable	Percentile		
		P25	P50	P75
Replenishing staff	VPR1	6.00	7.50	8.25
	VPR2	2.75	3.00	4.25
	VPR3	5.00	5.00	5.00
	VPR4	3.75	4.50	5.00
	VPR5	4.75	5.00	5.00
	VPR6	3.75	5.00	5.00
	VPR7	5.00	5.00	5.00
	VPR_Total	29.00	35.50	36.25
Vehicles and Transportation	VVT1	0.00	0.00	7.00
	VVT2	2.75	3.00	4.00
	VVT3	5.00	5.00	5.00
	VVT4	3.75	4.00	5.00
	VVT5	3.75	4.00	5.00
	VVT6	2.00	3.00	4.00
	VVT7	1.00	3.50	5.00
	VVT_Total	21.00	23.00	30.25
Location of machines	VUM1	4.75	5.00	5.00
	VUM2	3.75	4.00	4.00
	VUM3	5.00	5.00	5.00
	VUM4	4.00	4.00	4.25
	VUM_Total	16.75	17.00	18.25

VPR1= There is a training plan for replenishing staff - maximum score = 10

VPR2= There is evidence of the implementation of the previous plan - maximum score = 5

VPR3= Use of suitable clothes, exclusively used for replenishing - maximum score = 5

VPR4= The level of cleanliness of the clothes and the hygienic appearance is globally acceptable - maximum score = 5

VPR5= Personal grooming is globally suitable - maximum score = 5

VPR6= Proper cleaning of hands - maximum score = 5

VPR7= Cuts are protected with waterproof dressings - maximum score = 5

VPR\_Total = Total valuation obtained from VPR1 to VPR7 - maximum score = 40

VVT1= The vehicle for the route is isothermal and/or refrigerated - maximum score = 10

VVT2= It has elements to ensure the cold chain - maximum score = 5

VVT3= It has a plan of cleaning, disinfection, disinsectization and deratization - maximum score = 5

VVT4= There is evidence of compliance with the previous plan - maximum score = 5

VVT5= Proper cleaning of the vehicle - maximum score = 5

VVT6= Transportation of perishable products at appropriate temperatures - maximum score = 5

VVT7= Transport of cleaning products perfectly separated from the food - maximum score = 5

VVT\_Total = Total valuation obtained from VVT1 to VVT7 - maximum score = 40

VUM1= Separated from the wall - maximum score = 5

VUM2= Away from sources of contamination - maximum score = 5

VUM3= The site area is ventilated - maximum score = 5

VUM4= The exterior hygienic aspect can be considered acceptable - maximum score = 5

VUM\_Total = Total valuation obtained from VUM1 to VUM4 - maximum score = 20

**Table 7. Spearman correlations (p-value) between the valuation variables of the route manager and the vending machine scores.**

Valuations	Food handlers examination	Route manager (VPR+VVT+VUM)
Route manager (VPR + VVT + VUM)	-0.095 (0.769)	
Vending machine (common aspects)*	0.226 (0.479)	-0.238 (0.457)
Vending machine (common aspects + specific aspects)*	0.340 (0.280)	-0.434 (0.159)

(\*) Average scores of machines assigned to each route manager

VPR= Replenishing staff score

VVT= Vehicles and Transportation score

VUM= Machines location score

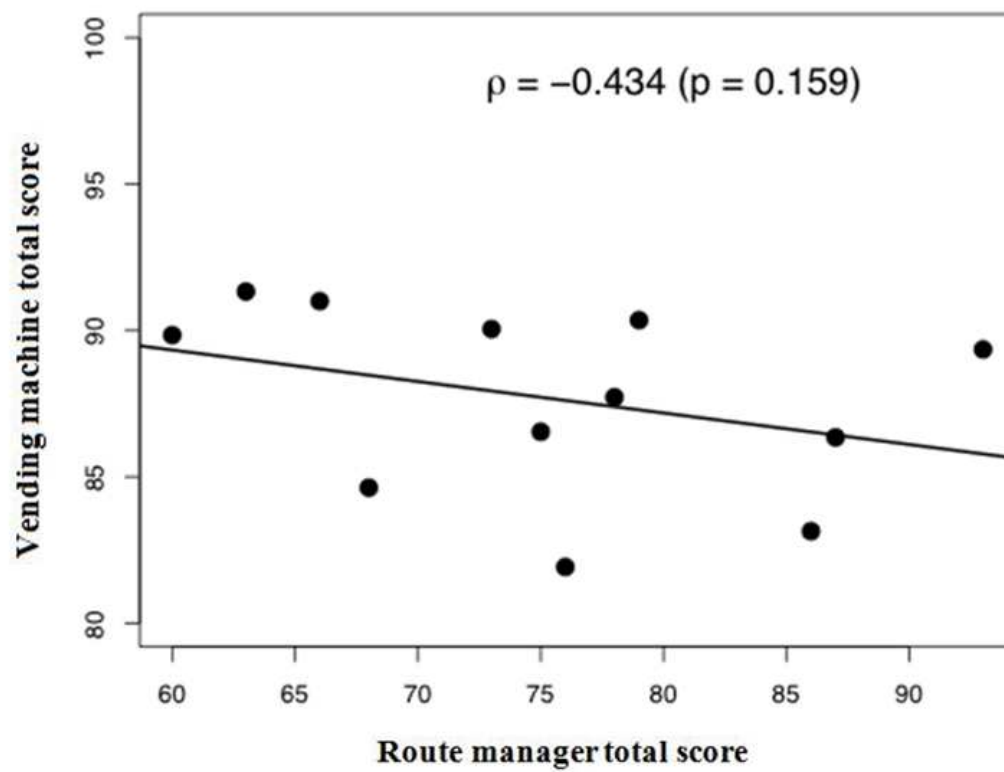
**Table 8. Water physicochemical evaluation.**

Determinations	Results		Reference parameters	
	$\bar{x}$	$\sigma$		
free from residual chlorine (ppm)	0.27	0.19	*	$\leq 1$
pH	7.98	0.23	*	6.5 – 9.5
conductivity ( $\mu\text{S}/\text{cm}$ )	648.38	90.59	*	$\leq 2500$
Turbidity (NTU)	0.67	0.57	*	$\leq 5$
			**	< 70: very soft water
				70 – 140: soft water
hardness (mg/l)	68.95	26.26	140 – 320: intermediate hardness	
				320 – 540: hard water
				> 540: very hard water

\*SRD 140/2003

\*\*FACSA (2013)

Figure 1. For each manager, total score of assigned vending machines versus route manager total score.



**Highlights**

- Analysis of quality and safety parameters of food products sold in vending machines
- A hygienic-sanitary assessment was conducted on 338 vending machines
- The microbiological analysis showed that 5.7% of the 105 food samples were contaminated with *Listeria monocytogenes*
- Deficit of vehicles able to transport perishable food at proper temperatures should be noted