4. RESULTS

The study was conducted to determine the microbiological profiles of pork dumplings sold in Chiang Mai, Thailand, including a comparison between industrial samples and items from small enterprises (street vendors, markets and restaurants). Additionally, the effect of the reheating for consumption on the microbiological load was characterized. Finally, the study aims to compare the results with official food criteria and other standards, and these results will lead to establish an appropriate quality assurance system for the food hygiene and food safety of Dim sum production.

One hundred and eighty samples and seventy parallel samples were collected and analyzed by conventional cultural methods for the enumeration of total mesophilic aerobic bacteria, lactic acid bacteria, *Enterobactericeae*, coliforms, *Pseudomonas spp*. and coagulase-positive staphylococci.

4.1 Result of temperature measurement

The average temperatures are presented in Figure 10. The arithmetic mean of the temperature of deep frozen industrial samples was -5.49 (±1.82) ºC and the arithmetic mean of the temperature of small enterprise samples was 60.73 (±10.38) ºC

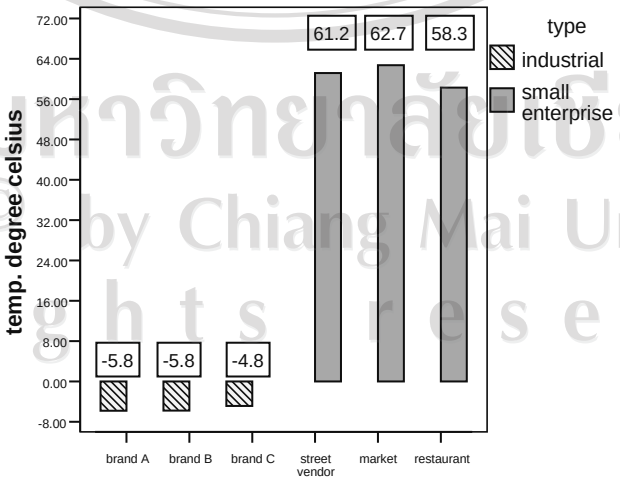


Figure 10 Bar chart of average temperatures

Concerning the reheating experiment the average temperature of industrial samples at the original state was -6.15 (±1.8) ºC, and after reheating the temperature increased to 67.45 (±12.86) ºC (Figure 11).

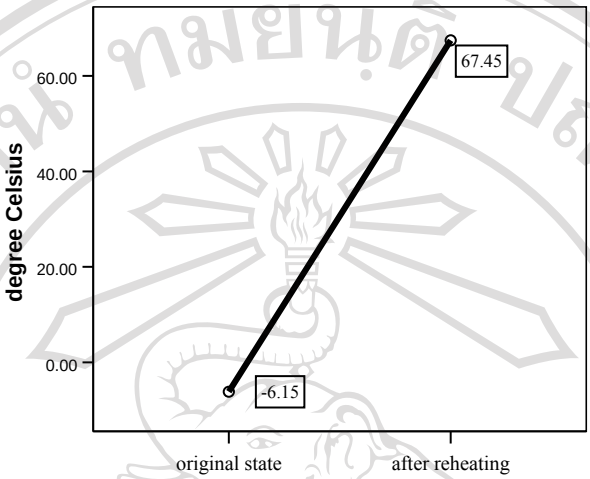


Figure 11 Line chart of average temperature of industrial samples concerning the experiments of reheating

The average temperature of small enterprise samples at their original state was 61.68 (±10.31) ºC, and the temperature decreased to 20.76 (±2.06) ºC after storage at room temperature and increased to 68.73 (±8.54) ºC after reheating (Figure 12).

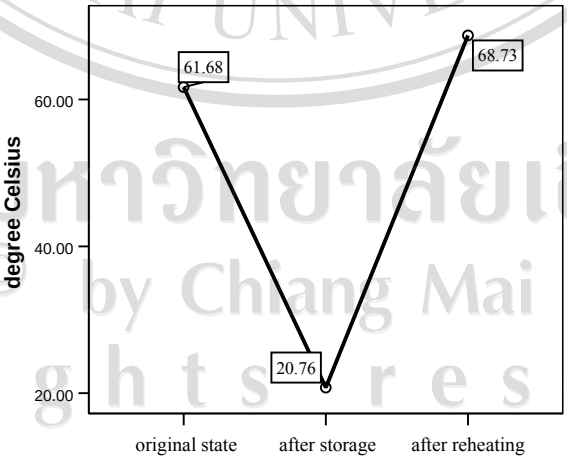


Figure 12 Line chart of average temperature of small enterprise samples concerning the experiments of reheating

4.2 Result of pH measurement

The pH values are presented in Table 7 and Figure 13. The average pH value of industrial samples was 6.76 (±0.24) and the average pH value of small enterprise samples was 7.33 (±0.64).

Table 7 Descriptive statistics of pH measurement

Sources of samples	n	pH measurement						
		Mean	Median	S.D[a]	Min	Max	Range	IQR[b]
Industrial samples	**90**	**6.76**	**6.76**	**0.24**	**6.22**	**7.97**	**1.75**	**0.19**
Brand A	30	6.74	6.70	0.35	6.23	7.97	1.74	0.32
Brand B	30	6.79	6.75	0.17	6.50	7.31	0.81	0.23
Brand C	30	6.77	6.77	0.16	6.22	7.26	1.04	0.13
Small enterprises samples	**90**	**7.33**	**7.24**	**0.64**	**6.19**	**9.01**	**2.82**	**0.78**
Street vendor samples	30	7.59	7.49	0.72	6.51	9.01	2.50	1.03
Market samples	30	7.24	7.25	0.61	6.19	8.77	2.58	0.71
Restaurant samples	30	7.15	7.11	0.52	6.38	8.77	2.39	0.82

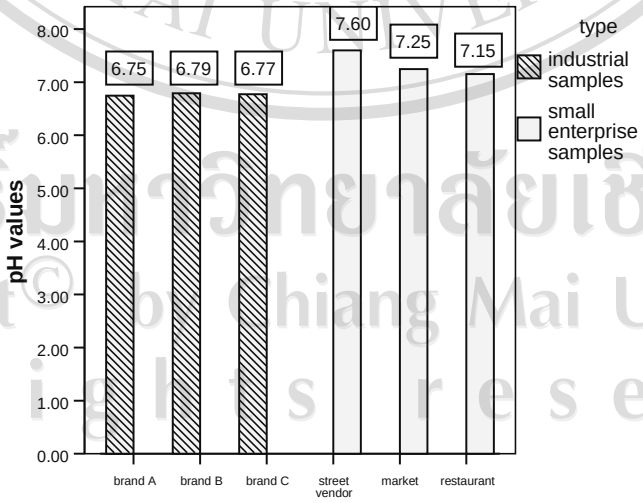


Figure 13 Bar chart of average pH values

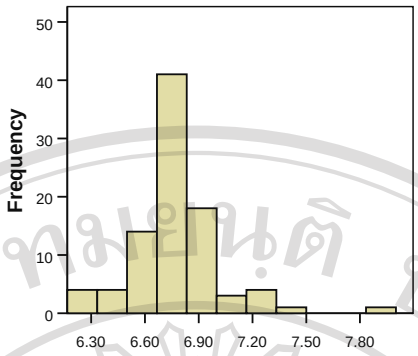


Figure 14 Histogram showing the distribution of pH value of industrial samples

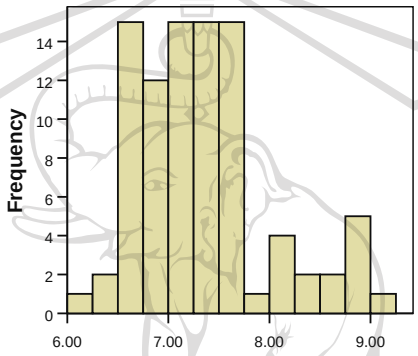


Figure 15 Histogram showing the distribution of pH value of small enterprise samples

In the reheating test the average pH value of industrial samples at the original state was 6.74 (±0.24). After reheating the pH value increased to 6.78 (±0.33) (Figure 16)

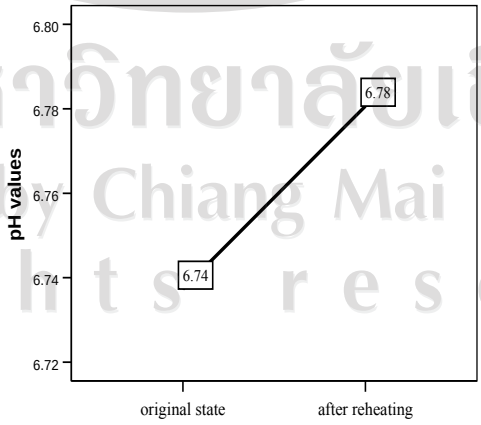


Figure 16 Line chart of average pH values of industrial samples concerning the experiments of reheating

The average pH value of small enterprise samples at the original state was 7.26 (±0.71). The pH value increased very slightly to 7.27 (±0.71) after storage at room temperature and increased to 7.46 (±0.60) after reheating (Figure 17)

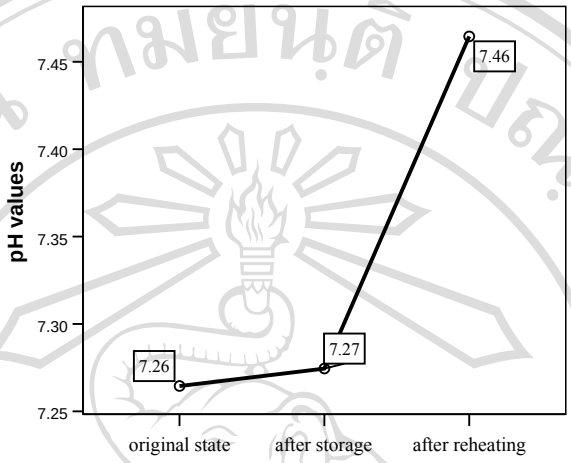


Figure 17 Line chart of average pH values of small enterprise samples concerning the experiments of reheating

4.3 Result of enumeration of total aerobic bacteria

The statistical values of the total aerobic bacteria counts are presented in Table 8 and Figure 18. The median aerobic bacteria count of industrial samples was 1.09 log cfu/g and the median aerobic bacteria count of small enterprise samples was 2.64 log cfu/g. A statistically significant difference was found between the aerobic bacteria counts of the industrial samples and the samples of small enterprises ($p \leq 0.05$ [$p = 0.001$]). In addition to that, slightly differing arithmetic means and medians have been found between the three brands of industrial pork dumplings; however, there was no statistically significant difference between these 3 brands ($p > 0.05$ [$p=0.236$]). The average aerobic colony counts of street vendor samples, market samples, and restaurant samples seemed to be nearly equal. There was also no statistically significant difference between these 3 different sources of the small enterprises ($p > 0.05$ [$p=0.982$]).

Table 8 Descriptive statistics of total aerobic mesophilic bacteria counts (log cfu/g)

Sources of samples	n	Total aerobic mesophilic bacteria						
		Mean	Median	S.D[a]	Min	Max	Range	IQR[b]
Industrial samples	**90**	**1.38**	**1.09**	**0.77**	**0.70**	**3.66**	**2.96**	**1.28**
Brand A	30	1.63	1.60	0.94	0.70	3.66	2.96	1.44
Brand B	30	1.32	1.09	0.65	0.70	2.39	1.69	1.26
Brand C	30	1.20	0.70	0.66	0.70	2.42	1.72	1.11
Small enterprises samples	**90**	**3.12**	**2.64**	**1.83**	**0.70**	**7.49**	**6.79**	**2.53**
Street vendor samples	30	3.06	2.61	1.82	0.70	6.53	5.83	2.82
Market samples	30	3.08	2.55	1.71	0.70	7.34	6.64	2.34
Restaurant samples	30	3.23	2.79	1.99	0.70	7.49	6.79	2.68

[a] SD, standard deviation, [b] IQR, Interquartile Range

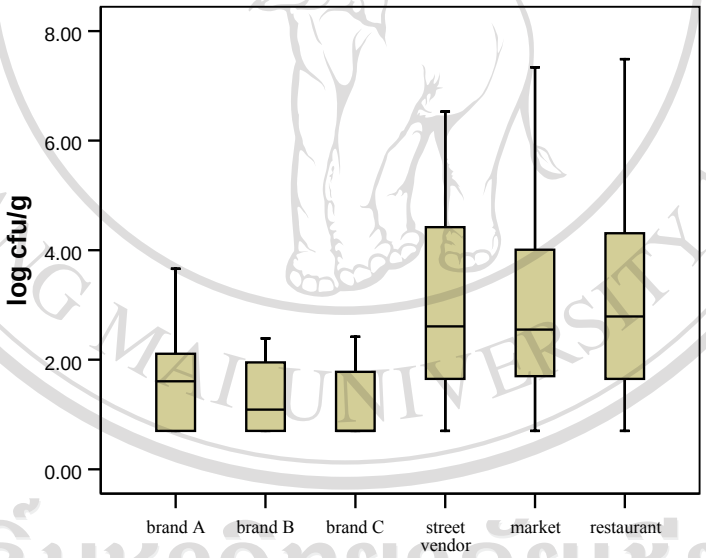


Figure 18 Box plot of total aerobic bacteria counts in different sources

The distribution of total aerobic bacteria count is presented in Table 9, Figure19 and Figure 20. The most frequent bacteria contaminations of all data are found in the class with aerobic plate counts of < 10 cfu/g (28.33 % [n=180]) because 48.89 % of the industrial samples showed such results. 27.78 %, 20 % and 3.33 % of the industrial samples were found in the range of 10 to $<10^2$, 10^2 to $<10^3$ and 10^3 to $<10^4$ respectively. With regard to small enterprises, the largest density of results was found

in the range of 10 to $<10^2$. Moreover, 7.78 % revealed plate counts of <10 cfu/g. 28.89 % of the small enterprise samples showed a bacteria load of 10^4 cfu/g and higher. However, none of the industrial pork dumplings showed these results.

Table 9 Classified distribution of total aerobic bacteria counts

Total aerobic bacteria range (cfu/g)	Number and percentage of samples in following sources		
	Industrial samples (n=90)	Samples of small enterprise (n=90)	Total (n=180)
< 10 [< log 1]*	44 (48.89 %)	7 (7.78 %)	51 (28.33 %)
10 to $<10^2$ [log 1- <2]	25 (27.78 %)	23 (25.56 %)	48 (26.67 %)
10^2 to $<10^3$ [log 2- <3]	18 (20.00 %)	21 (23.33 %)	39 (21.67 %)
10^3 to $<10^4$ [log 3- <4]	3 (3.33 %)	13 (14.44 %)	16 (8.89 %)
10^4 to $<10^5$ [log 4- <5]	0	11 (12.22 %)	11 (6.11 %)
10^5 to $<10^6$ [log 5- <6]	0	4 (4.44 %)	4 (2.22 %)
10^6 to $<10^7$ [log 6- <7]	0	6 (6.67 %)	6 (3.33 %)
10^7 to $<10^8$ [log 7- <8]	0	5 (5.56 %)	5 (2.78 %)

* = Not detected in 25 g of samples, the aerobic plate counts were performed by pouring method.

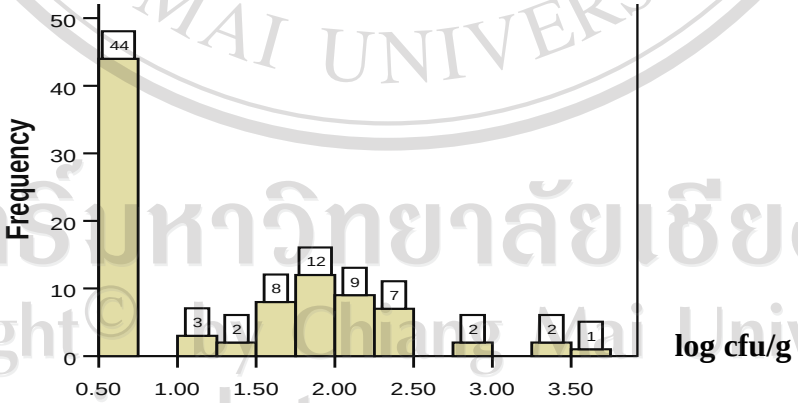


Figure 19 Histograms of industrial samples

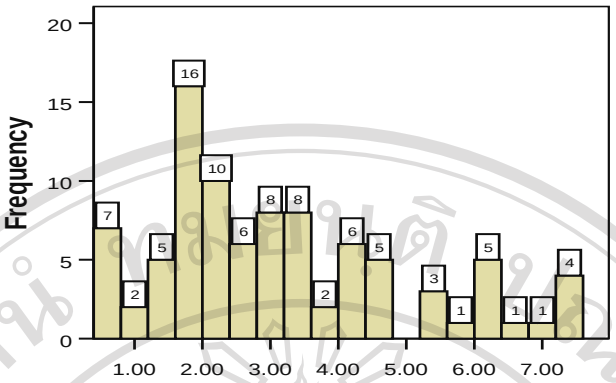


Figure 20 Histograms of small enterprise samples

The analysis of the effect of reheating started with median aerobic bacteria count of 1.09 log cfu/g for the industrial samples at the original state. This number was reduced to 0.7 log cfu/g in parallel samples after reheating by microwave (Table10). However, there was a clear but not a statistically significant difference between the counts at original state and after reheating ($p > 0.05$ [p=0.058]).

Nevertheless, the median aerobic bacteria count of small enterprise samples at their original state was 3.03 log cfu/g. This number increased to 5.68 log cfu/g after storage at room temperature for 6-8 hours and was reduced to 3.49 log cfu/g after reheating by microwave (Table 11). Statistically significant differences between the counts at the original state, after storage and after reheating could be detected ($p \leq 0.05$ [p=0.001]).

Table 10 Descriptive statistics of industrial samples concerning the experiment of reheating (log cfu/g)

Type	n	Mean	S.D	Min	Max	Percentiles		
						25th	50th	75th
Original samples	30	1.38	0.78	0.70	3.66	0.70	1.09	1.96
Parallel samples after reheating	30	1.05	0.64	0.70	3.22	0.70	0.70	1.21
Difference (Reheating-original)	30	-0.32	-0.11	0.00	-0.44	0.00	-0.39	-0.75

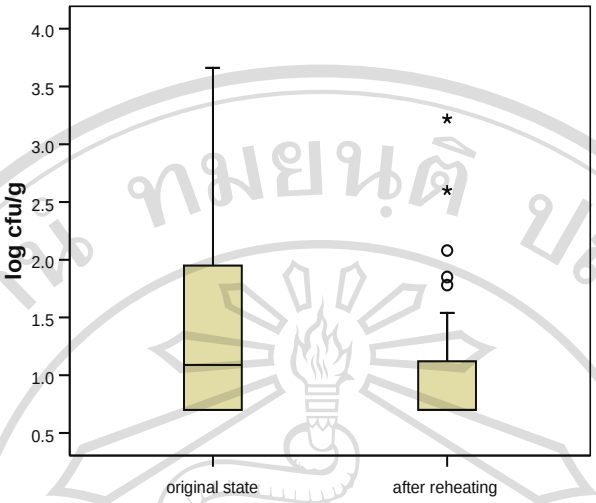


Figure 21 Box plots of industrial samples concerning the experiment of reheating

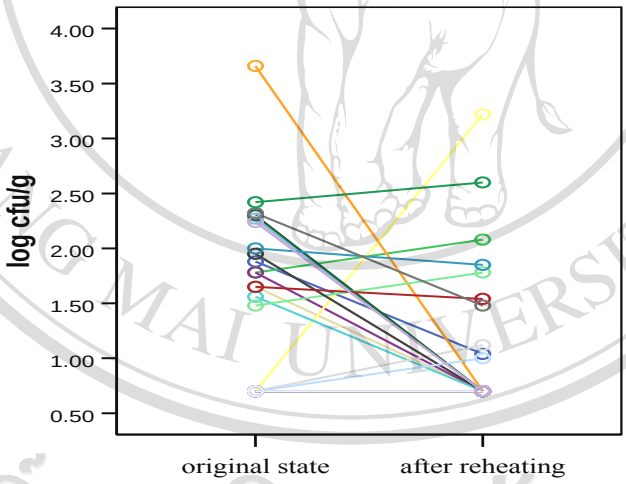


Figure 22 Projection lines of individual industrial samples before and after reheating

Table 11 Descriptive statistics of small enterprise samples concerning the experiment of reheating (log cfu/g)

Type	n	Mean	S.D	Min	Max	Percentiles		
						25th	50th	75th
Original samples	20	3.54	1.95	0.70	7.09	1.95	3.03	5.67
Parallel samples after storage	20	5.16	1.69	1.68	7.37	3.52	5.68	6.55
Parallel samples after reheating	20	3.81	1.82	0.70	6.38	2.49	3.49	5.71

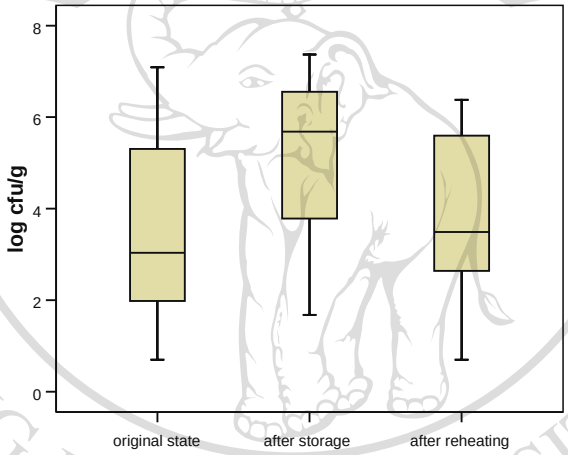


Figure 23 Box plots of small enterprises samples concerning the experiment of reheating

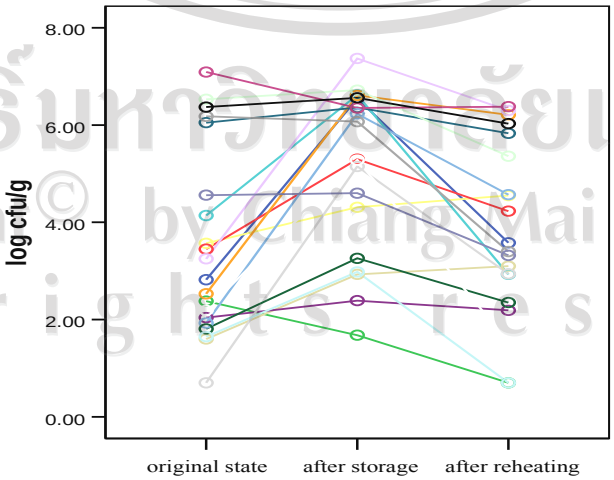
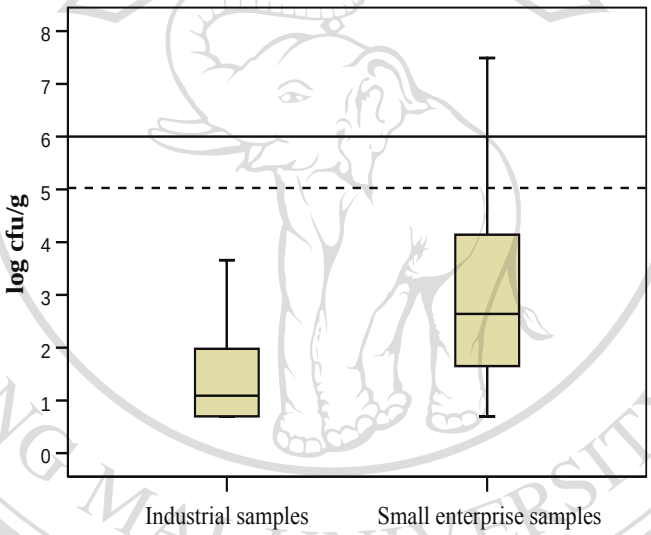


Figure 24 Projection lines of individual small enterprises samples at original state, after storage and after reheating.

The suggested levels for the microbiological standards of cooked-frozen or cooked-chilled food that have to be reheated before consumption i.e. dim sum, pizza (the Food and Drug Administrative, the Ministry of Public Health, Thailand) prescribe total aerobic bacteria counts of **less than 10^5** [less than 5 log cfu/g] in the case of frozen pork dumplings**,** and **less than 10^6** [less than 6 log cfu/g] in the case of ready-to-eat pork dumplings. All of the industrial samples were found to have total aerobic bacteria counts below the indicated levels. However, 12.22 % of the small enterprise samples were found to have an aerobic plate count exceeding the indicated limit as shown in Figure 25.



------ official limit for frozen pork dumplings

____ official limit for ready-to-eat pork dumplings

Figure 25 Box-plots and reference lines

4.4 Result of enumeration of lactic acid bacteria

The results of the total lactic acid bacteria counts are given in Table 12 and Figure 26. The average lactic acid bacteria count of industrial samples amounts to 0.705 log cfu/g and the average lactic acid bacteria count of small enterprise samples was 1.25 log cfu/g. The median of industrial samples and small enterprise samples was constant at 0.7 log cfu/g. A statistically significant difference was found between

the lactic acid bacteria counts of industrial samples and small enterprise samples ($p \leq 0.05$ [$p = 0.001$]), but the counts within the respective sub-groups revealed that the two main-groups produced similar in-group results. There was no a statistically significant difference between the two main groups ($p > 0.05$; [$p=0.36$ in case of 3 brands and $p=0.94$ in case of 3 different sources of small enterprises (street vendors, markets and restaurants]).

Table 12 Descriptive statistics of total lactic acid bacteria count

Sources of samples	n	Total lactic acid bacteria (log cfu/g)						
		Mean	**Median**	**SD[a]**	**Min**	**Max**	**Range**	**IQR[b]**
Industrial samples	**90**	**0.705**	**0.70**	**0.05**	**0.70**	**1.18**	**0.48**	**0.00**
Brand A	30	0.70	0.70	0.00	0.70	0.70	0.00	0.00
Brand B	30	0.70	0.70	0.00	0.70	0.70	0.00	0.00
Brand C	30	0.716	0.70	0.088	0.70	1.18	0.48	0.00
Small enterprises samples	**90**	**1.248**	**0.70**	**1.07**	**0.70**	**5.27**	**4.57**	**0.70**
Street vendor samples	30	1.32	0.70	1.67	0.70	5.27	4.57	0.85
Market samples	30	1.21	0.70	1.06	0.70	4.43	3.73	0.69
Restaurant samples	30	1.20	0.70	1.02	0.70	4.45	3.75	0.63

[a] SD, standard deviation,

[b] IQR, Interquartile Range

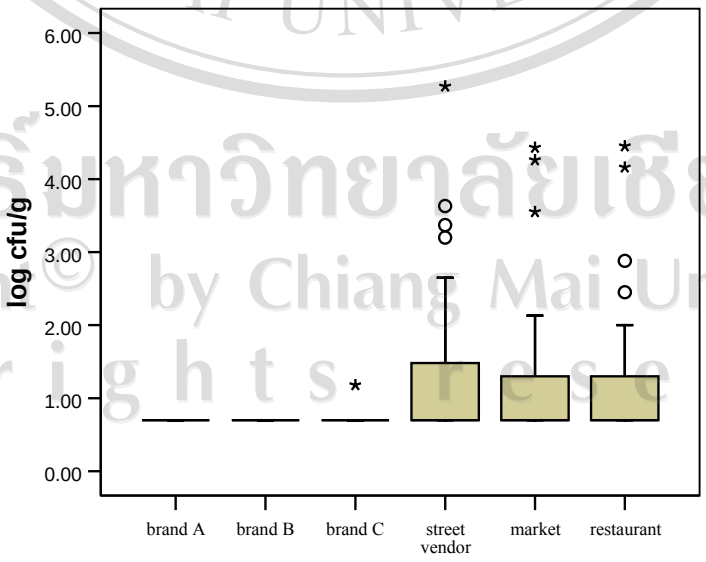


Figure 26 Box plot of lactic acid bacteria counts

The distribution of total lactic acid bacteria is presented in Table 13. The most frequent bacterial contamination of all data of the industrial products is found in the class of total lactic acid counts < 10 cfu/g (98.89 % [89/90]), whereas 71.11 % of the small enterprise samples were found to have lactic acid bacteria counts of < 10 cfu/g. In overall, the largest group was the class with the lactic acid count of < 10 cfu/g (85 % [153/180]. Similar to the mesophilic aerobes classes with higher density of lactic acid bacteria were concentrated on the small enterprise samples.

Table 13 Classified distribution of total lactic acid bacteria counts

Total lactic acid range (cfu/g)	**Number and percentage of samples in following sources**		
	Industrial samples (n=90)	**Small enterprise samples (n=90)**	**Total (n=180)**
< 10 [< log 1] *	89 (98.89 %)	64 (71.11 %)	153 (85 %)
10 to $<10^2$ [log 1- <2]	1 (1.11 %)	11 (12.22 %)	12 (6.67 %)
10^2 to $<10^3$ [log 2- <3]	0	6 (6.67 %)	6 (3.33 %)
10^3 to $<10^4$ [log 3- <4]	0	4 (4.44 %)	4 (2.22 %)
10^4 to $<10^5$ [log 4- <5]	0	4 (4.44 %)	4 (2.22 %)
10^5 to $<10^6$ [log 5- <6]	0	1 (1.11 %)	1 (0.56 %)

* = Not detected in 25 g of samples, the lactic acid counts were performed by pouring method

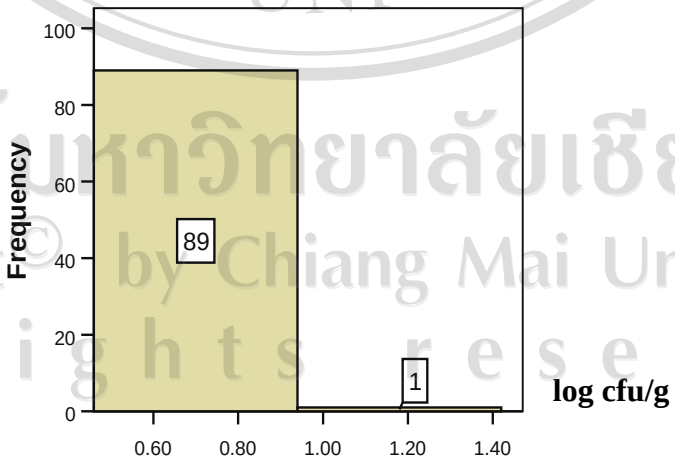


Figure 27 Histograms of industrial samples

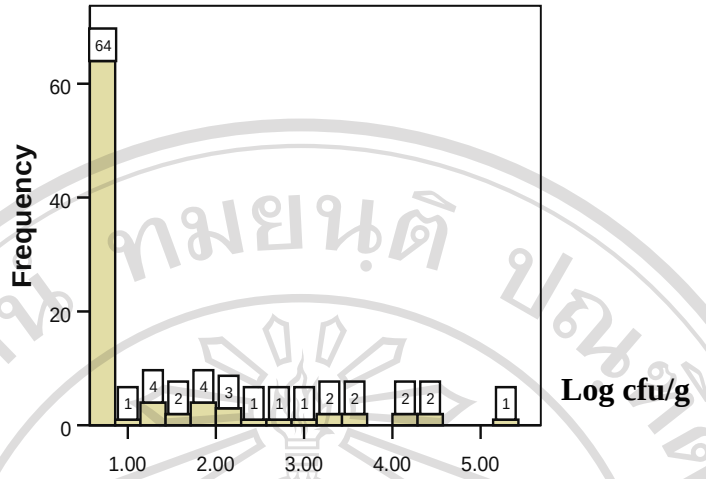


Figure 28 Histograms of small enterprise samples

The median lactic acid bacteria count of industrial samples at the original state and after reheating was constant at 0.7 log cfu/g (Table 14). This number was under the detection limit of the pour plate method (the detection limit of pour plate method is < 10 cfu/g and the results were registered with half of the detection line, that means 10:2 = 5 = $\log_{10}$ 0.7). In contrast, the median lactic acid bacteria count of small enterprise samples at their original state was 0.7 log cfu/g. This number increased to 2.675 log cfu/g after storage at room temperature for 6-8 hours and was reduced to 0.7 log cfu/g after reheating by microwave (Table 15). There was a statistically significant difference between the counts at the original state, after storage, and after reheating ($p \leq 0.05$ [$p = 0.02$]).

Table 14 Descriptive statistics of industrial samples concerning the experiments of reheating (log cfu/g)

Type	n	Mean	S.D	Min	Max	Percentiles		
						25th	50th	75th
Original samples	30	0.7160	0.876	0.7	1.18	0.7	0.7	0.7
Parallel samples after reheating	30	0.7300	0.164	0.7	1.60	0.7	0.7	0.7
Difference (Reheating-original)	30	0.014	-0.712	0.00	0.42	0.0	0.0	0.0

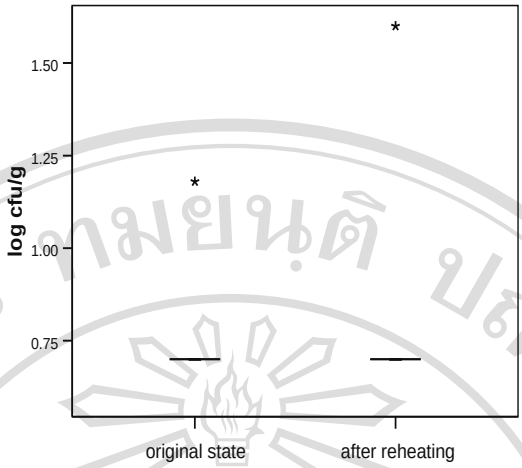


Figure 29 Box plots of industrial samples concerning the experiments of reheating

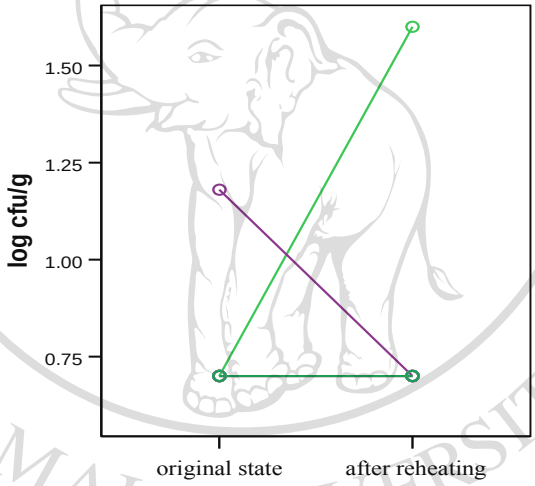


Figure 30 Projection lines of individual industrial samples before and after reheating

Table 15 Descriptive statistics of small enterprise samples concerning the experiments of reheating (log cfu/g)

Type	n	Mean	S.D	Min	Max	Percentiles		
						25th	50th	75th
Original samples	20	1.418	1.34	0.7	5.27	0.7	0.7	1.655
Parallel samples after storage	20	2.614	1.83	0.7	5.64	0.7	2.675	4.292
Parallel samples after reheating	20	1.917	1.56	0.7	5.51	0.7	0.7	3.18

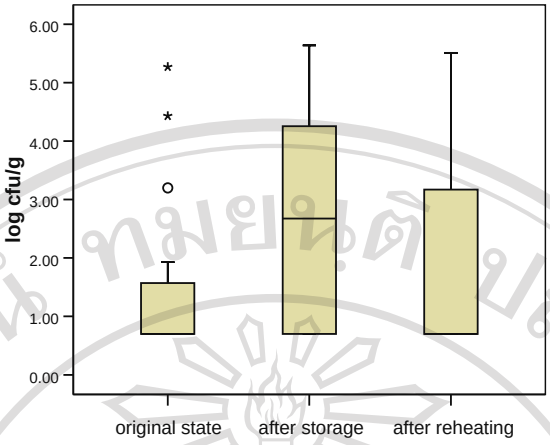


Figure 31 Box plots of small enterprise samples concerning the experiments of reheating

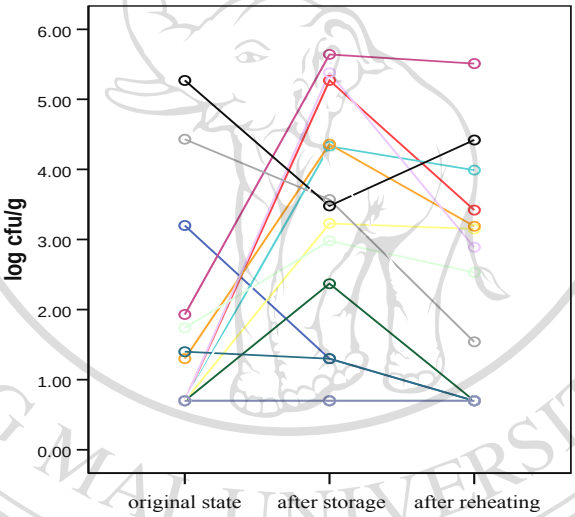


Figure 32 Projection lines of individual small enterprises samples at original state, after storage and after reheating

4.5 Result of enumeration of *Enterobacteriaceae*

The results of *Enterobacteriaceae* counting is presented in Table 16 and Figure 33. The median *Enterobacteriaceae* count of industrial samples and small enterprise samples stayed constant at 0.30 MPN/g. However, the statistically significant difference was found between the counts of these two types of samples ($p \leq 0.05$ [$p = 0.001$]). The different median have been found among 3 different sources of small enterprises samples (street vendors, markets and restaurants);

however, there was no statistically significant difference among three different sources ($p > 0.05$ [p=0.67]). Compared with brand A and especially with brand B the brand C showed the higher average counts, standard deviation and data range. Furthermore, street vendor and restaurant pork dumplings revealed a higher average counts, standard deviation and interquartile range than market food.

Table 16 Descriptive statistics of total *Enterobacteriaceae* counts (MPN/g)

Sources of samples	**n**	**Total *Enterobacteriaceae* counts**						
		Mean	**Median**	**S.D[a]**	**Min**	**Max**	**Range**	**IQR[b]**
Industrial samples	**90**	**0.819**	**0.30**	**2.22**	**0.30**	**15.00**	**14.70**	**0.00**
Brand A	30	0.64	0.30	1.65	0.30	9.3	9.00	0.00
Brand B	30	0.32	0.30	0.11	0.30	0.92	0.62	0.00
Brand C	30	1.49	0.30	3.42	0.30	15.00	14.70	0.00
Small enterprises samples	**90**	**24.22**	**0.30**	**43.21**	**0.30**	**111.00**	**110.70**	**23.7**
Street vendor samples	30	32.19	0.33	49.03	0.30	111.00	110.70	109.7
Market samples	30	9.04	0.30	22.80	0.30	111.00	109.70	2.50
Restaurant samples	30	31.45	0.30	49.48	0.30	111.00	110.70	110.7

[a] SD, standard deviation, [b] IQR, Interquartile Range

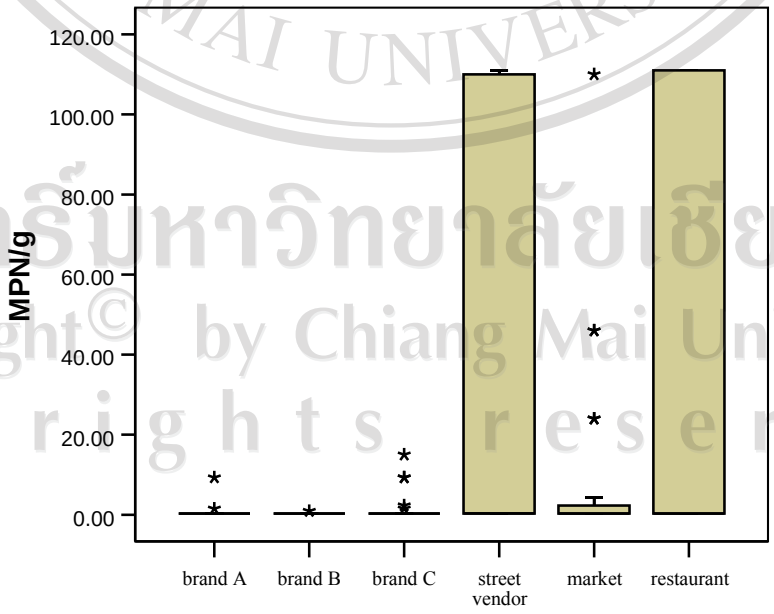


Figure 33 Box plot of total *Enterobacteriaceae* counts

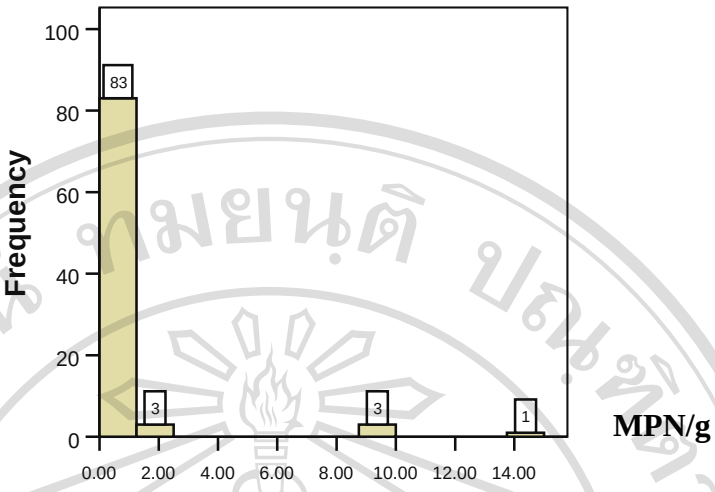


Figure 34 Histograms of industrial samples

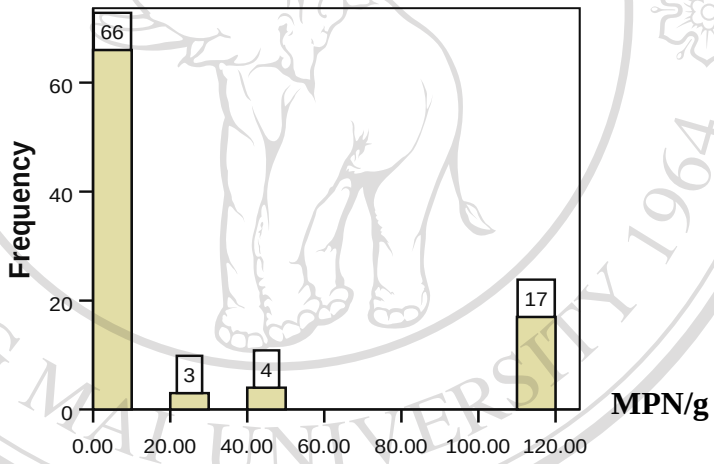


Figure 35 Histograms of small enterprise samples

The distribution of *Enterobacteriaceae* count is presented in Table 17, Figure 34 and Figure 35. On the whole, the largest density of *Enterobacteriaceae* was found in the class of < 0.3 MPN/g (72.8 % [131/180]) representing the industrial samples by 91.1 % [82/90] and the small enterprise items by 54.4 % [49/90]. Still, 15.6 % [14/90] of the small enterprise samples was found to have *Enterobacteriaceae* counts of > 110 MPN/g.

Table 17 Classified distribution of *Enterobacteriaceae* counts

Total *Enterobacteriaceae* count (MPN/g) according MPN index	Number and percentage of samples in following sources		
	Industrial samples (n=90)	Small enterprise samples (n=90)	Total (n=180)
< 0.3 *	82 (91.1 %)	49 (54.4 %)	131 (72.8 %)
0.36	-	4 (4.44 %)	4 (2.22 %)
0.74	-	1 (1.11 %)	1 (0.56 %)
0.92	1 (1.11 %)	4 (4.44 %)	5 (2.78 %)
1.5	2 (2.22 %)	3 (3.33 %)	5 (2.78 %)
2.3	1 (1.11 %)	3 (3.33 %)	4 (2.22 %)
4.3	-	2 (2.22 %)	2 (1.11 %)
9.3	3 (3.33 %)	-	3 (1.67 %)
15	1 (1.11 %)	-	1 (0.56 %)
24	-	3 (3.33 %)	3 (1.67 %)
46	-	4 (4.44 %)	4 (2.22 %)
110	-	3 (3.33 %)	3 (1.67 %)
> 110	-	14 (15.6 %)	14 (7.78 %)

* = Not detected in 25 g of samples, the detection limit of MPN technique is < 0.3 MPN in 1 g of sample

The analysis of the effect of reheating started in the case of industrial samples at the original state and after reheating with the constant median *Enterobacteriaceae* count of 0.3 MPN/g (Table 18). Nonetheless, the median *Enterobacteriaceae* count of small enterprise samples at the original state amounted to 0.3 MPN/g. This number increased to 111.0 MPN/g after storage at room temperature for 6-8 hours and was reduced to 6.8 MPN/g after reheating by microwave (Table 19). There was a statistically significant difference between the counts at the original state, after storage, and after reheating ($p \leq 0.05$ [p=0.001]).

Table 18 Descriptive statistics of industrial samples concerning the experiments of reheating (log cfu/g)

Type	n	Mean	S.D	Min	Max	Percentiles		
						25th	50th	75th
Original samples	30	0.66	1.64	0.30	9.30	0.30	0.30	0.30
Parallel samples after reheating	30	0.49	0.54	0.30	2.30	0.30	0.30	0.30
Difference (Reheating-original)	30	-0.16	-1.10	0.00	-7.00	0.00	0.00	0.00

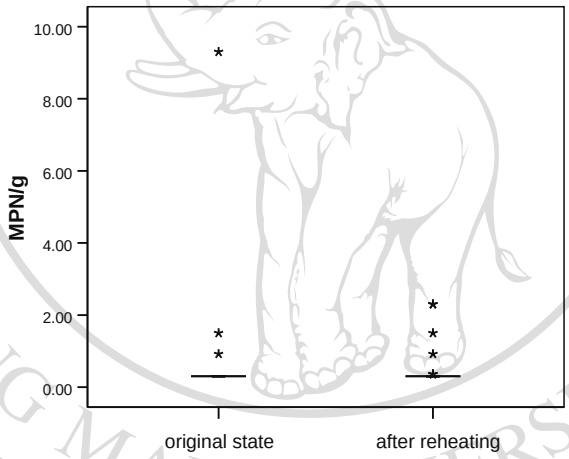


Figure 36 Box plots of industrial samples concerning the experiments of reheating

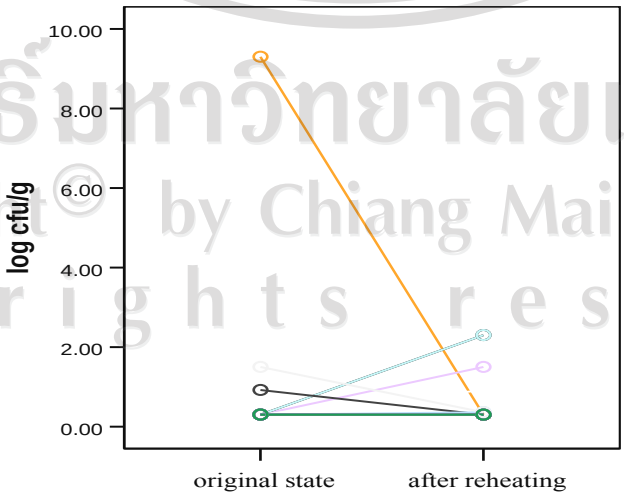


Figure 37 Projection lines of individual industrial samples before and after reheating

Table 19 Descriptive statistics of small enterprise samples concerning the experiments of reheating (log cfu/g)

Type	n	Mean	S.D	Min	Max	Percentiles		
						25th	50th	75th
Original samples	20	22.65	45.19	0.30	111.00	0.30	0.30	2.30
Parallel samples after storage	20	71.32	50.86	0.30	111.00	6.22	111.00	111.00
Parallel samples after reheating	20	42.26	51.99	0.30	111.00	0.30	6.80	110.75

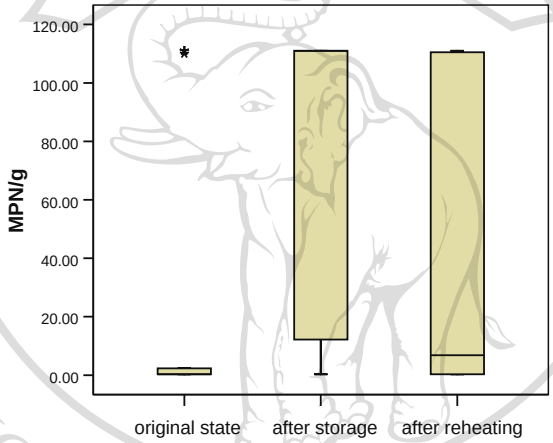


Figure 38 Box plots of small enterprise samples regarding the experiments of reheating

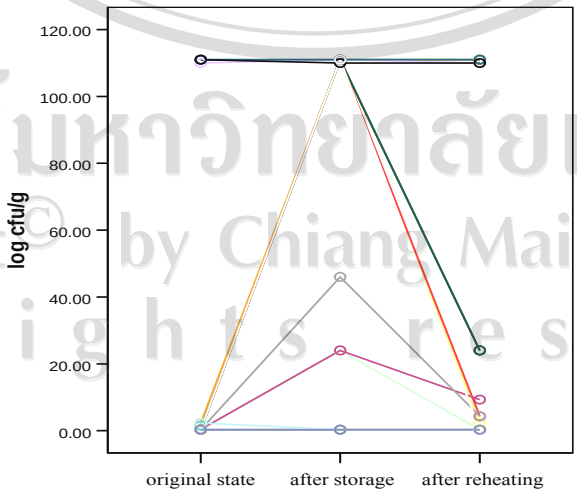


Figure 39 Projection lines of individual small enterprises samples at original state, after storage and after reheating

4.6 Result of enumeration of coliforms

The results of coliforms counts are presented in Table 20 and Figure 40. The median of the coliforms count of industrial samples was equal to the median of small enterprise sample at 0.3 MPN/g. However, a statistically significant difference was found between the coliforms count of industrial samples and small enterprise samples ($p \leq 0.05$ [$p = 0.001$]). Within the industrial samples brand B showed the lowest arithmetic mean and a very narrow range of the data in contrast to brand A and brand C which revealed a number of very high results. There was no the statistically significant difference between these three brand ($p > 0.05$ [$p=0.168$]). A similar situation occurred regarding the small enterprise samples. In contrast to street vendor and restaurant samples the market samples did not show any extreme result. There was not found the statistically significant difference between these three different sources of small enterprise ($p > 0.05$ [$p = 0.406$]).

Table 20 Descriptive statistics of total coliforms counts (MPN/g)

Sources of samples	n	Total coliforms count						
		Mean	**Median**	**S.D[a]**	**Min**	**Max**	**Range**	**IQR[b]**
Industrial samples	**90**	**0.665**	**0.30**	**1.67**	**0.30**	**9.3**	**9.00**	**0.00**
Brand A	30	0.62	0.30	1.64	0.30	9.3	9.00	0.00
Brand B	30	0.32	0.30	0.11	0.30	0.92	0.62	0.00
Brand C	30	1.05	0.30	2.35	0.30	9.3	9.00	0.00
Small enterprises samples	**90**	**13.79**	**0.30**	**35.02**	**0.30**	**111.00**	**110.70**	**0.16**
Street vendor samples	30	16.85	0.30	37.93	0.30	111.00	110.70	2.50
Market samples	30	1.90	0.30	8.33	0.30	46.00	45.70	0.06
Restaurant samples	30	22.61	0.30	44.95	0.30	111.00	110.70	1.47

[a] SD, standard deviation [b] IQR, Interquartile Range

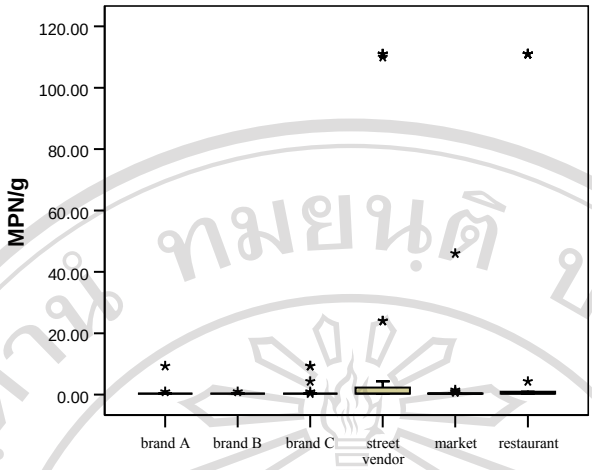


Figure 40 Box plot of total coliforms count

The distribution of total coliforms counts is presented in Table 21, Figure 41 and Figure 42. Regarding the frequency distribution of coliforms, 79.4 % [143/180] of all the samples have been found in the class < 0.3 MPN/g comprising of 91.1 % [82/90] of the industrial products and 67.8 % [61/90] of the small enterprise food. 10 % (9/90) of small enterprise samples were found to have coliforms > 110 MPN/g.

Table 21 Classified distribution of total coliforms count

Total coliforms count (MPN/g) according MPN index	Number and percentage of samples in following sources		
	Industrial samples (n=90)	Small enterprise samples (n=90)	Total (n=180)
< 0.3 *	82 (91.1 %)	61 (67.8 %)	143 (79.4 %)
0.36	1 (1.11 %)	7 (7.78 %)	8 (4.44 %)
0.74	-	1 (1.11 %)	1 (0.56 %)
0.92	3 (3.33 %)	3 (3.33 %)	6 (3.33 %)
1.5	-	2 (2.22 %)	2 (1.11 %)
2.3	-	1 (1.11 %)	1 (0.56 %)
4.3	1 (1.11 %)	2 (2.22 %)	3 (1.67 %)
9.3	3 (3.33 %)	-	3 (1.67 %)
24	-	2 (2.22 %)	2 (1.11 %)
46	-	1 (1.11 %)	1 (0.56 %)
110	-	1 (1.11 %)	1 (0.56 %)
> 110	-	9 (10 %)	9 (5.00 %)

* = Not detected in 25 g of samples, the detection limit of MPN technique is < 0.3 MPN in 1 g of sample

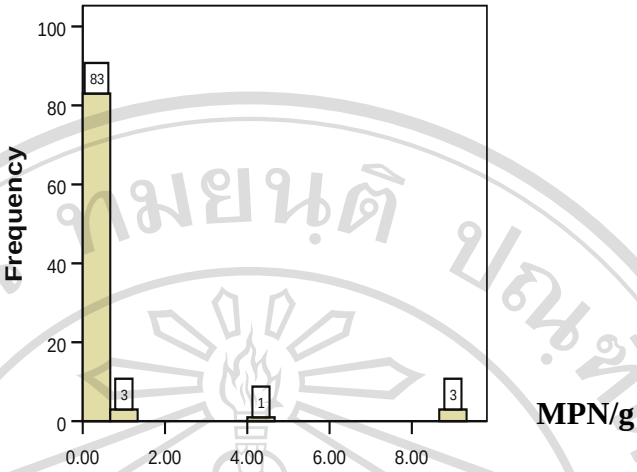


Figure 41 Histograms of industrial samples

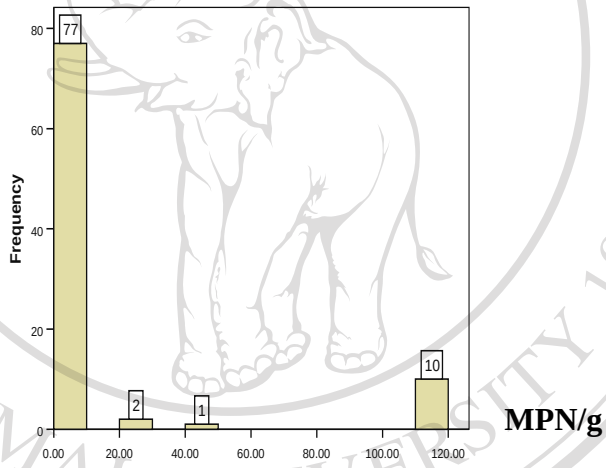


Figure 42 Histograms of small enterprise samples

The median of coliforms count of industrial samples at original state and after reheating was constant at 0.3 MPN/g (Table 22). In contrast, the median of coliforms count of small enterprise samples at original state was 0.3 MPN/g. This number increased to 78.0 MPN/g after storage at room temperature for 6-8 hours and was reduced to 0.61 MPN/g because of reheating by microwave (Table 23). There was found a statistically significant difference between the counts at the original state, after storage and after reheating ($p \leq 0.05$ [$p = 0.001$]).

Table 22 Descriptive statistics of industrial samples concerning the experiments of reheating (log cfu/g)

Type	n	Mean	S.D	Min	Max	Percentiles		
						25th	50th	75th
Original samples	30	0.64	1.64	0.30	9.3	0.3	0.3	0.3
Parallel samples after reheating	30	0.30	0.01	0.30	0.36	0.3	0.3	0.3
Difference (Reheating-original)	30	-0.34	-1.63	0.00	-8.94	0.0	0.0	0.0

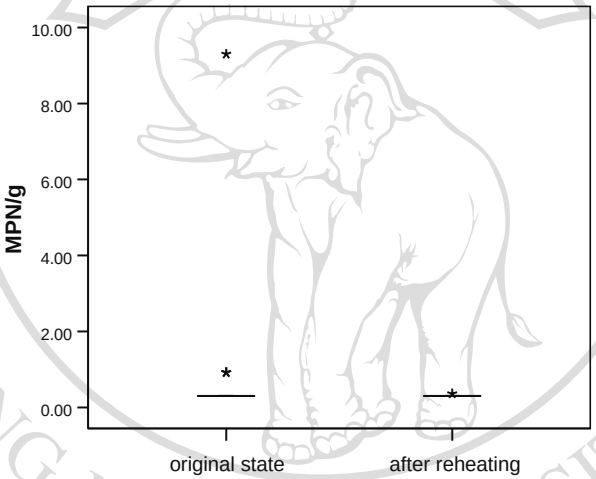


Figure 43 Box plots of industrial samples concerning the experiments of reheating

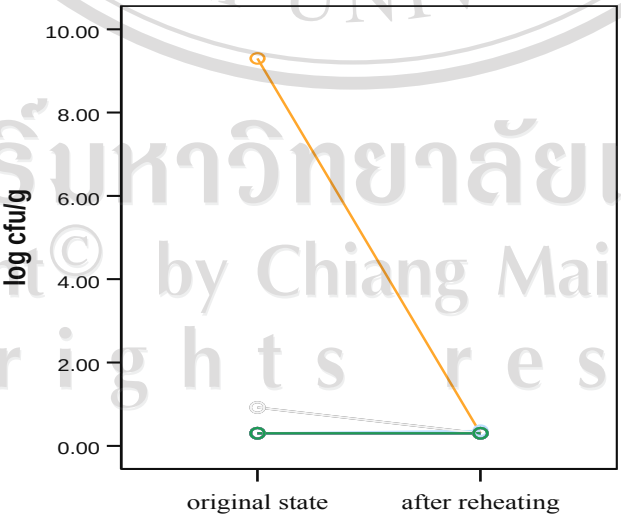


Figure 44 Projection lines of individual industrial samples before and after reheating

Table 23 Descriptive statistics of small enterprise samples concerning the experiments of reheating (log cfu/g)

Type	n	Mean	S.D	Min	Max	Percentiles		
						25th	50th	75th
Original samples	20	7.33	24.96	0.30	111.00	0.30	0.30	0.36
Parallel samples after storage	20	59.53	53.72	0.30	111.00	0.60	78.00	111.00
Parallel samples after reheating	20	19.68	39.85	0.30	111.00	0.30	0.61	19.07

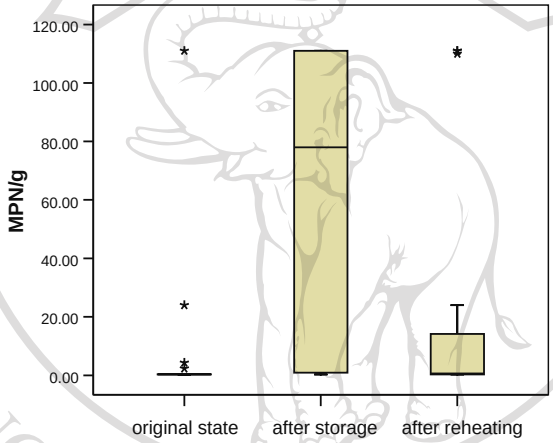


Figure 45 Box plots of small enterprise samples concerning the experiments of reheating

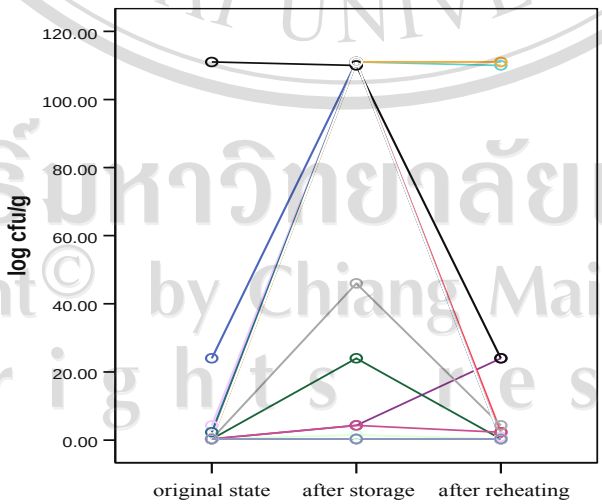
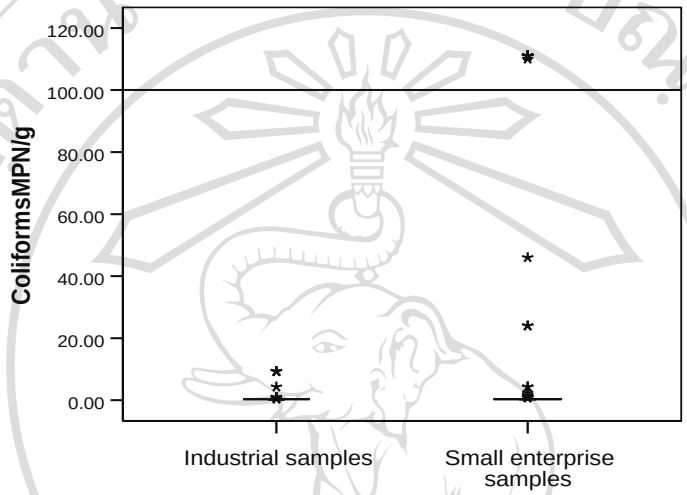


Figure 46 Projection lines of individual small enterprises samples at original state, after storage and after reheating

All of the industrial samples were found to have coliforms count below the official maximum level of < 100 MPN/g. Still, 11.11 % (10/90) of the small enterprise samples exceeded the indicated level of < 100 MPN/g for coliforms (Figure 47).



___ Reference line of frozen pork dumplings (<100 MPN/g)

Figure 47 Box-plots and reference lines

4.7 Result of enumeration of *Pseudomonas spp.*

The results of *Pseudomonas spp.* counting are described in Table 24 and Figure 48. The median *Pseudomonas spp.* count of industrial samples was 1.70 log cfu/g, this number was equal to the corresponding value of small enterprise samples. However, the statistically significant difference was found between the counts of the industrial samples and the small enterprise samples ($p \leq 0.05$ [$p = 0.001$]). There was no difference of *Pseudomonas spp.* count between 3 brands of industrial. Street vendor and restaurant samples have higher average *Pseudomonas spp.* counts than market samples. However, there was not found the statistically significant difference between these 3 different sources ($p > 0.05$ [$p = 0.063$]).

Table 24 Descriptive statistics of *Pseudomonas spp.* count

Sources of samples	n	Total *Pseudomonas spp.* (log cfu/g)						
		Mean	**Median**	**SD[a]**	**Min**	**Max**	**Range**	**IQR[b]**
Industrial samples	**90**	**1.70**	**1.70**	**0.00**	**1.70**	**1.70**	**0.00**	**0.00**
Brand A	30	1.70	1.70	0.00	1.70	1.70	0.00	0.00
Brand B	30	1.70	1.70	0.00	1.70	1.70	0.00	0.00
Brand C	30	1.70	1.70	0.00	1.70	1.70	0.00	0.00
Small enterprises samples	**90**	**1.83**	**1.70**	**0.44**	**1.70**	**4.10**	**2.40**	**0.00**
Street vendor samples	30	1.907	1.70	0.54	1.70	4.02	2.32	0.00
Market samples	30	1.70	1.70	0.00	1.70	1.70	0.00	0.00
Restaurant samples	30	1.902	1.70	0.53	1.70	4.10	2.40	0.00

[a] SD, standard deviation, [b] IQR, Interquartile Range

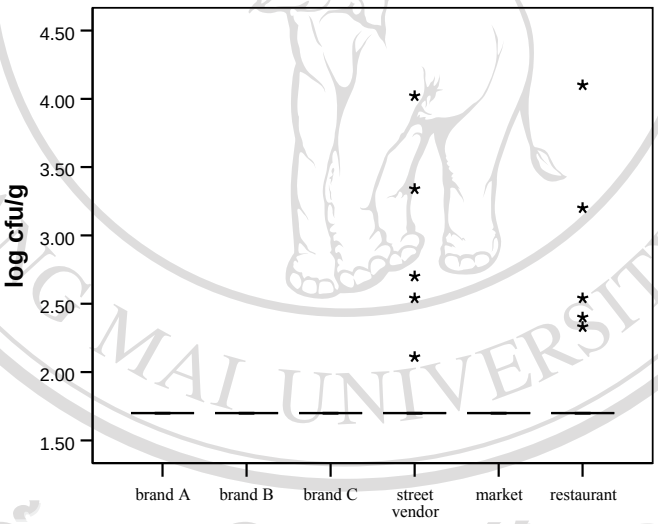


Figure 48 Box plot of *Pseudomonas spp.* count

Regarding the distribution of *Pseudomonas spp.* counts (Table 25), all of the industrial pork dumplings were found to have *Pseudomonas spp.* of < 100 cfu/g, because none of the samples developed any colony performing the spreading method on *Pseudomonas* CFC agar. Furthermore, the detection rate of *Pseudomonas spp*. in small enterprise samples amounted to 11.1 % [10/90] (6.67 %, 2.22 % and 2.22 % of the small enterprise samples were found to have *Pseudomonas spp.* in range of 10^2 to $<10^3$, 10^3 to $<10^4$ and 10^4 to $<10^5$ respectively).

Table 25 Classified distribution of total *Pseudomonas spp.* count

Total *Pseudomonas spp.* range (cfu/g)	Number and percentage of samples in following sources		
	Industrial samples (n=90)	Small enterprise samples (n=90)	Total (n=180)
< 100 [< log 2] *	90 (100 %)	80 (88.9 %)	170 (94.4 %)
10^2 to <10^3 [log 2- <3]	-	6 (6.67 %)	6 (3.33 %)
10^3 to <10^4 [log 3- <4]	-	2 (2.22 %)	2 (1.11 %)
10^4 to <10^5 [log 4- <5]	-	2 (2.22 %)	2 (1.11 %)

* =Not detected in 25 g of samples, The *Pseudomonas spp.* counts were performed by spreading method

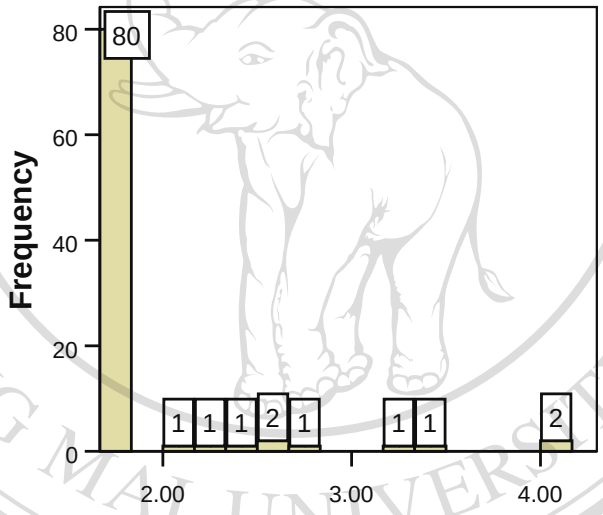


Figure 49 Histograms for small enterprise samples

The study of the effect of reheating showed that the average *Pseudomonas spp.* count of the industrial samples at their original state and after reheating stayed constant at 1.70 log cfu/g (Table 26) similar with the median *Pseudomonas spp.* count of the small enterprise samples at the original state and after reheating. However, there was a statistically significant difference among the counts of small enterprise samples at their original state, after storage and after reheating ($p \leq 0.05$ [$p = 0.04$]).

Table 26 Descriptive statistics of industrial samples concerning the experiments of reheating (log cfu/g)

Type	n	Mean	S.D	Min	Max	Percentiles		
						25th	50th	75th
Original samples	30	1.70	0.00	1.70	1.70	1.70	1.70	1.70
Parallel samples after reheating	30	1.70	0.00	1.70	1.70	1.70	1.70	1.70
Difference (Reheating-original)	30	0.00	0.00	0.00	0.00	0.00	0.00	0.00

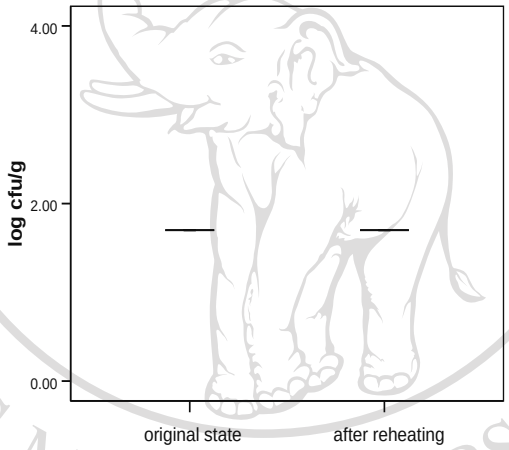


Figure 50 Box plots of industrial samples concerning the experiments of reheating

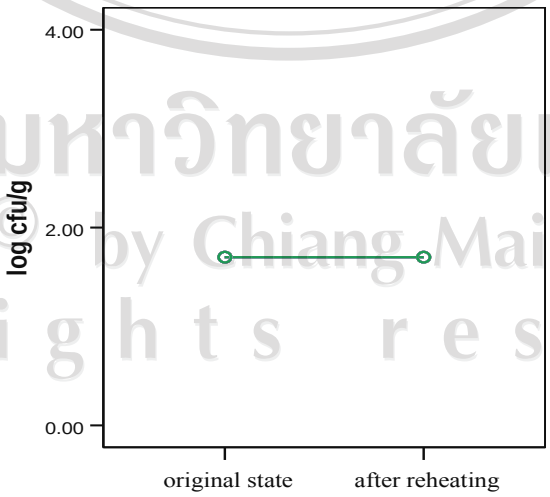


Figure 51 Projection lines of individual industrial samples before and after reheating

Table 27 Descriptive statistics of small enterprise samples concerning the experiments of reheating (log cfu/g)

Type	n	Mean	S.D	Min	Max	Percentiles		
						25th	50th	75th
Original samples	20	1.81	0.51	1.70	4.02	1.70	1.70	1.70
Parallel samples after storage	20	2.20	1.13	1.70	6.07	1.70	1.70	2.08
Parallel samples after reheating	20	1.72	0.10	1.70	2.18	1.70	1.70	1.70

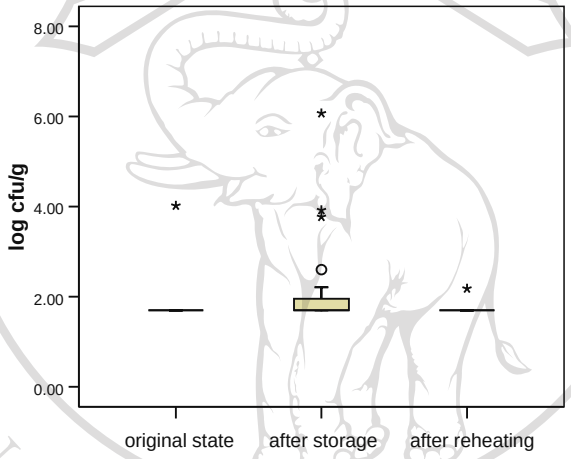


Figure 52 Box plots of small enterprise samples concerning the experiments of reheating

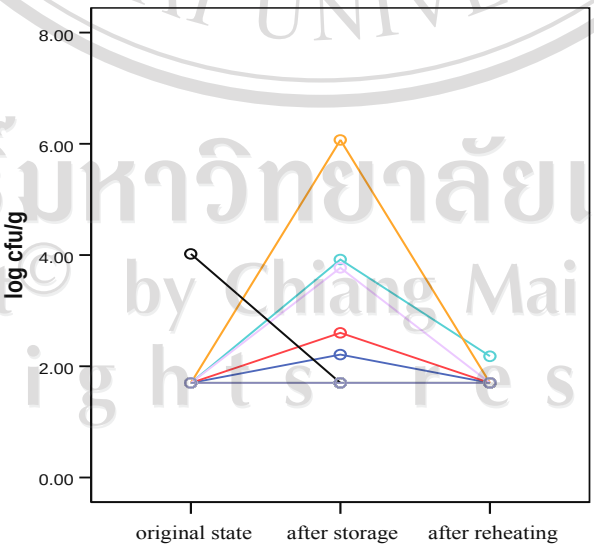


Figure 53 Projection lines of individual small enterprises samples at original state, after storage and after reheating

4.8 Result of enumeration of coagulase-positive staphylococci

The results of the coagulase-positive staphylococci counts are given in Table 28 and Figure 54. The median of coagulase-positive staphylococci counts of industrial samples and small enterprise samples was identical at 1.70 log cfu/g. It is plausible that there was no statistically significant difference between these two groups ($p > 0.05$ [$p = 0.99$]). In order to understand the results it must be taken into account that negative results are registered with half of the detection line, that means in the case of staphylococci 100:2 = 50 = log 1.70. Because in none of the samples could be detected staphylococci, all the values were transformed to log 1.70. There are no differences between any of the 3 brands of industrial samples (brand A, brand B and brand C), and there are also no differences between the 3 different sources of small enterprise samples (street vendors, markets and restaurants).

Table 28 Descriptive statistics of coagulase-positive staphylococci count

Sources of samples	n	Total coagulase-positive staphylococci (log cfu/g)						
		Mean	**Median**	**SD[a]**	**Min**	**Max**	**Range**	**IQR[b]**
Industrial samples	**90**	**1.70**	**1.70**	**0.00**	**1.70**	**1.70**	**0.00**	**0.00**
Brand A	30	1.70	1.70	0.00	1.70	1.70	0.00	0.00
Brand B	30	1.70	1.70	0.00	1.70	1.70	0.00	0.00
Brand C	30	1.70	1.70	0.00	1.70	1.70	0.00	0.00
Small enterprises samples	**90**	**1.70**	**1.70**	**0.00**	**1.70**	**1.70**	**0.00**	**0.00**
Street vendor samples	30	1.70	1.70	0.00	1.70	1.70	0.00	0.00
Market samples	30	1.70	1.70	0.00	1.70	1.70	0.00	0.00
Restaurant samples	30	1.70	1.70	0.00	1.70	1.70	0.00	0.00

[a] SD, standard deviation,

[b] IQR, Interquartile Range

The distribution of the coagulase-positive staphylococci count is presented in Table 29. These microorganisms were only found in 2 parallel samples from market enterprises which have been stored at room temperature for 6-8 hours before the analysis. The registered numbers of coagulase-positive staphylococci were 5.74 and 5.32 log cfu/g. After reheating, the numbers of coagulase-positive staphylococci were reduced to 3.1 log cfu/g and < 1.70 log cfu/g respectively.

Table 29 Classified distribution of coagulase-positive staphylococci counts

coagulase-positive staphylococci (cfu/g)	Number and percentage of samples in following sources			
	Industrial samples (n=90)	Small enterprise samples (n=90)		
		original (n=90)	after storage (n=20)	after reheating (n=20)
< 100* [< log 2]	90 (100%)	90 (100%)	18 (90%)	19 (95%)
10^2 to <10^3 [log 2-<3]	0	0	0	0
10^3 to <10^4 [log 3-<4]	0	0	0	1 (5%)
10^4 to <10^5 [log 4-<5]	0	0	0	0
10^5 to <10^6 [log 5-<6]	0	0	2 (10%)	0

* = Not detected in 25 g of samples, the coagulase-positive staphylococci counts were performed by the spreading method

The study of the effect of reheating produced no staphylococci-positive result for industrial samples at the original state and after reheating (Table 30). In the other case, the median coagulase-positive staphylococci count of small enterprise samples at the original state, after storage at room temperature for 6-8 hours and reheating by microwave were constant at 1.7 log cfu/g (Table 31). There was no statistically significant difference among the counts of small enterprise samples at the original state, after storage and after reheating ($p > 0.05$ [$p = 0.156$]).

Table 30 Descriptive statistics of industrial samples concerning the experiments of reheating (log cfu/g)

Type	n	Mean	S.D	Min	Max	Percentiles		
						25th	50th	75th
Original samples	30	1.70	0.00	1.70	1.70	1.70	1.70	1.70
Parallel samples after reheating	30	1.70	0.00	1.70	1.70	1.70	1.70	1.70
Difference (Reheating-original)	30	0.00	0.00	0.00	0.00	0.00	0.00	0.00

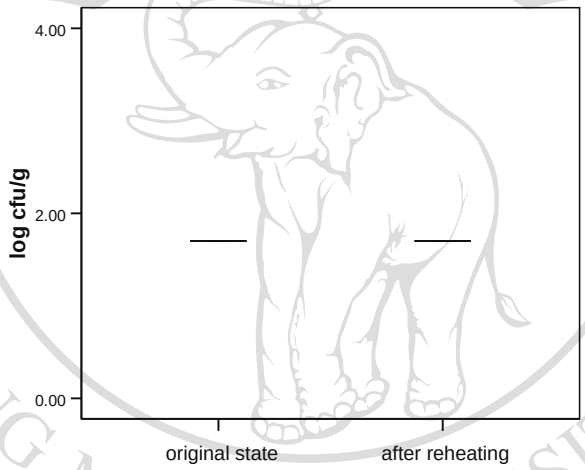


Figure 54 Box plots of industrial samples concerning the experiments of reheating

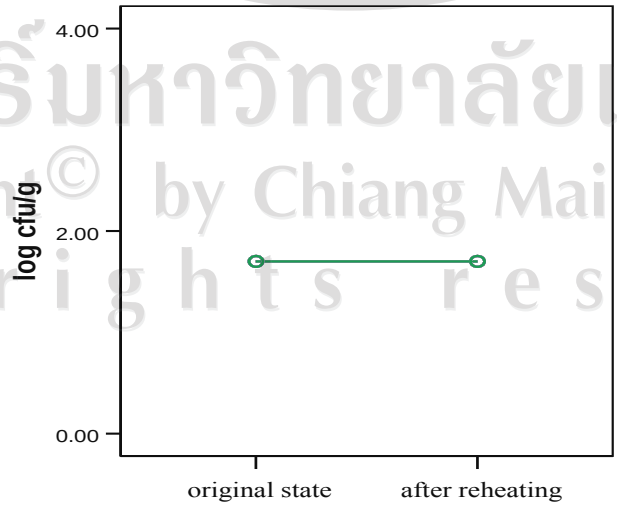


Figure 55 Projection lines of individual industrial samples before and after reheating

Table 31 Descriptive statistics of small enterprise samples concerning the experiments of reheating (log cfu/g)

Type	n	Mean	S.D	Min	Max	Percentiles		
						25th	50th	75th
Original samples	20	1.70	0.00	1.70	1.70	1.70	1.70	1.70
Parallel samples after storage	20	2.08	1.18	1.70	5.74	1.70	1.70	1.70
Parallel samples after reheating	20	1.77	0.31	1.70	3.10	1.70	1.70	1.70

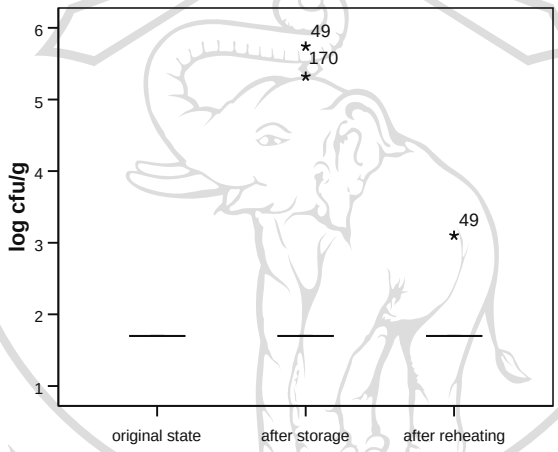


Figure 56 Box plots of small enterprise samples concerning the experiments of reheating (* = sample number)

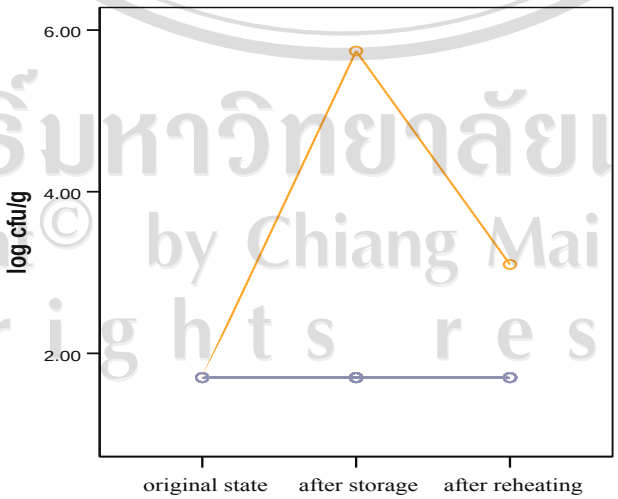
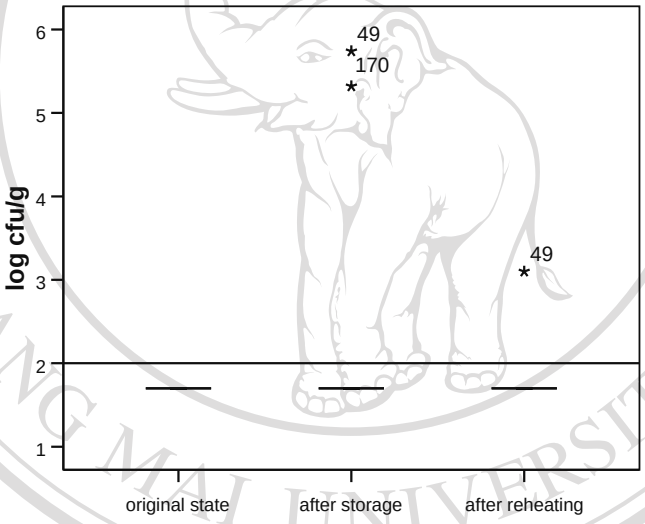


Figure 57 Projection lines of individual small enterprises samples at original state, after storage and after reheating

According to the official maximum level of *Staphylococcus aureus*, which is the most important food-borne pathogen in the staphylococcus species, frozen pork dumplings should not contain *Staphylococcus aureus* > 50 cfu/g, and ready-to-eat pork dumplings should not contain *S. aureus* > 100 cfu/g.

In this study, all of the industrial and small enterprise samples were found to have a coagulase-positive staphylococci count below 100 cfu/g, which was the limit of detection. However, 2 small enterprise samples were found to have coagulase-positive staphylococci above the allowed level of 100 cfu/g, but these items had been "mishandled" because of they were stored at room temperature for 6-8 hours.



___ Reference line of ready-to-eat pork dumplings

Figure 58 Box-plot and reference line

Table 32 Distribution of the microbiological analyses

Microorganism	Number of samples in the following range (cfu/g)							
	<10	$<10^2$	$<10^3$	$<10^4$	$<10^5$	$<10^6$	$<10^7$	$<10^8$
Total aerobic bacteria (a)	44*	25	18	3	0	0	0	0
Total aerobic bacteria (b)	7*	23	21	13	11	4	6	5
Lactic acid bacteria (a)	89*	1	0	0	0	0	0	0
Lactic acid bacteria (b)	64*	11	6	4	4	1	0	0
Pseudomonas spp. (a)	-	90*	0	0	0	0	0	0
Pseudomonas spp. (b)	-	80*	6	2	2	0	0	0
Coagulase+staphylococci(a)	-	90*	0	0	0	0	0	0
Coagulase+staphylococci(b)	-	90*	0	0	0	0	0	0

* = not detected in 25 g of samples

a = industrial samples (n = 90), b = small enterprise samples (n = 90)

Table 33 Distribution of the microbiological analyses (continue)

Microorganism	Number of samples in the following range (MPN/g)											
	<0.3 *	0.36	0.74	0.92	1.5	2.3	4.3	9.3	15	24	46	110	>110
Enterobacteriaceae (a)	82*	-	-	1	2	1	-	3	1	-	-	-	-
Enterobacteriaceae (b)	49*	4	1	4	3	3	2	-	-	3	4	3	14
Coliforms (a)	82*	1	-	3	-	-	1	3	-	-	-	-	-
Coliforms (b)	61*	7	1	3	2	1	2	-	-	2	1	1	9

* = not detected in 25 g of samples

a = industrial samples (n = 90), b = small enterprise samples (n = 90)

4.9 Results of sensory test

2 samples of market enterprises were found to have a deviation from the normal sensory profile. The pork dumplings had turned rancid and showed a soft texture.