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Efficacy of Germicidal Hand Wash Agents in Use in a Meat Processing Plant

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ABSTRACT

The in-use efficacy of a selected range of germicidal hand wash agents was tested in a meat processing plant. The hand washes included non-germicidal soaps and germicidal agents containing chlorhexidine, iodophor and Irgasan DP 300 as active ingredients. A laboratory study was done under controlled conditions with standardized procedures for hand washing; in the meat plant, "normal" (unstandardized) hand wash procedures were followed. Levels of contamination on hands varied markedly between work units. Only in the meat cutting area could a significant difference be attributed to hand wash agents against transient-type bacteria on workers' hands. The hand wash agent with 4% chlorhexidine gluconate, the iodophor with 0.75% available iodine and the gel containing 0.3% Irgasan DP 300 were the only products that gave a significantly better reduction of transient bacteria than non-germicidal soap. Transient bacteria were detected on hands after washing, indicating that under the in-use conditions in the meat processing plant, hand wash techniques did not remove all of these bacteria from hands. The plant workers generally indicated a dislike for the iodophor products as hand germicides.

Hand washing is an important component of a hygiene program for food handlers. Hands can be a source of direct or indirect contamination of foods with pathogenic microorganisms *(3,11,18)*. It is generally considered that a germicidal hand wash agent is preferable to a non-germicidal agent *(2)*. This principle was developed with exclusive use of germicidal soaps such as those containing 2 or 3% hexachlorophene *(12)*. However, other studies revealed that intermittent use *(28)* or a single application *(13)* of hexachlorophene soaps was no more effective than non-germicidal soap. Despite certain limitations, hexachlorophene was a popular germicidal agent for hand hygiene *(8,17)*. Subsequently, the possibility of toxic absorption of hexachlorophene through the skin led to restrictive regulation of its use *(6,10,16)*.

Based on criteria for satisfactory hand hygiene, Crisley and Foter *(4)* selected iodine compounds (iodophors) as the best agents for hand washing by food handlers. Since then, several other germicidal agents have gained acceptance for use in hand hygiene, including chlorhexidine *(23)*, triclosan or Irgasan DP 300 *(9)* and para-chloro-meta-xylenol *(5)*. In our studies *(19-22,27)*, the only agents tested that met our criterion of reduced numbers of bacteria released from hands after a 15-s standardized hand wash were a 4% chlorhexidine gluconate liquid detergent (4% chlorhexidine) and an iodophor product containing 0.75% available iodine (0.75% iodophor). Products containing Irgasan DP 300 and para-chloro-meta-xylenol did not achieve a significant reduction in numbers of bacteria released from hands when they were compared with a non-germicidal soap. Products containing low concentrations of available iodine also failed to meet our experimental criterion *(27)*. The purpose of this study was to compare the efficacy of a selected range of chlorhexidine, iodophor and Irgasan DP 300 germicidal hand wash products with two non-germicidal products under in-use conditions in a meat processing plant.

MATERIALS AND METHODS

Two experiments were done concurrently, *(a)* a laboratory study with four volunteers who washed their hands according to a standardized hand wash procedure, and *(b)* an in-use study in a meat processing plant in which four workers in each of three work units washed their hands in their "normal" way. The three work units were selected to represent workers with heavily soiled hands (meat cutting), moderately soiled hands (kitchen area) and clean hands protected with plastic gloves (processed meat packaging area).

Hand wash agents tested

A total of nine agents was tested: 4% and 2% chlorhexidine gluconate liquid detergents (Hibitane, Ayerst Laboratories, Montreal, Canada); iodophor hand wash agents containing 0.02% (theoretically 0.005%) and 0.75% available iodine (West Chemicals Ltd., Montreal, Canada) and 0.10% available iodine (West Design Chemical Group, West Agro-Chemicals Inc., Westwood, Kansas, U.S.A.); a bacteriostatic hand soap containing 0.5% Irgasan DP 300 (Bacto-Wash, Du Bois Chemicals of Canada Ltd., Weston, Ontario, Canada); a non-germicidal gel skin cleanser (Sceptre) and the same product containing 0.3% Irgasan DP 300 (Florafree, Deb Swarfega Inc., Waterford, Ontario, Canada); and a non-germicidal hand "cleansing lotion" (West Chemicals Ltd., Montreal, Canada). The available iodine concentration of the iodophor products was deter-

mined by titration of available iodine against standardized sodium thiosulfate solution *(1)*.

Laboratory (controlled) study

The efficacy of the hand wash agents was tested against transient bacteria, *Escherichia coli* and *Pseudomonas fluorescens*, inoculated onto hands from ground beef containing approximately 1×10^7 and 1×10^8 colony forming units (cfu) per gram, respectively. Inoculation and hand wash procedures were outlined in our previous study *(27)*. Four volunteers washed their hands with the test agent on two successive days of each week. Hands were sampled before (X_0) and after (X_1) washing, by immersion and rinsing of the selected hand in 100 ml of letheen broth (Difco), as described by Sheena and Stiles *(19)*, except that the glass beads were excluded from the rinse solution.

In-use study

Four randomly selected workers in each of the three main work units of a meat processing plant were used for this study. Hand wash agents were placed in 1-L capacity dispensers (Hypor Soap Cartridge System, Deb Swarfega Inc., Waterford, Ontario, Canada) installed on the wall adjacent to the hand wash facilities in each section of the plant. The dispensers had a locking mechanism which made them tamper resistant. Dispensers were filled with the new agent to be tested, immediately after the final sampling of the previous agent had been completed. Therefore, workers used the new agent for 2 d before sampling was started. Sequencing of the agents was selected to avoid cross-reactions or to minimize the possible influence of one agent on another, as follows: *(a)* non-germicidal (lotion) soap; *(b)* 2% and *(c)* 4% chlorhexidine gluconate; iodophor products containing *(d)* 0.02%, *(e)* 0.10%, and *(f)* 0.75% available iodine; *(g)* non-germicidal gel; *(h)* 0.3% Irgasan DP 300 gel (Deb Swarfega); and *(i)* 0.5% Irgasan DP 300 (Du Bois). Clean, previously unused cartridges were used for dispensing agents 1, 2, 4, 7, 8 and 9. When cartridges were re-used, they were thoroughly rinsed before adding the new agent. The assigned agents were placed in the dispensers and used by all workers in that section for the full week (5 working days).

Workers participating in the trial were instructed to wash their hands in their "normal" manner. Hands were sampled before (X_0) and after (X_1) washing, as described for the laboratory study, on 3 successive working days (Monday to Wednesday), after the plant had been in operation for 3 h. Hand rinse samples were taken to the laboratory for bacteriological analysis within 30 min of collection. The amount of hand wash product used each week was recorded. Workers were asked about the acceptability of each product.

Bacteriology

The same bacteriological analyses were done on the laboratory and in-use hand rinse samples. In the laboratory study, X_0 samples were plated onto growth media without delay, X_1 samples were held at room temperature (22°C) for 1.5 h before plating to allow for resuscitation of injured cells. The meat plant samples were handled in the same way after they were received at the laboratory. The different microbiological parameters were determined by surface plating appropriate dilutions of each sample onto Standard Plate Count agar (SPC, Difco), Baird-Parker medium (B-P, Difco) and CFC agar prepared in the laboratory with Heart Infusion agar (Difco) supplemented with 50 μg cephaloridine, 10 μg fucidin and 10 μg cetrimide per ml *(14;* antibiotics obtained from Sigma Chemicals, St. Louis, U.S.A.). Appropriate dilutions were also pour-plated onto two sets of Violet Red Bile agar (VRB, Difco), overlayered with an additional 5 ml of VRB. Inoculated plates were incubated as follows: SPC plates at 35°C for 24 h for the total aerobic colony count; B-P plates at 35°C for 48 h for the Micrococcaceae-type count *(27);* CFC plates at 22°C for 72 h for a presumptive *Pseudomonas* count; and the two sets of VRB plates at 45 and 35°C for 24 h to obtain presumptive fecal and total coliform counts, respectively. Isolated colonies were picked from the VRB plates incubated at 45°C and identified using the Minitek identification technique *(26)*.

Statistical analyses

Data were calculated as the $\log_{10}$ ratios of the number of microorganisms released from hands after washing (X_1) to the number released before washing (X_0). The data were analysed in a Repeated Measures analysis of variance (BMDP2V, Biomedical Computer Program, P-Series, 1983, University of California Press) to determine the effect of agents and repeated use of the agents on the microorganisms released from hands. The significance of the differences among treatment means was determined using Duncan's multiple range test.

RESULTS

Laboratory study

Hands contaminated with *E. coli* and *P. fluorescens* were washed under the standardized conditions for 15 s. Mean percentage reductions in counts for *E. coli* and *P. fluorescens* (transient) and mean percentage change in counts for Micrococcaceae-type (resident) bacteria are shown in Table 1. Initial mean counts were calculated from the initial counts of the four volunteers for the two successive testing days. Mean percentage reductions or changes in counts were calculated from the percentage reduction or change in count observed for each hand washing. All hand wash agents tested, including the non-germicidal products, achieved 99% reduction in *E. coli* and *P. fluorescens* counts. Results for the change in resident-type bacteria varied markedly between agents. The 4% chlorhexidine gluconate and 0.75% iodophor products generally caused a decrease in numbers of microorganisms released from hands. Other agents gave very variable results. Non-germicidal soaps generally caused an increased number of microorganisms to be released from hands after the 15-s wash.

Results for the analyses of variance using $\log_{10}$ reduction or change ratios indicated significant effects attributable to agents against *E. coli* ($P=0.04$) and *P. fluorescens* ($P<0.001$), but not against resident bacteria measured on B-P medium ($P=0.27$). Variances of data for resident bacteria were large, contributing to the non-significant effect. Differences among reduction ratio means determined for *E. coli* using 0.75% iodophor resulted in a significant reduction in number of bacteria released from hands compared with 0.02 and 0.1% iodophor products, 2% chlorhexidine or the non-germicidal soaps. For *P. fluorescens*, the 0.3% Irgasan DP 300, 4% chlorhexidine and 0.75% iodophor products gave significant reductions compared with all other products.

TABLE 1. *Mean initial counts of bacteria released from hands and percentage reduction or change in counts as a result of 15 s exposure to hand wash agents under standardized, laboratory conditions.*

Hand wash agent	*E. coli*[a] Initial count ($\times 10^3$)	*E. coli*[a] Reduction (%)	*P. fluorescens*[b] Initial count ($\times 10^3$)	*P. fluorescens*[b] Reduction (%)	Micrococcaceae[c] Initial count ($\times 10^1$)	Micrococcaceae[c] Change (%)
Non-germicical soap	7.6	(99.0)	4.8	(98.9)	6.3	(135)
Chlorhexidine (2%)	6.5	(99.0)	3.9	(99.2)	5.4	(92)
Chlorhexidine (4%)	6.3	(99.7)	5.0	(99.7)	3.8	(53)
Iodophor (0.02%)	5.2	(99.2)	3.7	(99.1)	4.2	(100)
Iodophor (0.12%)	7.6	(99.4)	3.5	(99.2)	3.0	(97)
Iodophor (0.75%)	6.5	(99.8)	3.4	(99.6)	2.2	(73)
Non-germicidal gel	6.3	(99.3)	3.1	(99.0)	2.5	(103)
Irgasan DP300 (0.3%)	7.5	(99.5)	4.2	(99.8)	8.0	(93)
Irgasan DP300 (0.5%)	6.8	(99.6)	3.8	(99.2)	5.9	(102)

[a]Counts obtained on VRB agar at 45°C.
[b]Counts obtained on CFC agar at 22°C.
[c]Counts obtained on B-P medium at 35°C.

TABLE 2. *Initial contamination of hands of workers in three departments of the meat processing plant over the nine-week study period.*

Microbial count[a]	Meat cutting (cfu/ml of hand rinse solution)	Kitchen (cfu/ml of hand rinse solution)	Packaging (cfu/ml of hand rinse solution)
VRB (45°C)	76	1.4	<1.0
VRB (35°C)	1.5×10^4	5.1×10^2	2.0
CFC (22°C)	5.8×10^5	8.7×10^3	50
B-P (35°C)	1.3×10^5	8.5×10^3	3.9×10^3
SPC (35°C)	1.2×10^6	5.6×10^4	1.1×10^4

[a]VRB (45°C), counts of presumptive "fecal" coliform bacteria.
VRB (35°C), counts of total coliform bacteria.
CFC (22°C), counts of presumptive pseudomonad bacteria.
B-P (35°C), counts of Micrococcaceae-type bacteria.
SPC (35°C), total aerobic colony count.

In-use study

Hand wash procedures for the in-use study were not standardized. Workers were requested to wash their hands in the "normal" way. This generally involved 8 to 10 s to wash and rinse hands. Workers in the meat cutting unit generally washed their hands so that the visible soil was removed. Hand wash samples were taken immediately before the morning break on three successive days at the beginning of each week. Treatment means are the result of testing one wash by each of the four workers on each of the three test days. The marked differences in the degree of hand soiling of workers in the three work units (shown in Table 2) led to the results for each work unit being analyzed separately. Workers in the meat cutting area had heavily soiled hands, yielding a total aerobic bacterial count approximately 1×10^6 cfu/ml of hand rinse solution. High counts on the selective growth media indicated not only coliform and pseudomonad-type bacteria as transient microorganisms on hands, but also an elevated gram-positive Micrococcaceae-type count. In contrast, workers in the processed meat packaging area wore plastic gloves, and the microbial load on their hands resembled that of "socially" clean hands. Workers in the kitchen area had moderately soiled hands. Mean SPC counts for these workers ranged from 3.1×10^4 to 1.0×10^5 cfu/ml of hand rinse solution over the 9 weeks of the study.

Initial mean counts and percentage reduction of presumptive fecal coliform bacteria (VRB at 45°C) and pseudomonads (CFC at 22°C) on hands of workers in the meat cutting area are shown in Table 3. Percentage reductions in counts varied between agents, ranging from 77.6 to 96.7% for fecal coliform bacteria and 85.6 to 99.6% for pseudomonads. Analyses of variance of the data indicated significant differences attributable to hand wash agents for each parameter measured: VRB (45°C) $P=0.02$; CFC $P=0.002$; B-P $P=0.006$; and SPC $P=0.003$. Differences among reduction ratio means were determined using Duncan's multiple range test at the 95% confidence level. The data shown in Table 4 indicate that 4% chlorhexidine gave a significantly greater reduction in fecal coliform and pseudomonad counts than other agents, except for 0.75% iodophor and Irgasan DP 300 (0.3%) products against fecal coliform bacteria, and 0.75% iodophor against pseudomonads. The 0.75% iodophor product was more effective than many of the other agents used. The remaining agents, with a few exceptions, were similar to the non-germicidal soaps in their action against coliform and pseudomonad organisms. No effect of repeated use of the agents (from day to day) was detected. None of the germicidal agents, under these conditions of use, eliminated the fecal coliform or pseudomonad bacteria from hands. Residual fecal coliform bacteria on hands after washing ranged from a mean count of 0.7 cfu/ml of rinse solution after the 4% chlorhexidine wash to 27 cfu/ml after the 0.1% iodophor wash. Similar data for the pseudomonad bacteria were 7×10^2 cfu/ml of rinse solution after 4% chlorhexidine and 3.5×10^5 cfu/ml after 0.1% iodophor.

TABLE 3. *Mean initial counts of bacteria released from hands and percentage reduction in counts as a result of the use of the hand wash agents in the meat cutting area.*

Hand wash agent	VRB 45°C[a] Initial count ($\times 10^1$)	VRB 45°C[a] Final count ($\times 10^0$)	VRB 45°C[a] Reduction (%)	CFC 22°C[b] Initial count ($\times 10^4$)	CFC 22°C[b] Final count ($\times 10^3$)	CFC 22°C[b] Reduction (%)
A Non-germicidal soap	8.4	17	(83.5)	6.6	11	(85.6)
B Chlorhexidine (2%)	11	21	(80.0)	77	32	(95.8)
C Chlorhexidine (4%)	2.2	0.7	(96.7)	17	0.7	(99.6)
D Iodophor (0.02%)	2.3	5.1	(78.0)	28	14	(95.4)
E Iodophor (0.12%)	12	27	(78.5)	263	357	(86.7)
F Iodophor (0.75%)	7.6	4.6	(94.2)	198	20	(99.1)
G Non-germicidal gel	15	14	(89.9)	69	71	(89.8)
H Irgasan DP 300 (0.3%)	17	8.5	(96.2)	56	34	(94.4)
I Irgasan DP 300 (0.5%)	7.3	16	(77.6)	132	185	(86.3)

[a]Counts on VRB at 45°C indicate fecal coliform bacteria.
[b]Counts on CFC at 22°C indicate pseudomonad bacteria.

TABLE 4. *Significance of differences among hand wash agent means (for meat cutters) determined at the 95% confidence level using Duncan's Multiple Range test.*[a,b]

	Rank order of treatment means								
VRB, 45°C	C	H	F	G	A	B	E	D	I
CFC, 22°C	C	F	B	D	H	G	E	I	A

[a]For key to product codes see Table 3.
[b]Agents underlined with an unbroken line are not statistically different.

The percentage reduction in total (SPC) and Micrococcaceae-type (resident) bacterial counts are shown in Table 5. The 4% chlorhexidine product gave >90% reduction in counts. The 0.75% iodophor product gave >90% reduction for the total (SPC) count and 86.7% reduction in Micrococcaceae-type count. However, most agents were better than the non-germicidal (lotion) soap against the gram-positive, Micrococcaceae-type bacteria that grow on B-P medium.

RESULTS

For workers in the kitchen and processed meat packaging units, no significant differences in reduction of bacteria released from hands could be attributed to hand wash agents. Mean percentage decrease in number of bacteria released from hands was less when compared with results for workers in the meat cutting area. However, hands were less soiled, both visibly and bacteriologically. Initial mean counts and mean percentage reductions for four of the microbial parameters (excluding fecal coliform bacteria) for workers in the kitchen area are shown in Table 6. Reductions in microbial counts were poor, ranging from 58.3 to 91.3% for the different parameters with 4% chlorhexidine and 50.6 to 88.3% with 0.75% iodophor. Transient bacteria were detected on hands after washing, including fecal coliform bacteria, despite the fact that the level of contaminating fecal coliforms was low (see Table 2). Similar results were obtained for hand washing in the processed meat packaging area.

A total of 72 random colonies growing on VRB at 45°C was selected for identification by the Minitek iden-

TABLE 5. *Mean initial counts of bacteria released from hands and percentage change in counts as a result of the use of the hand wash agents in the meat cutting area.*

Hand wash agent	SPC 35°C[a] Initial count ($\times 10^5$)	SPC 35°C[a] Final count ($\times 10^4$)	SPC 35°C[a] Reduction (%)	B-P 35°C[b] Initial count ($\times 10^4$)	B-P 35°C[b] Final count ($\times 10^3$)	B-P 35°C[b] Reduction (%)
Non-germicidal soap	2.9	16	(41.8)	1.5	23	(159)[c]
Chlorhexidine (2%)	45	78	(82.8)	38	76	(79.7)
Chlorhexidine (4%)	10	2.2	(98.2)	2.0	0.4	(98.0)
Iodophor (0.02%)	4.6	24	(49.0)	6.5	55	(16.0)
Iodophor (0.12%)	26	8.4	(66.6)	55	184	(66.6)
Iodophor (0.75%)	21	0.7	(96.8)	32	42	(86.7)
Non-germicidal gel	8.4	14	(84.0)	28	73	(74.3)
Irgasan DP 300 (0.3%)	17	22	(86.5)	19	52	(71.7)
Irgasan DP 300 (0.5%)	14	29	(79.6)	18	37	(81.1)

[a]Counts on SPC at 35°C indicate total aerobic cfu.
[b]Counts on B-P medium.
[c]( ) indicates percent change in count.

TABLE 6. *Mean initial counts of bacteria released from hands and percentage reduction in counts as a result of the use of the hand wash agents in the kitchen area.*

Hand wash agent[e]	VRB 35°C[a] Init. count ($\times 10^2$)	VRB 35°C[a] Reduction (%)	CFC 22°C[b] Init. count ($\times 10^4$)	CFC 22°C[b] Reduction (%)	B-P 35°C[c] Init. count ($\times 10^3$)	B-P 35°C[c] Reduction (%)	SPC 35°C[d] Init. count ($\times 10^3$)	SPC 35°C[d] Reduction (%)
A	2.6	(80.9)	2.2	(63.7)	11.0	(8.0)	3.1	(20.6)
B	3.6	(72.2)	11.8	(85.6)	6.2	(48.0)	4.8	(54.6)
C	11.5	(84.9)	5.8	(91.3)	9.0	(58.3)	9.5	(71.4)
D	7.7	(60.6)	38.5	(71.9)	6.4	(28.0)	10.3	(31.0)
E	3.7	(83.8)	6.2	(73.8)	11.0	(40.9)	5.0	(37.2)
F	2.1	(81.8)	4.2	(88.3)	5.3	(50.6)	6.5	(63.3)
G	6.7	(79.8)	6.5	(67.5)	8.7	(23.3)	3.2	(26.4)
H	5.4	(82.6)	16.5	(87.6)	11.0	(48.6)	6.1	(60.3)
I	9.8	(81.0)	18.7	(76.2)	10.3	(44.5)	6.3	(45.9)

[a]Counts on VRB at 35°C indicate coliform bacteria.
[b]Counts on CFC at 22°C indicate pseudomonad bacteria.
[c]Counts on B-P medium indicate Micrococcaceae-type bacteria.
[d]Counts on SPC indicate total aerobic colony count.
[e]For key to product codes, see Table 3.

TABLE 7. *Acceptability and volume of each hand wash agent used during a five work day period.*

Hand wash agent	Acceptability[a] No. of workers A	NC	U	Meat cutting	Kitchen [volume (ml) hand wash used]	Packaging	Total
Non-germicidal soap	16	0	0	325	225	250	800
Chlorhexidine (2%)	13	1	2	550	170	450	1170
Chlorhexidine (4%)	12	2	2	460	245	550	1255
Iodophor (0.02%)	6	4	6	400	225	420	1045
Iodophor (0.12%)	2	4	10	240	170	300	710
Iodophor (0.75%)	0	3	13	250	140	250	640
Non-germicidal gel	15	1	0	380	400	400	1180
Irgasan DP 300 (0.3%)	14	2	0	350	410	410	1170
Irgasan DP 300 (0.5%)	3	3	10	300	275	280	855

[a]Acceptability recorded from opinions expressed by workers: A = acceptable, NC = no comment; U = unacceptable.

tification technique. Of the 72 isolates, 49 (68%) of the isolates were *E. coli* that grew in EC broth at 45°C. An additional 11 isolates grew at elevated temperature in EC broth, including 9 *Klebsiella pneumoniae* and 2 *Enterobacter* isolates. A total of 12 isolates failed to grow in EC broth at 45°C; these were identified as *E. coli, K. pneumoniae, Klebsiella oxytoca, Enterobacter* (4 isolates) and *Serratia rubidaea*. These data indicate that colonies growing on VRB at 45°C should not be considered as fecal "*E. coli.*"

The volumes of each agent used per week and the responses to questions about the acceptability of the hand wash products are shown in Table 7. The opinions expressed about the hand wash agents are generally supported by the volumes used. An exception to this is the non-germicidal (lotion) soap which was ranked highly acceptable, but a relatively low total volume was used. This might be attributed to the fact that this was the first agent tested, and workers were still becoming accustomed to the hand wash experiment. Specific objections accounting for the poor acceptability of 0.1 and 0.75% iodophor products were their color and smell. The product containing 0.5% Irgasan DP 300 was also criticized for its color and smell. The non-germicidal gel and 0.3% Irgasan DP 300 products were generally well accepted, with favorable comments about color and "softness" of the product.

DISCUSSION

Most studies of germicidal agents for hand hygiene have been done under standardized "laboratory" conditions, using controlled exposure times and specified hand wash procedures. Efforts to simulate practical conditions by contaminating hands with a transient microflora, apart from contaminating hands with specific bacteria, have included contamination of nurses' hands when changing diapers in a neonatal ward *(24)*, changing of wound dressings *(15)* and, in our previous studies, contamination of hands with ground beef inoculated with specific bacteria *(21,27)*.

The laboratory trial was included in this study to pro-

vide a cross-reference to our previous studies in which Latin Square experimental designs were used to compare hand wash agents. A Latin Square design was impractical for use in the meat plant because of the number of workers that would be entailed and the problem of using different hand wash agents in the plant at the same time. A sequential-type study was planned, in which the order of use of the agents was rationalized, and all workers used the same agent in each test location at the same time. In fact, all workers in a unit used the experimental hand wash agent, but only four workers in each unit were included in the study.

Results for the laboratory study were consistent with our previous report for transient bacteria inoculated onto hands *(27)*. Although some agents gave a significantly greater reduction in number of test organisms released from hands after the 15-s hand wash, the practical significance of these differences may be questioned. However, both the 4% chlorhexidine and the 0.75% iodophor products gave greater than 99.5% reduction in number of transient bacteria released from hands after washing. Products with Irgasan DP 300 showed more promise against transient bacteria than we reported in an earlier study *(21)*. The same Irgasan DP 300 (0.3%) product was used in the earlier and current studies. The non-germicidal and germicidal gels (products G and H) have the same basic formula, except for inclusion of 0.3% Irgasan DP 300 in the germicidal agent. Hence, a definite effect can be ascribed to Irgasan DP 300 as the active ingredient, but the practical importance of this effect is limited.

In the meat processing plant, large differences in level of contamination of workers' hands with transient microorganisms were associated with differences in type of work. The visible contamination of hands of meat cutters might have caused a more thorough hand wash by these workers, resulting in greater reductions in bacterial count and in significant differences attributable to hand wash agents. No apparent improvement in efficacy of the agents (substantive effect) could be associated with continuous use of the agents from day-to-day. The reductions in fecal coliform and pseudomonad counts (VRB 45°C and CFC 22°C, respectively) were smaller than noted for the controlled laboratory study. This might be caused by shorter washing time, unstandardized washing procedures, and heavier load of meat soil on hands. Considerable numbers of transient bacteria remained on the hands of meat cutters after washing, indicating that the hand wash procedures were not sufficient to eliminate contaminating bacteria. The meat cutters also had an elevated gram-positive microflora on their hands, probably as a part of the transient flora from meats, as evidenced by the elevated B-P counts. The resident Micrococcaceae-type flora (B-P count) of socially clean hands in the laboratory study was usually about 50 cfu/ml of hand rinse (see Table 1), whereas B-P counts for meat cutters were 2×10^4 to 6×10^5 cfu/ml of hand rinse solution (Table 5). Hand washing also failed to remove these transient bacteria.

For workers in the kitchen and meat packaging areas, initial contamination of their hands with transient microorganisms was much lower than workers involved in meat cutting. This could be attributed to the nature of the work, and the fact that in the processed meat packaging area the workers wore plastic gloves. The type of plastic glove did not occlude the skin, which might cause an increase in the resident microflora *(7,12,25)*. However, hand washing in both the kitchen and processed meat packaging areas did not eliminate transient microorganisms contaminating hands.

In the meat plant, the only unit in which differences could be attributed to hand wash agents was in the meat cutting area. The 4% chlorhexidine gluconate liquid detergent and the iodophor product containing 0.75% available iodine were the hand wash agents of choice. However, in some instances the 0.3% Irgasan DP 300 gel also showed promise. The iodophor product was poorly accepted by the workers, in comparison with the 4% chlorhexidine and 0.3% Irgasan DP 300 gel products. Lower concentration iodophor products were developed to reduce user objections to iodophor compounds. The product containing 0.1% available iodine did not overcome the user objections, and neither of the lower concentration iodophor products in this study could be recommended bacteriologically for control of bacteria on workers' hands. Under the conditions of this study, therefore, the lower concentration iodophor products, the Irgasan DP 300 formulation containing 0.5% active ingredient and the 2% chlorhexidine gluconate product were similar in effect to the non-germicidal products.

The in-use study in a meat processing plant indicated that the initial step to effective hand hygiene would be improved hand washing practice. The washing time of 8 to 10 s is too short for the hand wash agents to be effective. The effectiveness of some of the agents in the meat cutting area can be attributed to the longer washing time necessary to remove the meat soil on hands. Some of the agents were more effective than others in reducing "transient" bacteria on hands, and may be considered more effective than non-germicidal hand wash agents in achieving hand hygiene.

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