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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 ± 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 (< 8ºC) 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.

1. Introduction

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

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

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

Under the HACCP system, food business operators ensure that all stages of production, processing and distribution of food under their control satisfy the relevant hygiene requirements laid down in Regulation (EC) No. 852/2004. Successful implementation of the procedures based on HACCP principles requires the full cooperation and commitment of food business employees. To this end, employees 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*

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

2.2.4 Food control

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

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

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

agar (bioMérieux, Marcy-I´Etoile, France) (AFNOR, BIO 12/19 - 12/06), incubated at 37ºC for 24-48 hours.

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

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

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

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

Microbiological analyses were performed using the membrane filtration technique according to ISO protocols, for the detection of *E. coli* (ISO 9308-1:2002, 2002); *P. aeruginosa* (ISO 16266:2008, 2008b); *Enterococcus* spp. (ISO 7899-2:2003, 2003); and heterotrophic plate count (HPC) at 22 and 37ºC (ISO 6222:2001, 2001). Water samples of 250 mL each were filtered through a hydrophilic mixed cellulose ester 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 42ºC for 24 h, at 37ºC for 48 h, at 37ºC for 48 h, and at 22-37ºC 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 42ºC.

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 μS/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 –

265 turbidity, measured by a turbidity meter (Hanna Instruments, Eibar, Spain. Model HI
266 93703) and the results were expressed in NTU.
267
268 *2.3 Statistical analysis:*

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

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

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

285 For the physicochemical parameters of water contained in hot drinks machines
286 we proceeded to calculate means and standard deviations for the different
287 determinations of the physicochemical parameters.
288
289

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).

315 *3.1.2 Cold drink machines*

316

317 These results, shown in Table 3 indicate that specific aspects of cold drink
318 machines had a high score, as reflected in the 48 points of the V_Total corresponding to
319 the P50 when the maximum score was 60. Notably, 75% of this type of machine
320 obtained the maximum score in the variables V2, V3, V4, and V7, verifying that there
321 was a correct replacement of food in the machines, thus permitting maximum
322 compliance with the *first in - first out* (FIFO) criterion, which states that products with a
323 closer expiry date should be the first to be expended from the machine. The fact that
324 75% of cold drink machines had their packaging in perfect integrity and cleanliness is a
325 good indicator of the hygienic-sanitary conditions of the products displayed in these
326 machines, this fact being supported by the good assessment of the remaining variables,
327 especially considering that the glass, external panels and product collection area were
328 also found to be in a state of maximum cleanliness.

329

330 *3.1.3 Snack vending machines*

331

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

336

337 *3.1.4 Refrigerated vending machines dispensing solid food products*

338

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

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

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

3.2 Food replenishment route in vending machines HAS survey

Based on the analysis of the results shown in Table 6, regarding the route of food replenishment in vending machines, it is important to highlight the good score obtained in the groups Replenishing Staff and Machine Location, as shown by the P50 of 35.5 and 17 points (out points 40 and 20 respectively). Regarding the Vehicles and Transportation group, their total obtained valuation (VVT_Total) was significantly lower (P50 out of 23 points), positively highlighting the VVT1 variable. An improvement in these results would be obtained by increasing the number of isothermal 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 338 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 ≥ 75, corresponding to 58% of the total number of route managers evaluated. The mean total valuation (Groups: Replenished Staff + Machines Location) was 75.3 ± 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

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

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

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

3.4 Route manager/vending machine association

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

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

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

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

3.5 Microbiological evaluation of processed foods in the vending company

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

438 Europe, was found in sandwiches (Wilson, 1996; Dawson *et al*., 2006; Little *et al*.,
439 2008; Little *et al*., 2009; Pesavento *et al*., 2010). One possibility to reduce the likelihood
440 of the development of *L. monocytogenes* would be to package it in a modified
441 atmosphere (Sørheim *et al*., 2004) or through the addition of nitrites (Kouakou *et al*.,
442 2009).

443 The average total aerobic mesophilic count, was $18x10^3$ CFU/g ± $15x10^3$ CFU/g,
444 meaning that all samples analysed were presented in accordance with the criteria
445 established by SRD 3484/2000, which lays down the health rules for the production,
446 distribution and sale of prepared meals. Although this SRD is repealed in paragraphs 11
447 and 12 of Article 6 and Annex by SRD 135/2010, meaning that there are repealed
448 provisions relating to microbiological criteria for foodstuffs, it was considered
449 important to perform the aerobic mesophilic count and compare it with the criteria
450 established by the SRD as a parameter of quality for prepared foods.

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

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

463 The absence of *Salmonella* spp., *E. coli* and *S. aureus* counts in the analysed
464 samples are in agreement with the results of a similar study conducted on prepared
465 foods (Pérez *et al.*, 2011).
466
467 *3.6 Evaluation of food processors' hygienic knowledge*
468
469 All the food processors (9) obtained at least 75% correct answers in the food
470 handlers' examination test which was carried out, with an average score of 21.4 ± 1.24,
471 out of a maximum of 25 points. These results indicate the high level of knowledge they
472 had, similar to that demonstrated by route managers. This high level of hygiene
473 knowledge could explain the generally acceptable results of the microbiological food
474 assessment noted above, except for the six cases with *L. monocytogenes*. These cases,
475 could be attributed to a loss of proper temperature control in the food, since poor
476 handling practices are not indicated by the results of the food handlers' examination
477 test. On the other hand, we can also assume that the transfer of knowledge and the
478 implementation of hygienic knowledge of the food handlers in the kitchen, is
479 questionable due to the presence of *L. monocytogenes*, which could be due to a failure
480 in hygiene during processing
481
482 *3.7 Evaluation of microbiological and physicochemical parameters of water*
483 *contained in hot drinks machines*
484
485 Microorganisms were not detected in any of the samples (34) that were taken to
486 carry out microbiological analysis of the water to be used for hot drinks, demonstrating
487 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 (σ) 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 mg/l ± 26.26 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) Percentile			No (n = 268) 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 N = 70	No 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.

N = 111	Percentile		
Variable	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 5ºC - 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.

		Percentile		
Group	Variable	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

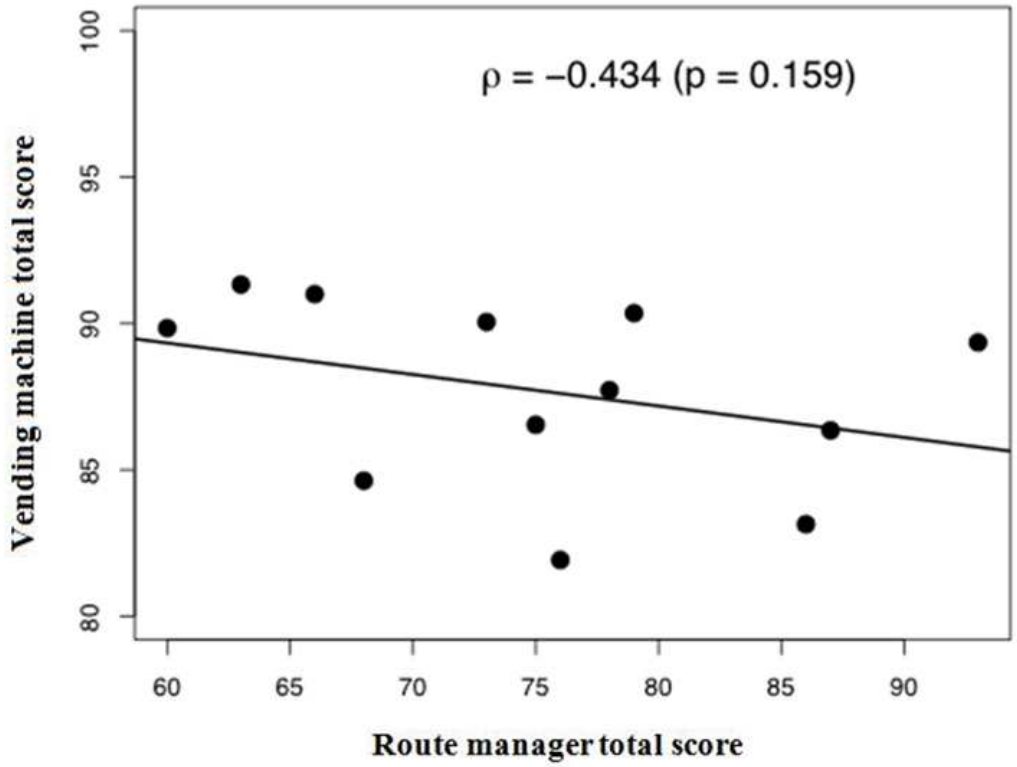
VPR= Replenishing staff score
VVT= Vehicles and Transportation score
VUM= Machines location score

Table 8. Water physicochemical evaluation.

Determinations	Results		Reference parameters	
	$\bar{x}$	σ		
free from residual chlorine (ppm)	0.27	0.19	*	≤ 1
pH	7.98	0.23	*	6.5 – 9.5
conductivity (μS/cm)	648.38	90.59	*	≤ 2500
Turbidity (NTU)	0.67	0.57	*	≤ 5
hardness (mg/l)	68.95	26.26	**	< 70: very soft water 70 – 140: soft water 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