Optimal cleaning to prevent slippery floors in restaurants

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Abstract

The objective of this investigation was to collect data on floor cleaning in restaurants and to determine if the procedure could be improved in order to reduce floor slipperiness and hence slips and falls in the restaurant sector. Ten restaurants were visited and asked to prepare a cleaning solution in their usual way. The method was noted and the temperature of the water recorded. Samples of the floor cleaner and wash water solution were collected and sent for laboratory determination of the dilution ratio. This data was then used experimentally in the laboratory to reproduce floor cleaning.

In most cases, degreasers were over diluted, resulting in a reduction of the cleaning efficiency compared with using the dilution recommended by the manufacturers. Neutrals were often overdosed but with no significant improvement of their cleaning efficiency relative to the dilution recommended by the manufacturers.

Wash water prepared with water at 24°C was as effective as that prepared with water at 50°C.

It was found that in all but one case, the floor cleaning procedure could be improved by using a two-step cleaning method with a cleaning solution prepared with room temperature water and a degreaser at the dilution recommended by the manufacturer.

Although this investigation does not cover all the parameters that may affect the floor cleaning efficiency, it shows that simple actions such as changing the floor cleaning procedure may produce up to a seven-fold improvement of the floor cleaning efficiency, which in turn should result in less slippery and safer floors.

Key words: Floor cleaning efficiency, environmental health, restaurants, safety, slips, trips, falls.

Introduction

Chang *et al.* (2006) suggest that the average friction coefficient is a reasonably good indicator of floor slipperiness in fast-food restaurants. It is well known that the friction coefficient decreases with the accumulation of greasy contaminant at the surface of floorings. For instance, Underwood (1992) reported a rapid decrease of the friction coefficient of quarry tiles with increasing fat concentration at the surface and Quirion and Poirier (2006) correlated the sharp decrease of floor friction with its saturation with oil.

The purpose of floor cleaning is to eliminate dirt including the reduction of the level of fat and oil contamination. Reducing the amount of fat and oil at the surface of kitchen floors should contribute to making them less slippery. Leclercq *et al* (1997) however, noted that floor cleaning in the food industry led to either a significant increase or little change of floor friction depending on the type of flooring being cleaned. They also emphasised the importance of the choice of cleaning method and of the cleaning products used.

Since 1997, the Institut de recherche Robert Sauvé en santé et en sécurité du travail (IRSST) has conducted research projects on the optimisation of floor cleaning (Quirion 2004a) in order to reduce floor slipperiness in the food industry and restaurant sector. Quirion (2004b) found that the cleaning efficiency depends on the type and concentration of the floor cleaner used, the type of flooring to be cleaned, the type and amount of fat to be removed and, most of all, the cleaning method used.

In a field study, Quirion (2004c) observed that the floor friction did not increase much when the floor was cleaned “as usual” but it increased significantly (average of 24% in 12 restaurants) when a more vigorous cleaning method was used. This supports the idea that the optimisation of the floor cleaning procedure used in restaurants could be a means of increasing floor friction and thus help to reduce slips and falls.

The purpose of this investigation was to examine the hypothesis that the floor cleaning procedures currently in use in many restaurants around the world could be improved. Food safety officers from the London Borough of Bromley undertook the collection of data on the current cleaning procedures used in 10 restaurants in the South East of London. The cleaning efficiency of these procedures was then determined in the laboratory by QInc. The impact of the floor cleaner concentration, the wash water temperature and the cleaning method on the cleaning efficiency was determined to identify the optimal floor cleaning procedures.

Methodology

Wash water sampling and dilution

Ten European-style restaurants in the London Borough of Bromley were chosen at random. The restaurants were independently operated or part of a small chain (two or three premises) typically with 50 to 100 seats. Visits to the restaurants by the food safety officers were unannounced. After explaining the purpose of the visit, the manager was asked to have a floor wash water solution made up in its usual way. After noting the method for the preparation of the solution, its temperature was taken and a sample of the floor cleaner concentrate and the wash water solution were collected.

The floor cleaner and wash water samples were submitted to a UKAS accredited independent laboratory for the determination of the dilution ratio. The methods used were either acid-base titration, absorbance at a specific wavelength (either 440 nm, 520 nm or 650 nm) or turbidity measurement at 277 nm. The uncertainty is reported to be ± 5 dilution ratio units. For instance, the dilution ratio for site No 1 was 70, i.e. 70 ± 5 parts of water for one part of floor cleaner.

Flooring tested

In a previous field investigation (Quirion 2004c), it was noticed that kitchen floors were often covered with quarry tiles and that these tiles were smooth and impermeable to oil. This observation contrasted with the rather high roughness and porosity of new quarry tiles. It is known that porous floorings may become fouled if they are not initially sealed (Underwood 1992, Leclercq and Saulnier 2002).

For the purpose of this investigation, fouled and worn tiles quarry tiles were prepared from new tiles according to a procedure developed by Quirion and Massicotte (2002). The characteristics of the tiles before and after the treatment are summarised in Table 1.0. As noted earlier, fouled and worn tiles are smoother than new tiles as indicated by the higher reflectivity and the lower roughness. In this investigation, it is assumed that the onsite floorings were similar in nature to the fouled quarry tiles.

Cleaning Method: Damp and two-step mopping

It has been observed that most restaurant workers use damp mopping to clean the floors, i.e. they pass a damp mop (wet with the wash water but not dripping) over the floor and leave it to dry. Typically, the mop spends less than a second on a given area so that the ingredients of the floor cleaner do not have much time to work on the accumulated fat.

To increase the contact time for the floor cleaner to act, a two-step cleaning method may be used. In the first step, cleaning solution is applied to a section of the flooring with a wet mop (almost dripping). In the second step, the cleaning solution and the dirt it dislodged is recovered using a wrung-out mop. Between the application and the removal, the cleaning solution works on the dirt and improves the cleaning efficiency. Moreover, the recovery of the cleaning solution with a wrung-out mop leaves about one third less liquid on the floor than damp mopping alone so that it dries faster.

Cleaning efficiency

The cleaning efficiency was determined for the removal of olive oil (Extra-Virgin) by mopping the quarry tiles with a cleaning solution. The cleaning efficiency is expressed in terms of the residual coverage of oil on the quarry tiles after they were cleaned. The lower the residual coverage, the better the cleaning efficiency (Massicotte *et al*., 2000).

The determination of the oil coverage of a tile is based on the observation that the reflectivity of the tile, $\mathbf{R_c}$, increases from its value without oil, $\mathbf{R_o}$, to a plateau value when the surface becomes completely saturated, $\mathbf{R_p}$ with oil.

Table 1.0
Characteristics of the quarry tiles tested

	New tiles
Initial average roughness, R_a	5.1 ± 0.5 μm
Reflectivity[1] without oil, R_o	39.8 ± 1 %
	After fouling and wear
Average roughness, R_a	1.1 ± 0.1 μm
Reflectivity[1] without oil, R_o	49.6 ± 1 %
Oil saturation concentration	0.25 mg/cm^2
Reflectivity[1] at saturation, R_p	102.2 ± 1 %

[1] The reflectivity is relative to a shiny reference tile.

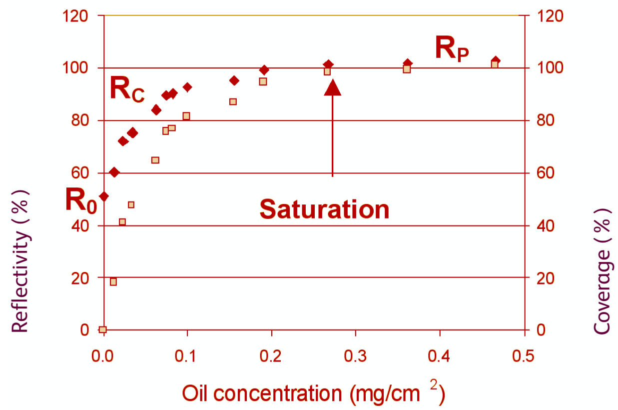


Figure 1.0
Reflectivity (black diamonds) and Coverage (grey squares) of a fouled and worn quarry tile as a function of the concentration of olive oil at the surface. R_0, R_C and R_P refer to the reflectivity without oil, at any oil concentration and at the plateau.

Reflectivity was determined experimentally using a light beam (LED, 633 nm, ϕ~1 cm) directed on the tile at an angle of 45° and the intensity of the specular reflection measured with a photoresistive cell. The reflectivity of a sample, ***R***, is expressed as the ratio of the intensity of the light reflected by the sample, I_{sample}, to the intensity of the light reflected by a reference tile, $I_{reference}$.

$$(1)\ R = 100\,\frac{I_{sample}}{I_{reference}}$$

The values of $\mathbf{R_c}$, $\mathbf{R_o}$ and $\mathbf{R_p}$ are combined in Equation 2 to calculate the oil coverage on a tile.

$$(2)\ \text{Coverage}(\%) = 100\,\frac{(R_C - R_O)}{(R_P - R_O)}$$

The evolution of the reflectivity and coverage of quarry tiles with olive oil is shown in Figure 1.0. The coverage, calculated from the reflectivity values, increases from 0 to 100 % with a saturation of the fouled and worn quarry tiles at 0.25 mg/cm^2 of olive oil. The $\mathbf{R_o}$ and $\mathbf{R_p}$ values are reported in Table 1.0. The $\mathbf{R_C}$ values necessary for the calculation of the residual coverage were determined after cleaning using either damp or two-step mopping.

For the cleaning efficiency experiments, the fouled and worn quarry tiles were initially covered with 0.30 mg/cm^2 of olive oil, i.e. over the saturation concentration. This is in accordance with Underwood (1992) who observed that a value higher than 0.43 mg/cm^2 was seldom encountered on fouled tiles from restaurants. Two 7.5 cm x 7.5 cm sample tiles were fitted into the set-up used for the cleaning experiments. Sixty gram mops (cut from 454 g mops) were immersed in a given amount of wash water and passed a given number of times over the sample tiles with no additional pressure other than the pressure exerted by the weight of the wet mops. The

Table 2.0
Description of the conditions for damp and two-step mopping

Cleaning methods characteristics	Damp mopping	Two-step mopping	
		Step 1	Step 2
Weight of dry mops[1]	60 g	60 g	60 g
Amount of wash water	150 ml	233 ml	70 ml
Number of passages	4	2	4
Time to dry	30 min	2 min[2]	30 min

[1] The size of the mops is 10 cm wide, 20 cm long and 2.5 cm thick.
[2] The cleaning solution left on the tiles after step 1 act on the oil for 2 minutes before being removed in step 2.

amount of wash water and the number of passages for damp and two-step mopping are reported in Table 2.0.

After the cleaning, the tiles were dried and the reflectivity, **R_C**, was measured at five different locations on each tile. Statistically, it was found that measuring five locations per tile on two tiles led to the same coverage, within experimental uncertainty, as measuring one location per tile on 10 tiles. It is thus assumed that the average results presented in this paper are equivalent to the average of 10 independent experiments.

Results

The first part of this section summarises the onsite floor cleaning procedures noted when visiting the 10 restaurants. The second part reports the results of a series of cleaning experiments performed in the laboratory to identify the optimal cleaning procedures for the eight floor cleaners collected onsite. The third compares the cleaning efficiency obtained using the onsite cleaning procedures with the cleaning efficiency using the optimal cleaning procedures.

Onsite cleaning procedures

The main observations gathered during the onsite visits are summarised in Table 3.0. A general description of a typical floor cleaning procedure is:

"Pour the floor cleaner in a bucket and then fill it with water. Wet the mop with the cleaning solution, wring it out so that it is still damp and pass it over the floor. Leave it to dry."

In addition to these observations, the restaurant owners confirmed that the most common types of fat likely to be found on the floor are olive oil, vegetable oil and butter. This supports our choice of olive oil as a typical fat to remove during floor cleaning activity.

For safety reasons the detergent should be added to the water to prevent the risk of eye and skin burns caused by the splashing of droplets of the concentrated cleaner. This may happen if water is added to the bucket already containing the detergent. Doing this will, however, cause the detergent to foam, thus obscuring the water level and making it more difficult to obtain the correct dilution ratio.

Eight different floor cleaners were used in the 10 restaurants visited. For the purpose of this investigation, two general categories were identified: neutrals and degreasers. The main differences between neutrals, **N**, and degreasers, **D**, are the higher pH and the presence of a significant amount of co-solvent (such as glycol ethers) for degreasers (Quirion 2004a). The physicochemical properties of the floor cleaners and their category are reported in Table 4.0 along with the wash water

Table 3.0
Frequency of the observations noted during the visits to the 10 restaurants

		Frequency
Type of floor cleaner	Degreaser	3 /10
	Neutral	7 /10
Addition of floor cleaner	Poured	8 /10
	Cap	2 /10
Floor cleaner added	Before water	8 /10
	After water	2 /10
Cleaning method	Damp mopping	10/10
	Two-step mopping	0 /10
Wash water temperature	35˚C and higher	5 /10
	Between 15 and 35˚C	3 /10
	15˚C and lower	2 /10

Site No[1]	Onsite		Recommended	Volatile[4]	Conc.[5]	pH
	Temp (°C)	Dilution[2] (1 in)	Dilution[3] (1 in)	(%)	(%)	(diluted)
D1	10	70	15	92.2	0.52	13.0
D2	72	140	12	90.1	0.82	13.2
D3	52	40	20	87.0	0.65	10.7
N4	36	70	30	96.4	0.12	7.7
N5	58	20	83	89.9	0.12	8.4
N6	19	150	100	84.5	0.15	11.6
N7	54	30	80	96.6	0.04[6]	7.2
N8	15	50	83	89.9	0.12	8.4
N9	22	10	58	87.8	0.21	11.3
N10	33	60	83	89.9	0.12	8.4

Table 4.0
Onsite conditions and physico-chemical properties of wash water at the recommended dilution

[1] Site number preceded by either N = neutral or D = degreaser.
[2] The uncertainty on the dilution ratio is ± 5.
[3] Average of the range recommended for normal and heavy cleaning.
[4] Air dried at low temperature (30-40°C) for 18 hours.
[5] Concentration based on non volatile ingredients at the recommended dilution.
[6] This product contains hydrogen peroxide which is a volatile ingredient.

temperature recorded on site. Notice that on site **D2**, a wash water temperature of 72°C was recorded, which is dangerously hot. The dilution recommended by the manufacturers was taken as the average for normal and heavy cleaning and it is compared with the dilution used at the restaurants.

The concentration of non-volatile active ingredients in the cleaning solution can be estimated using the volatile content and the dilution used. For instance, **D3** has a volatile content of 87.0% and a recommended dilution of 1 in 20. The active ingredient concentration is thus (100-87)/20 = 0.65 %. Table 4.0 shows that the recommended concentration of active ingredients is higher for the degreasers (0.52 – 0.82 %) than for the Neutrals (0.12 – 0.21 %).

Only three of the 10 sites used a degreaser. At this point, it is only possible to speculate on the reasons why. Maybe the owners do not know that it is better to use a degreaser or maybe it is because degreasers are more expensive than neutrals. Moreover, they are generally recommended for use at a higher concentration than neutrals, resulting in a higher cost per wash. For example, when using the dilution recommended by the manufacturer, the average cost per wash is around £4.10 for the degreasers and £0.70 for the neutrals. The average cost per wash based on the on-site dilution drops to £0.55 for the degreasers but increases to £1.10 for the neutrals. In other words, users tend to over dilute expensive products and overdose inexpensive ones.

Optimal cleaning conditions

In this section, the cleaning efficiency of the floor cleaners was optimised in terms of its concentration (dilution), temperature of the wash water and cleaning method. The experimental results obtained for the three degreasers are averaged and compared to the average obtained for the five neutrals. The lower the residual

Figure 2.0
Impact of the concentration of the floor cleaners on the coverage of olive oil on fouled quarry tiles using damp mopping at 24°C

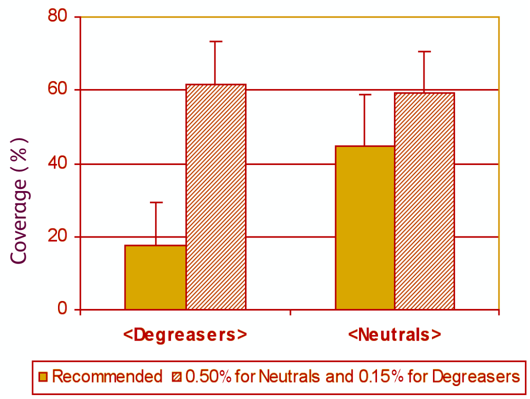


Figure 3.0
Impact of the temperature of the cleaning solution on the coverage of olive oil on fouled quarry tiles using damp mopping at the recommended concentration of floor cleaners.

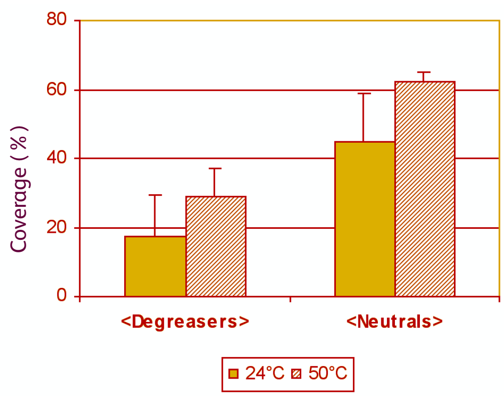
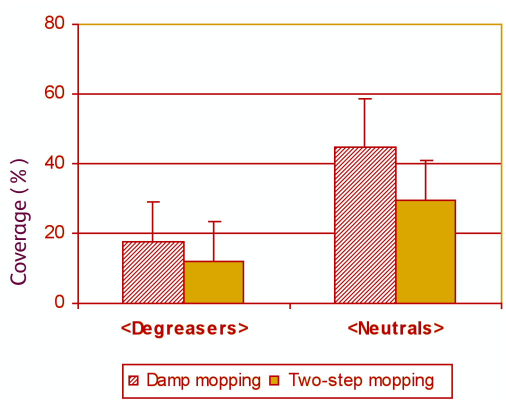


Figure 4.0
Impact of the cleaning method on the residual coverage of olive oil on fouled quarry tiles using damp mopping at 24°C at the recommended concentration of floor cleaners.



coverage the better the cleaning efficiency. The uncertainty bars represent the standard deviation of the average of the three or five results.

Impact of concentration

As observed in the previous section, people tend to over dilute degreasers and overdose neutrals with respect to their recommended dilution. Figure 2.0 shows that decreasing the concentration of the degreasers from their recommended concentration (0.5-0.8 %) to 0.15 % decreases significantly their cleaning efficiency. In the same way, increasing the concentration of neutrals from their recommended concentration (0.1-0.2 %) to 0.5 % also decreases their cleaning efficiency but the effect is not significant within experimental uncertainty. This suggests that the recommended dilution is optimal both for the degreasers and the neutrals.

Impact of temperature

For safety reasons, the temperature of a cleaning solution handled by workers should not be too hot and 50 ± 2˚C is often regarded as an upper limit (Katcher 1981). As seen in Figure 3.0, increasing the temperature from 24˚C to 50˚C slightly reduces the cleaning efficiency of both the degreasers and the neutrals, although the impact is not significant. This, combined with safety and economic considerations, makes wash water prepared at room temperature a better choice than at 50˚C (or over).

Impact of the cleaning method

Figure 4.0 compares the cleaning efficiency of the damp mopping and two-step mopping using wash water prepared at room temperature with the dilution recommended by the manufacturers. Not surprisingly, the longer time for action by the floor cleaner's ingredients for the two-step method results in an improved cleaning efficiency, both for the degreasers and the neutrals. This is in accordance with previous results obtained when cleaning stripped vinyl floorings covered with shortening (Quirion 2004b).

The optimal combination of detergent, temperature and method – as it provided the lowest level of residual oil and thus highest level of cleaning - is shown in Figure 4.0. The additional burden involved in applying the two-step method, however, might suggest that the relatively small improvement (6 %) in cleaning is uneconomical and that damp mopping with a degreaser is more commercially acceptable as an optimum method.

We feel, however, that there are other facts that should be taken into account. First, there are numerous types of flooring materials and finishes, some of which will be more difficult to clean than the rather smooth fouled and worn quarry tiles (Leclercq *et al.* 1997). In such cases, two-step mopping would prove to be significantly more effective, as demonstrated by Quirion (2004b). Second, it was observed that damp mopping leaves about three times as much cleaning solution on the flooring than two-step mopping does. The immediate result is that the floors will dry faster when two-step mopping is used. Wet floors are slippery and the quicker a floor can be returned to use completely dry the safer it will be. Third, the recommended concentration of active ingredients for cleaning solutions containing degreasers is typically around two to three times higher than for cleaning solutions containing a neutral cleaner (see Table 4.0). As the solution dries out, damp mopping with a degreaser will leave three times more 'detergent residues' than two-step mopping.

To reduce the drying time of the flooring and to eliminate 'detergent residues' from the floorings, the floor must be rinsed with clear water and a wrung-out mop. If this step is properly performed, then it would be acceptable to consider damp mopping with a degreaser as the optimal cleaning method for fouled and worn quarry tiles covered with olive oil. However Quirion (2004c) found that none of the 12 restaurants visited in an earlier study actually had a rinsing step in their cleaning process.

For these reasons, we prefer to recommend two-step mopping with a degreaser as a cleaning method that is generally more effective than damp mopping for many flooring-fat combinations.

Optimal vs. Onsite conditions

The results from the previous section suggest that the optimal cleaning procedure consists of two-step mopping with a floor cleaner diluted to the manufacturer's recommendations with water at room temperature (~24°C).

In this section, the cleaning efficiency of the optimised procedure is compared with the onsite procedures. The first part compares the degreasers with the neutrals while the second part compares the individual results.

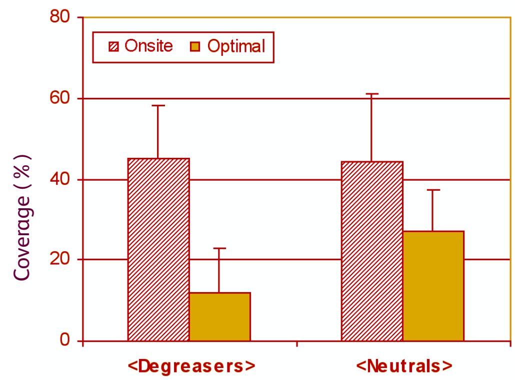


Figure 5.0
Comparison of the residual coverage of olive oil on fouled quarry tiles cleaned using onsite conditions (see Table 4) and optimal cleaning conditions (Two-step mopping at the recommended concentration of floor cleaner and at 24°C).

Degreasers vs Neutrals

Figure 5.0 shows that the optimised procedure provides a better cleaning efficiency (lower residual coverage) than the onsite procedure (see Table 4.0) both for the degreasers and the neutrals.

These results also confirm that degreasers are better suited to clean oily kitchen floors than neutrals.

Individual sites

Figure 6.0 compares the cleaning efficiency of the individual onsite procedures with that obtained using the optimal procedure. The first obvious observation is that the cleaning efficiency can be improved significantly in eight cases just by adopting an optimised procedure.

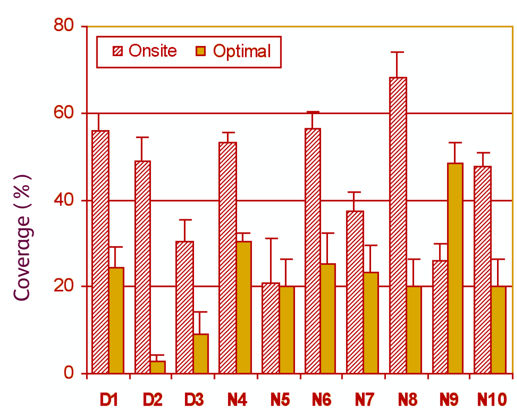


Figure 6.0
Comparison of the residual coverage of olive oil on fouled quarry tiles cleaned using onsite conditions (see Table 4) and optimal cleaning conditions (Two-step mopping at the recommended concentration of floor cleaner at 24°C).

Site **N5** gave the same cleaning efficiency as the optimised procedure while site **N9** gave better results than the optimal procedure. Nevertheless, we feel that it is not too strong to state that the use of an optimised cleaning procedure may improve the cleaning efficiency and thus reduce the amount of fat left on the floor.

The lowest residual coverage was obtained with two degreasers. The optimal cleaning procedure would thus be:

> *Two-step mopping with a wash water solution prepared with water at room temperature and a degreaser at the dilution recommended by the manufacturer.*

If it is assumed that the optimal residual coverage is the average of **D2** and **D3** in optimal conditions (~6%), then switching from the onsite to the optimal cleaning procedure would result, on average, in seven times less fat on the floorings following floor cleaning.

Conclusions

The objective of this investigation was to identify the floor-cleaning procedures in use in restaurants and evaluate the impact of simple changes on their efficiency in removing oil from the floors. To do so, the floor-cleaning procedures of 10 restaurants were documented during on-site visits and their cleaning efficiency was determined in the laboratory for the removal of olive oil from quarry tiles.

- Three degreasers and five neutral floor cleaners were collected and tested. In most cases, the expensive degreasers were over-diluted, resulting in a reduction of the cleaning efficiency with respect to the dilution recommended by the manufacturers. The cheaper neutrals were often overdosed but with no significant improvement in their cleaning efficiency relative to the dilution recommended by the manufacturers.
- Wash solutions prepared with water at 24°C was as effective as those prepared with water at 50°C.
- Two-step mopping allows the ingredients of the floor cleaner to act on the fat for a longer period of time resulting in a better cleaning efficiency than damp mopping.
- Overall, the cleaning eff-iciency of degreasers used in optimal conditions is better than that of neutrals.
- It is suggested that the optimal cleaning procedure is two-step mopping with a wash water solution prepared with water at room temperature and a degreaser at the dilution recommended by the manufacturer.
- The laboratory experiments suggest that switching from the onsite to an optimal procedure could improve floor-cleaning efficiency on average by a factor of seven.
- These results support our campaign to promote floor cleaning as the first step towards improving slip resistance in the restaurant industry.

Acknowledgements

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