Benchmarking the Hygiene of Utensils in Butcheries or Retail Stores

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ABSTRACT

This study is benchmarking the hygiene of utensils (knives, cleavers, trays) for butchery stores within supermarkets. Aerobic Plate Count, Coliform count and *E.coli* count were used as indicators. Sampling was performed upon 1297 surfaces of utensils of butcheries in supermarkets within a year. The benchmarking of hygiene developed by comparing surfaces of utensils, regions of the stores and time periods within a year. Final evaluation lead to characterization of the hygiene levels as satisfactory, acceptable or unsatisfactory, as well as to pass or fail decisions. The highest percentage of fail samples was observed for cutting trays, whilst two regions demonstrated most of the fail samples. Particularly most of the fail samples were observed during the period of January-February and July-August. Concerning Aerobic Plate Count 90% of the cases were satisfactory and acceptable, for Coliforms the satisfactory cases were 95% and for *E. Coli* the 99.4% of the cases were satisfactory.

Introduction

The insufficient hygiene standards are associated with contamination of surfaces in food companies [1,2]. Despite the fact that in most countries the hygiene standards, food processing practices and education of food handlers are in a good level, food-borne diseases remain an issue of public health [3]. In many studies, food processing utensils have proved to be a source of contamination for pathogens such as *Listeria monocytogenes* [4-7]. According to the EC Regulation 852/2004 [8], utensils in food contact must be effectively cleaned and, where necessary, disinfected. The cleaning and disinfection should be performed frequently enough to avoid the risk of contamination and utensils to be kept in good condition to minimize the risk of contamination. For these reasons, major retail chains, which desire full compliance with hygiene regulations, as well as to ensure maximum safety of the products, conduct a series of surface samplings in utensils of butchery departments. Microbiological contamination in butcher shops is reported by several authors [9,10].

All the retail stores should implement Food Safety Management System according to the HACCP (Hazard Analysis and Critical Control Points) principles of Codex Alimentarius [11]. Though most of the modern food safety management systems, like ISO 22000, are based on HACCP principles, there is limited literature comparing commercial food safety standards with applied sanitation procedures. According to Tomasevic *et al.* [12], the vast majority (96.1%) of surveyed meat operators in Serbia have cleaning and sanitation procedures in place. They demonstrated that the 93.5% of the meat operators have certified HACCP system, of which only the 9.1% with the ISO 22000 standard and 1.3% with the IFS standard. A few years earlier Poumeyrol *et al.* [13] demonstrated that many bacterial hazards, particularly *Listeria monocytogenes*, *Salmonella* and *Staphylococcus aureus* could be effectively controlled by good hygiene practices in pork butchery while preparing neat paté. Arvanitoyannis *et al.* [14] presented extensively the sanitation procedures for meat products regarding the simultaneous implementation of HACCP systems.

A microbial indicator demonstrates that a food product is exposed to conditions of possible contamination by a pathogen or it is held under conditions for pathogen growth [15-17]. The total viable counts, counts of *Enterobacteriaceae*, total Coliforms or *E. coli* are indicators associated with hygiene practices. Food contact surfaces contaminated with microorganisms that may survive and be transmitted on foodstuffs cause hygiene problems which may be fatal for the health of the consumers.

The purpose of this study was to benchmark cutting surfaces of butcheries, time periods within a year and geographical regions of the supermarket store upon hygiene indicators. Within the context of the sixth principle of HACCP, which is to validate the preventive measures, sampling was carried out with sterile contact plates on butchery utensils that were cleaned and disinfected according to the instructions of the daily cleaning plan. After sampling, the contact plates were used for analysis of Aerobic Plate Count, *E. coli* and Coliforms.

Material and Methods

Materials

For the collection and analysis of surfaces, ready sterilized contact plates, «Envirocheck Contact C, 1.02136.0001» were used [18]. These contact plates consist of a double surface and each surface has a different constitution of substrate. One side (Side 1) contains the "Plate Count Agar", which is a substrate appropriate for the isolation and measurement of total viable count [19], while the other side (Side 2) contains the «Chromocult Coliform Agar», which is appropriate for the isolation and measurement of Coliforms [18]. A portable refrigerator was used for the transportation of the samples to the laboratory, whilst a digital thermometer (EBI 300 Temperature Data Logger) was used to monitor the temperature at 2-4 °C [18]. The samples were placed in an incubator at 37 °C [19]. A colony counter device was used to count the colonies developed on the sterilized contact plates (Bibby Sterilin Ltd., Colony Counter, model SC-6).

Collection of data and preparation

The samples of the surfaces of butchery utensils were collected under aseptic conditions according to ISO 18593:2004 [20]. The sampling scheme all around a calendar year began at 18/01/2013 and finished at 11/01/2014. The procedure was as follows: Firstly the protective cover was removed and the contact plate was pressed carefully from both sides on the same sampling surface but on different locations. During one year, from 18/01/2013 to 11/01/2014, six samplings took place every second month, more or less at the same week distance from each previous sampling. The average number of samples per sampling period was 216, of which by average 68 from Attiki, 43 from Central Macedonia, 19 from Thessaly, 16 from Crete, 14 from Peloponnese, 13 from East Macedonia-Thrace, 11 from West Macedonia, 10 from Central Greece and West Greece and 3 from Ionian island and South Aegean respectively. A total number of 1297 samples was collected, of which 272 were from knifes, 590 from knifes stored in UV cabinet, 55 from cleaver, 95 from cleaver stored in UV cabinet, 282 from trays and 3 from trays stored in UV cabinet. The samples were sent for analysis to accredited microbiological laboratory. The data was registered on Microsoft Excel spreadsheets with the following variables: sampling period, geographical region, kind of utensils, stored in UV cabinet or not, Aerobic Plate Count, Coliform count, *E. coli* count, the hygiene level characterization (satisfactory, accepted or unsatisfactory) and the pass or fail decision. Statistical analysis was performed with the software PASW 19 (IBM 2010) and Statistica 8.0 (StatSoft Inc. 2007).

Methods

The total viable count (TVC) was performed with a colony counter (Bibby Sterilin Ltd. UK) on both sides of the plates after 48 hour incubation. All colonies were counted according to the Merck protocol [20]. The colonies on the one side (with plate count agar) were counted for Aerobic Plate Count (APC) and on the other side (with Chromocult Coliform agar) the red colonies were counted as Coliforms and the blue as *E. coli* [18].

The results were evaluated according to the following microbiological criteria: the Aerobic Plate Count was considered satisfactory if ≤4 cfu/cm^2, acceptable if >4 cfu/cm^2 to ≤12 cfu/cm^2 and unsatisfactory if >12 cfu/cm^2, the count for Coliforms was considered satisfactory if <1 cfu/cm^2 and unsatisfactory if ≥1 cfu/cm^2, the count for *E. coli* was considered satisfactory if <1 cfu/cm^2 and unsatisfactory if ≥1 cfu/cm^2. Upon having this characterization, samples were categorized to pass or fail. If at least one of the 3 indicators was unsatisfactory the case was a fail sample. All the other combinations were pass samples.

Results and Discussion

According to the statistical analysis, the hygiene level of butchery equipment concerning Aerobic Plate Count, Coliforms and *E. coli* was satisfactory to a level of 85.6%, 94.6% and 99.4% respectively. Among butchery utensils (knifes, cleavers, trays, or knifes, cleavers and trays stored in UV cabinet) the group with the highest percentage of satisfactory results were the cleavers stored in UV cabinet (94.7%), followed by knifes stored in UV cabinets (94.4%). The group of utensils that presented the highest percentage of unsatisfactory results were the trays stored in UV cabinets (33.3%), followed by the trays (25.5%). Comparing the periods of the sampling procedure we notice that during the period T1 (from 18 January 2013 to 4 March 2013) and T2 (from 8 March 2013 to 29 April 2013), we have the highest number of unsatisfactory samples for Aerobic Plate Count (11.4%) for both of periods (25 and 24 unsatisfactory of totally 219 and 211 samples respectively). Concerning Coliforms, the period T1 has the highest number of unsatisfactory samples (10%) with 22 unsatisfactory of totally 219 samples. Concerning *E. coli,* during the period T1 (from 18 January 2013 to 4 March 2013) and T4 (from 01 July 2013 to 31 August 2013), we have the highest number of unsatisfactory samples, 3 for each period. The benchmarking among sampling regions shows that the percentages of the pass samples are much more to the fail samples, with prevalent the region of Crete, where the percentage of pass samples was 97% (94 pass of totally 97 samples). The initial number of samples was 1297 and the number of pass samples was 1153 (88.9%). The process of elimination is presented in Figure 1.
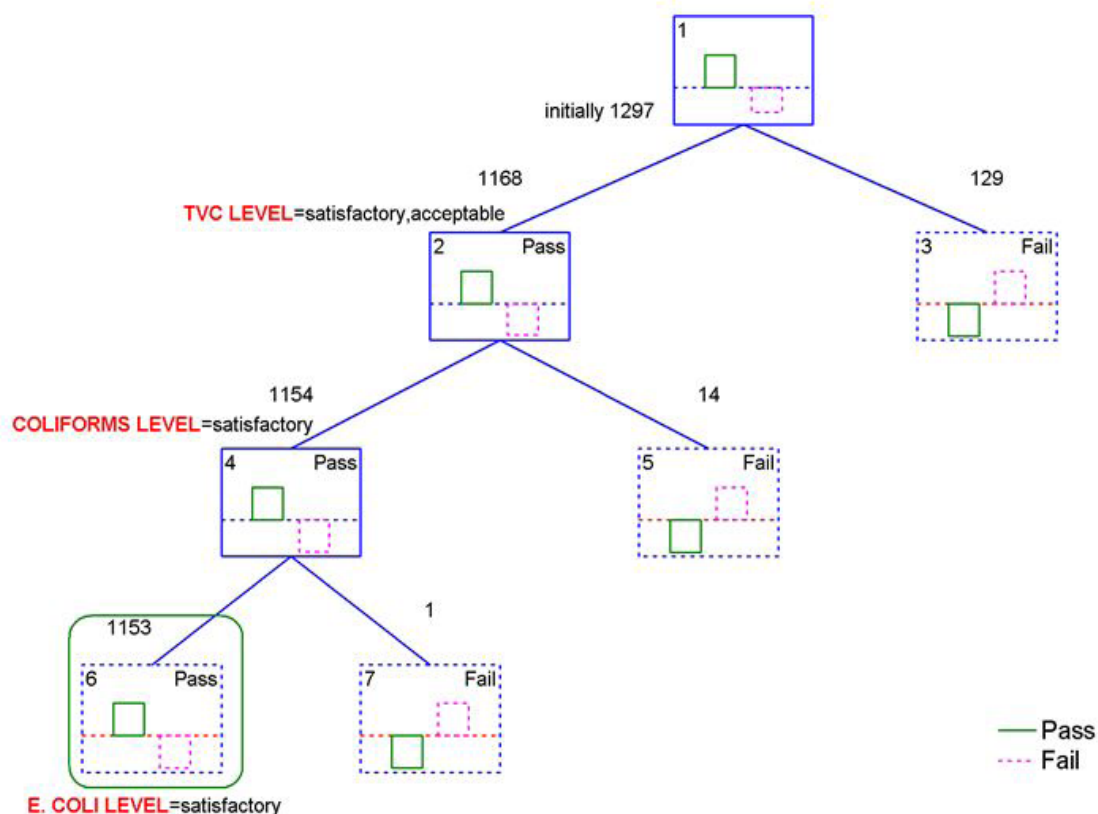
Figure 1: The process of elimination of the initial number of samples to final number of pass samples

Hygiene level of utensils for butcheries

The hygiene level of utensils is satisfactory for the three microbiological indicators. For Aerobic Plate Count the 85.6% of the samples are of satisfactory hygiene level that means 1100 satisfactory of totally 1297 samples. Also, the 9.9% of the samples are of unsatisfactory hygiene level (129 unsatisfactory of totally 1297 samples) and the 4.5% of the samples are of acceptable hygiene level (58 acceptable of totally 1297 samples). Moreover, the hygiene level of utensils, based on counts of Coliforms, is 94.6% of satisfactory hygiene level (1227 satisfactory of totally 1297 samples) and only 5.4% is of unsatisfactory hygiene level (70 unsatisfactory of totally 1297 samples). For *E. coli* counts, the hygiene level of utensils is 99.4% (1289 satisfactory of totally 1297 samples) of satisfactory level and only the 0.6 % is of unsatisfactory level (8 unsatisfactory of totally 1297 samples) (Table 1).

Levels	Frequency	Percent
Aerobic Plate Count		
Satisfactory	1110	85.6
Unsatisfactory	129	9.9
Acceptable	58	4.5
Total	1297	100.0
Coliforms		
Satisfactory	1227	94.6
Unsatisfactory	70	5.4
Total	1297	100.0
E. coli		
Satisfactory	1289	99.4
Unsatisfactory	8	0.6
Total	1297	100.0

Table 1: Microbiological indicators on surfaces of butchery utensils

Figure 2 presents the mean and the extreme values for each microbiological indicator separately. For the Aerobic Plate Count the mean is 3.87 cfu/cm^2 with the standard deviation to range from 3.53 cfu/cm^2 to 4.22 cfu/cm^2. However, we can observe that in some samples appeared values above this range, which are called extreme values. These values range from 6 cfu/cm^2 to 100 cfu/cm^2. For Coliforms the mean is 0.42 cfu/cm^2 and this value is enough below the limit of a satisfactory sample which is <1cfu/cm^2. The standard deviation ranges from 0.35 cfu/cm^2 to 0.49 cfu/cm^2, and in this case the samples remain below the limit of satisfactory samples. The extreme values for Coliforms are less than those for samples of Aerobic Plate Count with values to range from 3 cfu/cm^2 to 38 cfu/cm^2. For *E. coli*, the mean is 0.029 cfu/cm^2 with the standard deviation to range from 0.014 cfu/cm^2 to 0.045 cfu/cm^2. The extreme values for *E. coli* are less than those for the Aerobic Plate Count and Coliform count with values to range from 0.80 cfu/cm2 to 18 cfu/cm^2.
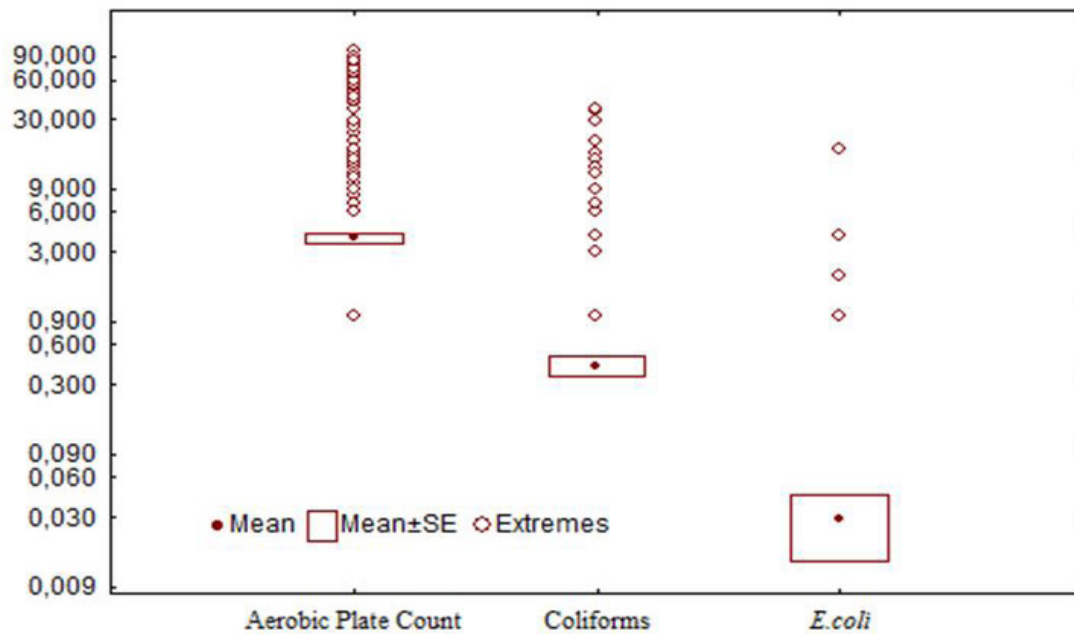

Figure 2: Box and whisker plots for Aerobic Plate Count, Coliform count and E. Coli count on the surfaces of butchery utensils

Utensils with the highest percentage pass and fail samples

The utensils were stored either on the workbench onto plastic trays or inside a UV cabinet. The UV treated cleavers have the largest percentage of pass samples with 94.7% and also have the largest positive deviation (5.8%) from the general mean of the pass samples (88.9%) (Table 2). In contrast with UV treated cleavers, the trays demonstrate the most fail samples with 33.3% for UV treated and 25.5% for not treated and the largest positive deviation from the general mean of fail samples with 22.2% for UV treated and 14.4% for not treated (Table 2).

Equipment	Pass	Totals	Percent of pass	Deviation from average
AVERAGE			88.9	0
Cleaver	49	55	89.1	0.2
Cleaver UV	90	95	94.7	5.8
Knife	245	272	90.1	1.2
Knife UV	557	590	94.4	5.5
Tray	210	282	74.5	-14.4
Tray UV	2	3	66.7	-22.2
All	1153	1297		

Table 2: Pass –fail samples of utensils butcheries

Sampling periods with the most satisfactory, acceptable and unsatisfactory samples in Aerobic Plate Count, Coliforms and *E. coli*

Samplings took place in six cycles every second month of the year. The first period was from January 18 to March 4, 2013 (T1), the second period was from March 8 to April 29, 2013 (T2), the third period was from May 2 to June 30, 2013 (T3), the fourth period was from July 1 to August 31 2013 (T4), the fifth period was from September 1 to November 3, 2013 (T5) and finally, the sixth period was from November 4 2013 to January 10, 2014 (T6).

According to the results for Aerobic Plate Count, the periods with most of the unsatisfactory samples are T1 and T2 with a percentage of 11.4 each. During the T1 period 25 unsatisfactory samples were identified and for T2 period 24 unsatisfactory samples. The most of the satisfactory and acceptable samples with percentage 92.8 were identified during the T6 period, 172 satisfactory and 21 acceptable of totally 208 samples (Table 3). Also, the periods T1 and T2 have the largest positive deviation, 1.5 units, from the mean of unsatisfactory samples which is 10 %. The T6 period showed the largest positive deviation, 2.7 units, from the mean of satisfactory samples which is 90.1 % (Table 3).

	Time	Satisfactory	Acceptable	% of Satisfactory & Acceptable	Deviation from average	Totals
Aerobic Plate Count	**T1**	194	0	88.6	-1.5	219
	T2	187	0	88.6	-1.5	211
	T3	210	8	90.8	0.7	240
	T4	174	11	90.7	0.6	204
	T5	173	18	88.8	-1.3	215
	T6	172	21	92.8	2.7	208
	All	1110	58			1297
	Time	**Satisfactory**		**% of Satisfactory**	**Deviation from average**	**Totals**
Coliforms	**T1**	197		90.0	-4.6	219
	T2	194		91.9	-2.7	211
	T3	227		94.6	0.0	240
	T4	198		97.1	2.5	204
	T5	208		96.7	2.1	215
	T6	203		97.6	3.0	208
	All	1227				1297
	Time	**Satisfactory**		**% of Satisfactory**	**Deviation from average**	**Totals**
E. coli	**T1**	216		98.6	-0.8	219
	T2	211		100.0	0.6	211
	T3	240		100.0	0.6	240
	T4	201		98.5	-0.9	204
	T5	213		99.1	-0.3	215
	T6	208		100.0	0.6	208
	All	1289				1297

Table 3: Satisfactory, acceptable and unsatisfactory samples per time period for Aerobic Plate Count

For the count of Coliforms, the T1 period has most of the unsatisfactory samples with percentage 10.0. During the T1 period 22 unsatisfactory samples were identified from a total of 219 samples. The T6 period is with most of the satisfactory samples, with a percentage 97.6 (Table 3). The T6 period remain with most of the satisfactory samples for both Aerobic Plate Count and Coliform count. Also, for the Coliform count, the T1 period has the largest positive deviation, 4.6 units, from the mean of unsatisfactory samples, which is 5.4 %. Similarly with the T6 period for Aerobic Plate Count, the T6 period for Coliforms remains the period with the largest positive deviation, 3.0 units, from the mean of satisfactory samples, which is 94.7 % (Table 3).

During T1 and T4 periods the counts for *E. coli* have most of the unsatisfactory samples with three (3) samples per period. At periods T2, T3 and T6, were identified most of the satisfactory samples and particularly there was a hundred percent of satisfactory samples. Moreover, the T1 and T4 periods, showed the largest positive deviations, 0.8 and 0.9 units, from the mean of unsatisfactory samples, which is 0,6 %. The T2, T3 and T6 periods, showed the largest positive deviations, 0.6 units, from the average of satisfactory samples, which is 94.6 % (Table 3).

Regions of Greece with pass or fail samples

The pass samples in all regions of Greece outnumber the fail samples. Specifically, the region of Crete with percentage 96.9 in pass samples outweighs other regions of Greece. From the region of Crete 97 samples took place, 94 samples were passing and only 3 samples were failing. Also, the region of Crete showed the largest positive deviations, 7.9 units, from the mean of pass samples which is 89%. The region of Epirus showed the largest positive deviations, 4.8 units, from the average of fail samples which is 11% (Table 4).

Area	Pass	Percent of Pass	Deviation from average	Totals	Fail	Percent of Fail	Deviation from average
Attica	369	90.9	1.9	406	37	9.1	-1.9
Crete	94	96.9	7.9	97	3	3.1	-7.9
Central Greece	58	93.5	4.5	62	4	6.5	-4.5
Central Macedonia	220	84.6	-4.4	260	40	15.4	4.4
Peloonnisos	75	92.6	3.6	81	6	7.4	-3.6
Thessalia	95	83.3	-5.7	114	19	16.7	5.7
West Greece	55	91.7	2.7	60	5	8.3	-2.7
West Macedonia	56	86.2	-2.8	65	9	13.8	2.8
Epirous	32	84.2	-4.8	38	6	15.8	4.8
East Macedonia-Thrace	65	85.5	-3.5	76	11	14.5	3.5
Ionian	16	88.9	-0.1	18	2	11.1	0.1
South Aegean	18	90	1	20	2	10	-1
All regions	1153	88.9 (mean)		1297	144	11.1 (mean)	

Table 4: Level of hygiene per time period for Coliforms and *E. coli*

Conclusion

This research work demonstrates that the frequent and regular hygiene control of the food contact surfaces in butcheries is useful for the benchmarking and the continuous improvement of hygiene. The staff training on food safety and hygiene issues may play a vital role and should be successful in order to comprehend the importance of good hygiene practice. In charge of hygiene training is the department of Quality Assurance of the super-market chain in this study. Actually the staff has gone recently through a training programme and the outcome of this study may determine the effectiveness of it. The internal committee of hygiene inspection may also utilize these finding in order to enhance the implementation of hygiene rules. It is important for the staff to realize that cleaning and disinfection, one of the most basic prerequisite programs of HACCP, can contribute to the maintenance of the hygiene to a satisfactory level. According to the requirements of ISO 22000:2005 (clause 7.2.3.h) [22] cleaning and sanitizing is one of the basic prerequisite programs. The new technical specification ISO/TS 22002-1:2009 [23] describes the cleaning and sanitizing procedures at chapter 11. From the benchmarking of the equipment we notice that disinfecting and storing the utensils within the UV cabinet, is a preventive measure that contributes to the maintenance of high sanitation level, comparing to others method of storing, such as in a cupboard or on a workbench. More specific, we notice the highest percentage of fail samples of trays (22.5%) because it is impossible to fit the trays to UV cabinets due to their size. As a consequence they are either stored in an open UV cabinets or in cupboards or on workbenches. It is quite obvious that open UV cabinets cannot function properly for sterilization of the surfaces. By comparing the sampling periods we notice that for Aerobic Plate Count and Coliform count the larger number of unsatisfactory samples were observed during T1 period (January-February), while for *E. coli* count the larger number of unsatisfactory samples were observed at the T4 period (July-August) at a percentage of 1.5%, with a small difference from the first period T1, where the percentage was 1.4%. The reason that the larger number of unsatisfactory samples was observed during the T1 period is due to the pause of the sampling for the Christmas holiday season, and probably the staff is less motivated to apply regularly the cleaning and disinfection program. The application of hygiene seems also to loose during the period of summer holidays, when the environmental temperature is high, even at air-conditioned stores. Regardless the current financial crisis in Greece, which may subsequently result to reduction of sanitation and control expenses, we observe that for the total number of Greece's regions, the percentage of pass samples exceed to a high degree to the fail samples (pass samples: 88.9% and fail samples: 11.1%). According to the benchmarking of Greece's regions, Crete prevails to the rest regions concerning the hygiene of utensils. Therefore, the stores of other regions, such as at Thessaly and Epirus, where the most of the fail samples appear, could acquire the know-how of Crete upon the sanitation

procedures. Monitoring surface hygiene with microbiological kits is vastly applied the last decade. Consumables for rapid tests become cheaper, the detection methods more sensitive and the quantitation methods more precise. Therefore there should be a committed management responsibility to monitor surface hygiene. The hygiene monitoring could be extended to other vital surfaces such as benches, cutting machines, wrapping material, vitrines and so on. Since there are is not legal basis to set decision points, benchmarking the results will compare sanitation procedures and lead to further improvement.

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