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Stainless steel vs. brass faucets: A study

A brewer's goal is to produce a quality tasting beer. To this end, the mash, wort, fermenting sugars and finished beer generally are kept in stainless steel tanks.

For many years, stainless steel has been the alloy of choice in breweries because of its ability to resist corrosion and metallic leaching which could be caused by either the sanitizers, the carbonation, and/or the low pH of beer. This is obviously why stainless steel kegs serve as the most common packaging system for draft beer transport from brewery to distributor, to restaurant or pub. However, once in the marketplace, the conditions from keg to glass change significantly.

In most establishments, the only stainless steel to be found are the kegs. Traditionally, keg couplers, wall brackets, line connectors, shanks, and draft beer faucets consist of brass or chrome plated brass. Brass is an alloy made primarily of copper and zinc with trace amounts of lead. Since brass is more porous than stainless steel, it could be highly susceptible to corrosion and leaching due to the carbonation and low pH of most beers.

Examination of traditional chrome plated keg couplers, "Y" wall brackets, shanks, and faucets revealed that the chrome was completely eroded thus exposing the beer to the porous brass which contained many pitted areas (see photos 1, 2 and 3).

These observations established the goals for this study, which are:

1. To determine whether a traditional chrome plated dispensing system contained more bacteria and yeast than a non-traditional, less porous stainless steel system,

2. To ascertain how much copper and lead leached from the exposed brass surface areas, and

3. To contrast the taste profiles of Budweiser and Bud Light samples drawn from chrome plated brass faucets with those samples drawn from stainless steel faucets.

To conduct this study, stainless steel faucets were essential. We wish to acknowledge Stainless One Dispensing Systems (Stainless One) of Derry, New Hampshire for installing their faucets at a local Sports Bar.

Photos courtesy of Lorraine D. Doucet and Forrest Thornton

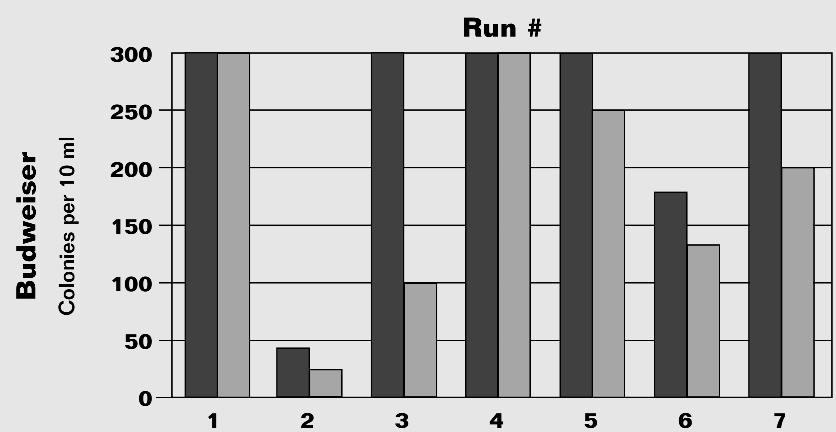
Photo 1. Keg coupler revealing brass surface

Stainless One faucets are built entirely of stainless steel grades 304 and 316. Once these were installed at the sports bar, we could compare microbiologicals, copper and lead levels, and taste profiles in test beer samples drawn from both faucet types.

Test faucets/lines

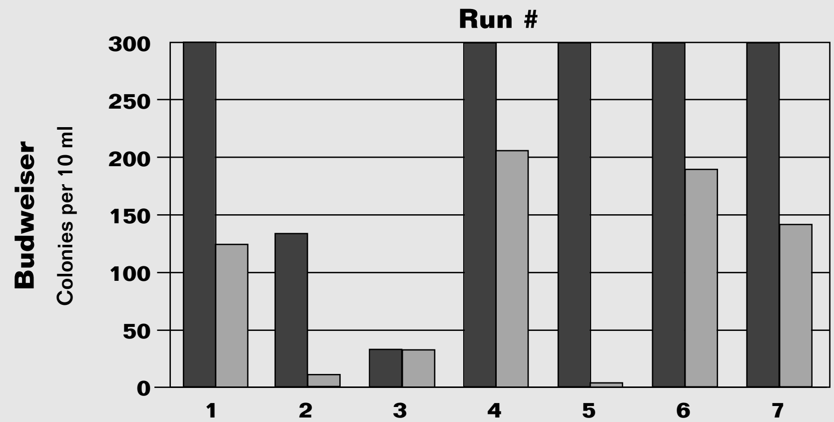
Four faucets were used at the sports bar. Two were traditional chrome plated faucets dispensing Budweiser and Bud Light respectively. The other two faucets were Stainless One faucets which also dispensed Bud and Bud

TABLE 1: TRADITIONAL FAUCETS VS. STAINLESS STEEL TSA



	1	2	3	4	5	6	7
Traditional Faucet	300	43	300	300	300	180	300
Stainless Steel	300	21	97	300	250	130	200
Percent Reduction	0%	51%	68%	0%	17%	28%	33%

TABLE 2: TRADITIONAL FAUCETS VS. STAINLESS STEEL EMB



	1	2	3	4	5	6	7
Traditional Faucet	300	133	30	300	300	300	300
Stainless Steel	125	11	30	210	5	190	142
Percent Reduction	58%	92%	0%	30%	98%	37%	53%

Light. The two Bud faucets (traditional and stainless steel) were connected to the same keg and vinyl lines through a "Y" wall bracket. This was also the case for the two Bud Light faucets. Since the traditional and stainless steel faucets received beer from the same keg and lines, the only variable was the faucet used.

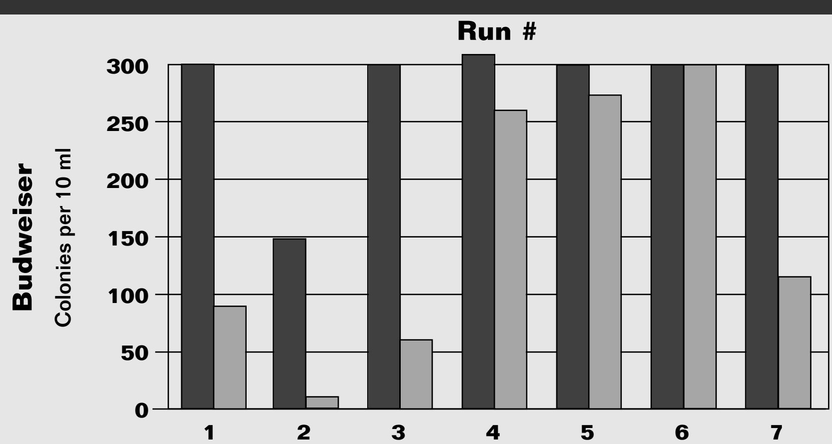
Keg couplers/shanks/wall brackets/line connectors

It must be noted that the keg couplers, line connectors, shanks, and "Y" wall bracket at the sports bar were made of chrome plated brass. Consequently, the beer flowing to all faucets, including the stainless steel ones, was exposed to some brass surfaces. However, since all test beers were exposed to the same brass couplers and connectors, any contrast in results could be directly attributed to the stainless steel faucets or the chrome plated brass faucets.

Sample collection

The samples were randomly collected over a six-month period. Seven test runs were performed on samples collected from the sports bar. Prior to each run, the outer edges of all test faucet nozzles were cleaned with sterile swabs containing 95 percent ethyl alcohol to eliminate airborne contaminants. The nozzles were swabbed with sterile water to flush the alcohol from the ends of the nozzles.

TABLE 3: TRADITIONAL FAUCETS VS. STAINLESS STEEL WA



	1	2	3	4	5	6	7
Traditional Faucet	300	150	300	400	300	300	300
Stainless Steel	90	13	62	260	275	300	120
Percent Reduction	70%	91%	79%	35%	8%	0%	60%

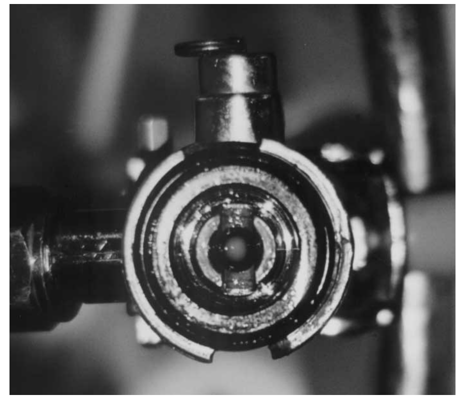


Photo 2. Pitted brass surface of keg coupler

The beer samples were collected in sterile whirl-paks and brought to the laboratory for analysis. Ten-milliliter aliquot samples of the test beers were membrane filtered. The filters were placed on trypticase soy agar, (TSA), eosin methylene blue agar (EMB), wort agar (WA), and a modified MRS agar. Duplicate plates of each were used throughout the study. TSA is a general purpose medium used to isolate and enumerate a wide range of aerobic bacteria. Since TSA is a non-selective medium, both Gram positive and Gram negative bacteria may grow on it. This medium was used to enumerate the total number of heterotrophic bacteria in the test beer samples.

EMB is a selective and differential medium which inhibits the growth of Gram positive bacteria and enhances the growth of Gram negative bacteria. This medium was used to isolate and enumerate coliform and enteric bacteria in the beer samples. WA is a medium which fosters the growth of yeast. WA was used to enumerate the yeast contained in the test beers. The TSA, EMB, and WA agar plates were incubated in aerobic incubators for two days at 27 degrees C.

A modified MRS agar was employed to enumerate beer spoiling pediococci and lactobacilli. All MRS plates were placed in an anaerobic incubator for 5 days at 27 degrees C. No pediococci or lactobacilli were observed on any of the plates throughout the study.

The yeast inhibitor actidione (cyclohexamide) (0.2 mg/l) was added to TSA, EMB, and MRS agars prior to autoclaving. Zinc sulfate was added to the WA to stimulate the growth of yeast .

Microbiological findings

Tables 1, 2, and 3 compare the numbers of total heterotrophic bacteria, coliform bacteria, and yeast contained in Budweiser drawn from traditional chrome plated brass faucets and stainless steel faucets. Data compiled from the seven runs on Budweiser, drawn from stainless steel faucets, show an overall average of 28 percent fewer total heterotrophic bacteria, 53 percent fewer coliform bacteria, and 49 percent fewer yeast cells than samples drawn from the chrome plated brass faucets.

Bud Light samples drawn from the stainless steel faucets demonstrated an even greater reduction in microorganisms. Bud Light samples had overall averages of 36 percent fewer total heterotrophic bacteria, 65 percent fewer coliform bacteria, and 74 percent fewer yeast cells than the overall average of microorganisms found in samples drawn from chrome plated faucets (Tables 4, 5, 6). Since all beer samples came from the same kegs and lines, and were equally exposed to the brass in the keg couplers, "Y" wall bracket, and line connectors, one can deduce that the major difference in numbers was due to the faucets themselves.

Valve design of Stainless One faucet

Both the design of the stainless steel faucets and stainless steel's resistance to corrosion are responsible for the lower numbers of bacteria and yeast recovered from the beers drawn from these faucets. The beer valve in the Stainless One faucet shuts off just above the nozzle creating a vacuum and surface tension which holds a droplet of beer in suspension at the end of the nozzle (photos 4, 5). This droplet and valve location not only prevent the influx of airborne bacteria into the faucet, but also inhibit the backflow of possible contaminants into the faucet and line. As the faucet is opened, the droplet cannot be lifted into the faucet valve.

Valve design of traditional brass faucet

The valve is further up in traditional faucets (photo 3). This allows airborne microorganisms to rise up in the faucet as the beer drains out of the faucet, when the valve is shut. Consequently, any contaminant in the faucet valve can be carried back into the line when the faucet is opened as the valve plunges back into the beer flow. Furthermore, the micro pitted pockets in the chrome plated brass faucets could permit unwanted bacterial and yeast growth (photo 3). The lower bacteria and yeast counts, observed in beer drawn from stainless steel faucets, could prove beneficial in prolonging beer flavor, stability, and saleability.

Line cleaning impact on microorganism count

The lines at the sports bar were cleaned every 14 days. Samples for runs 1 and 4 were col-

Photo 3. Traditional brass faucet with rough "pitted" brass surface

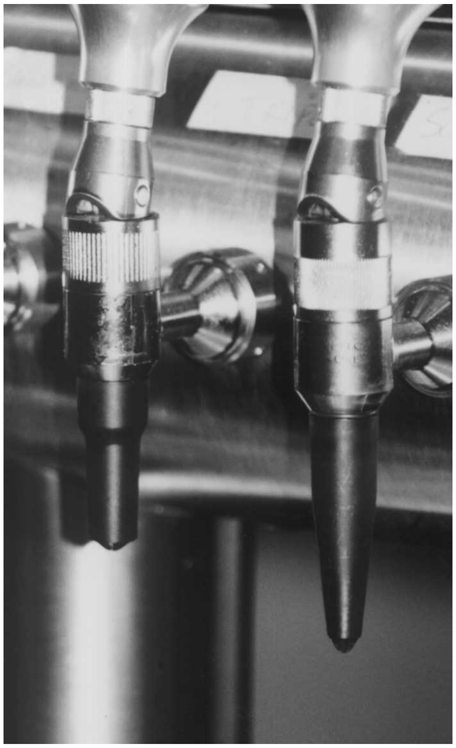


Photo 4. Note beer "droplet" at end of nozzle

lected immediately after the lines were cleaned. The other test samples were collected two to three days after cleaning. Tables 1, 4, 5, and 6 show an overall increase in the numbers of microorganisms in the samples drawn from both faucet types and both beers, when the samples were collected immediately after the lines were cleaned (runs 1, 4). It would appear that the cleaning dislodged bacteria and yeast from either the draft lines or the pitted pockets in the brass faucets, keg couplers, line connectors, or "Y" bracket, resulting in the isolation of greater numbers of bacteria and yeast.

Metals determination

All metal tests were performed in an independent, certified laboratory. A Perkins - Elmer AS50 graphite furnace was used to determine copper and lead levels according to EPA Code 200.9.

Copper levels

Trace amounts of copper are required by yeast for active growth, and since water may contain minimal amounts of copper, trace levels of copper would be present in the test beers. To ascertain a baseline level for copper, bottled Bud and Bud Light and keg samples of the same beers, drawn through an all stainless steel keg coupler and faucet, were used to establish a control level. All bottled beer and keg controls consistently contained 0.006 mg/l copper. Hence, any copper level higher than 0.006 mg/l would indicate leaching from the brass components in the dispensing system. Since all control samples of Bud and Bud Light contained 0.006 mg/l of copper, this amount was subtracted from the recovered copper levels to determine the actual amount of copper leaching from the entire brass dispensing system (Tables 7, 8).

Higher copper levels were observed in beer samples drawn from brass faucets (Tables 7, 8). Since stainless steel faucets do not contain copper, all copper detected in beer drawn from these faucets had to leach from the brass keg couplers, line connectors, shanks, and "Y" wall bracket shared by all test beers. Subsequently, copper levels higher than those obtained in beer samples drawn from stainless steel faucets were directly attributed to the brass faucets themselves (Tables 7, 8). Results indicate that the chrome plated brass faucets leached significantly higher levels of copper than did the brass couplers, connectors, shanks, and "Y" bracket (Tables 7, 8).

The stainless steel faucets demonstrated a positive impact by not contributing additional copper into the Bud and Bud Light test samples. Consequently, there was a significantly lower concentration of copper in Bud and Bud Light samples drawn from stainless steel faucets. This is evidenced by the reduced amount of copper detected in beer drawn from stainless steel faucets (Tables 7, 8).

Lead levels

Lead was not detected in any of the control samples taken from bottled Budweiser and Bud Light. Although no significant amount of lead leached into the beer samples drawn from traditional chrome plated brass faucets, trace amounts were detected in three of the seven runs on Bud and two of the seven runs on Bud Light (Table 9). It is unclear why the lead leached on some occasions and not on others. Unknown conditions in the lines could have attributed to the traces of lead in the Bud and Bud Light samples.

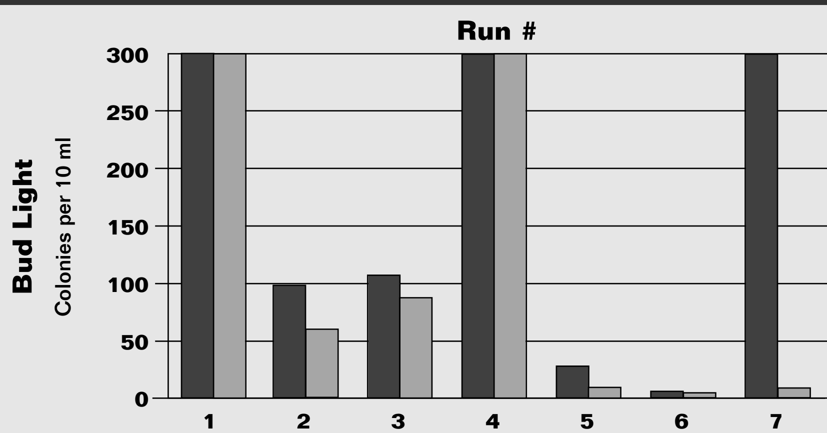
The faucets are the primary leaching agents. This is evidenced by the fact that no lead was detected in any of the Bud or Bud Light samples collected from stainless steel faucets which share common line connectors with the chrome plated brass faucets (Table 9).

Organoleptic testing

The consumer wants a fresh, drinkable, and consistent beer product. Draft beer should taste as good as bottled beer. Both taste profiles should be similar unless there are conditions or factors that alter the flavor of the draft beer.

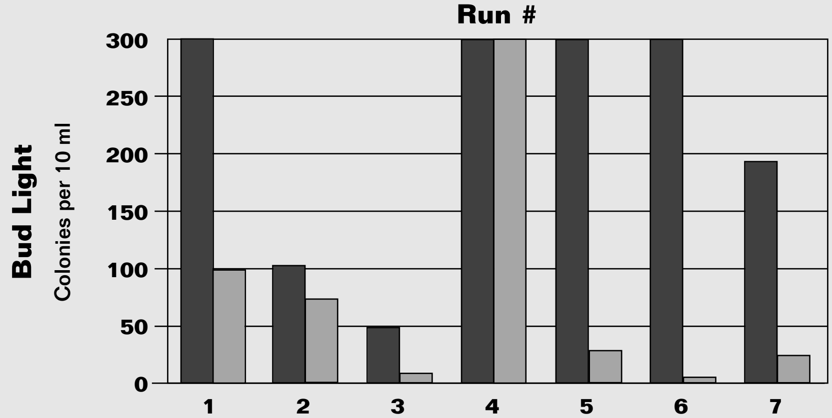
The comparative research between the traditional chrome plated brass and stainless steel faucets was rendered on known beer substrates. The beers used for testing these faucets were bottled Budweiser and Bud Light, produced by Anheuser-Busch in Merrimack, New Hampshire. The control beers used were microbiologically pure due to pasteurization. Sampling aliquots adhered to aseptic guidelines. In addition, the balance and blend of the beer notes (profiles), and the low bitterness units (I.B.U.) of both beers made these the desired media for the comparative taste test. These factors, combined with blended hopping, yield ideal controls.

TABLE 4: TRADITIONAL FAUCETS VS. STAINLESS STEEL TSA



	1	2	3	4	5	6	7
Traditional Faucet	300	101	109	300	28	8	300
Stainless Steel	300	67	89	300	10	5	12
Percent Reduction	0%	34%	18%	0%	64%	38%	96%

TABLE 5: TRADITIONAL FAUCETS VS. STAINLESS STEEL EMB



	1	2	3	4	5	6	7
Traditional Faucet	300	106	46	300	300	300	190
Stainless Steel	96	74	9	300	28	3	23
Percent Reduction	68%	30%	80%	0%	91%	99%	88%

A comparative organoleptic test was done on the test faucets at the Sports Bar. This establishment has both stainless steel faucets and traditional faucets. The control beer used was bottled Budweiser, returnable long neck, with a 12 day "born date". The profile of the bottled Budweiser was blended sweet, slight malt and esters, with no bitter after-taste or mouth feel.

A blind tasting was performed using six triangles. Three triangle, sets of three, were from the stainless steel faucets, the other set of three was poured from brass faucets. A total of 18 samples and controls were tasted at 42 degrees F.

Organoleptic results

All test samples drawn from the Sports Bar had beer notes that were slightly suppressed with general dryness, slight metallic and increased bitters at the end. This verified the traces of metals detected in both systems (traditional and stainless steel) due to the chrome plated keg couplers, "Y" connectors, and shanks present in the dispensing system. The metal level, however low, was detected by the taster, hence an alternative dispensing system was deemed essential. During our study, an all stainless steel dispensing system was set up at a Nashua, N.H. pub. Tasting tests were performed on Budweiser drawn from this system. Triangles, sets of three, again were used in the test. The control beer was bottled Budweiser, returnable long neck, with a 10 day "born date." The profile, of both the bottled and stainless steel system beers, was blended sweet with slight malt and esters, and with no bitter after taste or mouth feel. The test triangle was exactly as the control.

Metal determinations of the beer samples from the Nashua pub confirmed the taster's findings. Both the bottled Budweiser and Budweiser drawn from the stainless steel dispensing system contained 0.006 mg/l copper and no lead. Since 0.006 mg/l copper was established as the base level contained in bottled Budweiser, there was no additional metallic flavor added to the drawn beer samples and hence all triangles exhibited the same profiles and flavor characteristics.

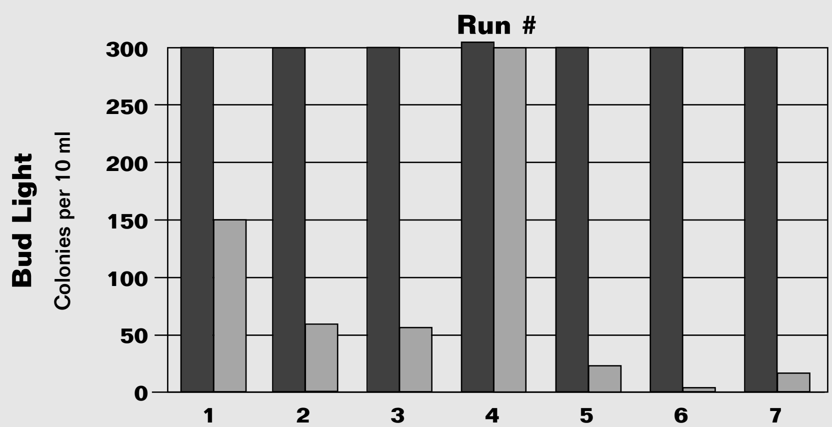
The co-author, a certified taster and microbiologist from the Quality Assurance Department at Anheuser-Busch, Inc. in Merrimack, N.H., performed the taste test for this study.

Conclusion: Microbiologicals

Test samples taken from Bud and Bud Light bottles, as well as samples aseptically drawn from kegs containing the same beers, were microbiologically pure, yet all the samples of the same beers drawn from the faucets contained significantly high numbers of bacteria and yeast (Tables 1-6). This has to be attributed to the lines and pitted pockets in the brass components of the dispensing system. Since beer samples taken from the stainless steel faucets contained fewer microorganisms, the brass faucets themselves were major contributors to microbial growth. The backflow of beer in the pitted pockets found in the brass taps seem to serve as bacterial and yeast growth sites. Sanitizers may remove surface microorganisms but fail to eliminate those embedded deeper in the "pockets" hence a bacterial and yeast resurgence occurs accounting for the continued high number of microorganisms recovered over a six month test period (Tables 1-6).

The effects of bacteria and yeast on beer flavor and shelf life are well documented. Although brewers have no control over the type of dispensing systems used in restaurants and pubs, breweries with laboratory facilities should conduct periodic quality assessment tests on their beers served on draft. Their findings could motivate restaurant and pub owners to consider alternative dispensing systems and line cleaning procedures. Owners may be reluctant to modify their dispensing system or sanitizer protocol, but a cleaner, better tasting draft beer could

TABLE 6: TRADITIONAL FAUCETS VS. STAINLESS STEEL WA



	1	2	3	4	5	6	7
Traditional Faucet	300	300	300	400	300	300	300
Stainless Steel	150	61	57	300	24	5	19
Percent Reduction	50%	80%	81%	25%	92%	98%	94%

TABLE 7: RECOVERED AND ACTUAL COPPER LEVELS IN BUDWEISER SAMPLES DRAWN FROM TRADITIONAL BRASS FAUCETS (BF) AND STAINLESS STEEL (SS)

Runs	Recovered Copper Levels (mg/l)		Actual Copper Levels (mg/l) (Recovered minus 0.006 mg/l Base Line)		Levels Attributed to Brass Connectors (mg/l)	Levels Attributed to Brass Faucets (mg/l)	% Reduction of Recovered Copper with Stainless Steel Faucets
	BF	SS	BF	SS			
1	0.027	0.009	0.021	0.003	0.003	0.018	67
2	0.080	0.009	0.074	0.003	0.003	0.071	89
3	0.092	0.012	0.086	0.006	0.006	0.080	87
4	0.030	0.010	0.024	0.004	0.004	0.020	67
5	0.086	0.025	0.080	0.019	0.019	0.061	71
6	0.071	0.028	0.065	0.012	0.012	0.053	61
7	0.049	0.033	0.043	0.006	0.006	0.037	33

increase draft beer sales which would help increase profits and reduce beer loss.

Metals

Past studies have indicated that brass, gun metal, phosphor-bronze, and aluminum-bronze impart copper and lead to beer. Furthermore, these studies have demonstrated that chromium plating does not resolve the problem since the plating frequently becomes damaged and eroded.

Erosion of copper and lead from a chrome plated brass dispensing system and components were evident in this study. Plates 1, 2 and 3 show erosion of the chrome plating and pitted areas within the interior of the brass keg coupler and faucet. Tables 7, 8 and 9 indicate leaching of the copper and lead from the brass alloy which altered the organoleptic quality of the beer as indicated by the taste test conducted in this study.

If draft beer is to attain the quality taste of bottled beer, then the dispensing system, couplers, and connectors should be made of a material that will not contribute to taste altering metallic off-flavors, or the enhancement of bacterial growth.

The only time the taste tester found draft beer to be "exactly as the bottled controls" was when the beer was drawn from all stainless steel faucets, line connectors, and keg couplers.

Although an all-stainless steel dispensing system cannot resolve the need for proper line cleaning, stainless steel dispensing systems with stainless steel couplers and connectors yielded a cleaner tasting draft product similar to its bottled counterpart. The stainless steel dispensing system at the Nashua, N.H. pub delivered a non-compromised draft beer with the same product integrity as its bottled counterpart.

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TABLE 8: RECOVERED AND ACTUAL COPPER LEVELS IN BUD LIGHT SAMPLES DRAWN FROM TRADITIONAL BRASS FAUCETS (BF) AND STAINLESS STEEL (SS)

Runs	Recovered Copper Levels (mg/l)		Actual Copper Levels (mg/l) (Recovered minus 0.006 mg/l Base Line)		Levels Attributed to Brass Connectors (mg/l)	Levels Attributed to Brass Faucets (mg/l)	% Reduction of Recovered Copper with Stainless Steel Faucets
	BF	SS	BF	SS			
1	0.037	0.007	0.031	0.001	0.001	0.030	81
2	0.076	0.007	0.070	0.001	0.001	0.069	81
3	0.070	0.019	0.064	0.013	0.013	0.051	73
4	0.038	0.027	0.032	0.021	0.021	0.011	29
5	0.158	0.036	0.122	0.029	0.029	0.093	77
6	0.072	0.030	0.066	0.024	0.024	0.042	58
7	0.053	0.041	0.047	0.035	0.035	0.012	23

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TABLE 9: LEAD LEVELS DETECTED IN BUDWEISER AND BUD LIGHT SAMPLES COLLECTED FROM BRASS FAUCETS (BF) AND STAINLESS STEEL FAUCETS (SS)

Runs	Budweiser (mg/l)		Bud Light (mg/l)	
	BF	SS	BF	SS
1	*ND	ND	ND	ND
2	0.012	ND	0.006	ND
3	0.006	ND	ND	ND
4	ND	ND	ND	ND
5	0.009	ND	0.006	ND
6	ND	ND	ND	ND
7	ND	ND	ND	ND

*ND = None Detected

Notes