# Use of an ATP Swab Test in quality control in meat processing factories:

## Establishment of benchmark based on an ATP Test and a microorganism test is also effective for audits in overseas factories

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This is a summary of a special lecture given by Mr. Michinobu Kato (NH Foods Ltd.) at the 110th Lumitester Seminar held by Kikkoman Biochemifa Company at Tsukishima Social Education Hall, Chuo-ku, Tokyo, on June 20, 2017. (Lumitester is the name of the ATP Swab Test device of Kikkoman Biochemifa Company.)

Mr. Kato has worked in quality audit in meat processing factories of NH Foods Group (40-50 factories per year in Japan and overseas) in recent years, and has used the ATP Swab Test to confirm cleanliness at individual sites. In food factories, one of the most important concerns is to perform cleaning effectively and efficiently by balancing the hygiene level to be achieved and the work and costs required for cleaning. NH Foods uses the ATP Swab Test to confirm whether the required cleaning has been performed. In the lecture, Mr. Kato described his experiences in establishing original benchmarks for his company using the ATP Swab Test and gave examples of effective use of the test. (Editorial Desk)

### Outline of NH Foods Group

NH Foods Group treats 990,000 tons of meat (410,000 tons of pork, 390,000 tons of chicken, and 180,000 tons of beef), which accounts for about 20% of meat sales in Japan, as of June 2016. In the sales of the Group, fresh meat accounts for about 60%, and the Group also sells processed foods, ham and sausage, fishery products, and milk products. The Fresh Meats Business Division, for which I work, mainly deals with fresh meat.

The Group has a policy of consistent control of all processes and logistics from production and breeding at farms to treatment and processing in factories. For meat processing, the Group has 8 factories with slaughtering facilities for beef and pork (operated by Nippon Food Packer, one of the Group companies) and 5 factories with slaughtering facilities for chicken (operated by Nippon White Farm, another Group company) around the nation.

The general production processes in a slaughtering facility for pork are summarized in **Figure 1**. Pigs are slaughtered and butch-

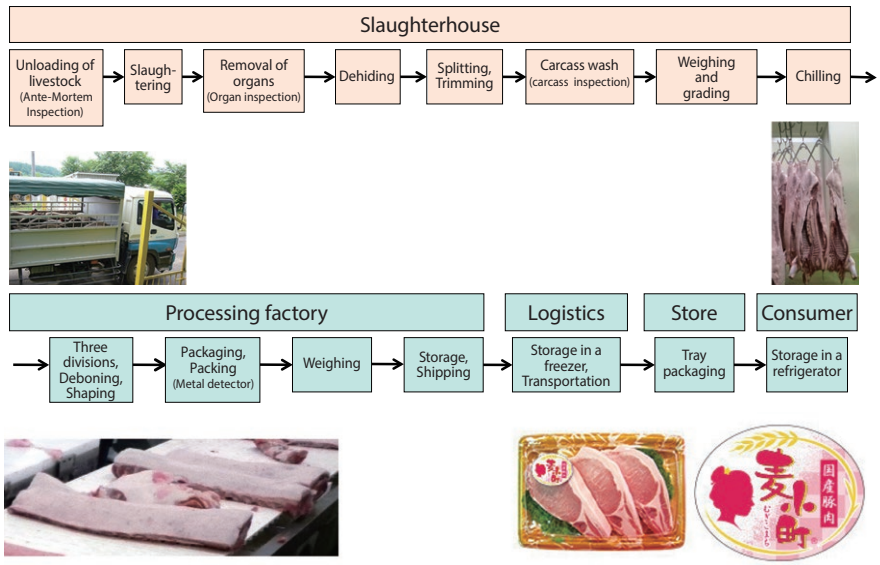
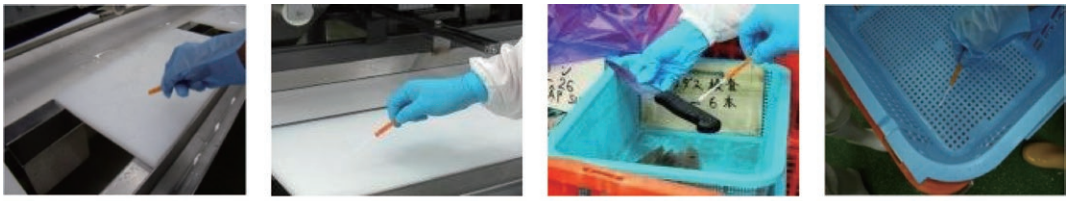



Figure 1:
Production process in a pork processing factory



Cutting board | Conveyor | Handle of a knife | Basket

Apron | Arm cover | Alcohol sprayer

Photo 1:
Importance of hygiene control for equipment (use of an ATP Test)

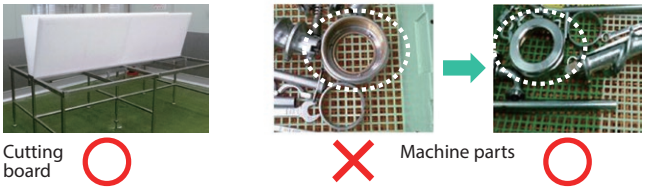



Photo 2: Effective drying with a gradient

ered into pieces to be shipped as block meat (the left lower photo in **Fig. 1** shows a pork loin). This block meat is processed (cut or sliced) and packed into a tray for sale at individual stores.

## Microbial risks in fresh meat and basics of hygiene control

### (1) No legal standards for microorganisms in fresh meat products

As mentioned above, block meat is the main final product of NH Foods Group. Due to its characteristics, the product is cooked before eating by consumers, and thus no legal standards for microorganisms have been established for fresh meat processing factories (although standards are available for meat products to be eaten raw). Therefore, a voluntary standard for microorganisms in the products is used in these factories.

### (2) Voluntary hygiene control for equipment

Since there is no heating process, the quality of the product before its best-before date is affected if careful attention is not paid to microbial control in all processes. Cleaning control for machines, devices, and clothing (hereinafter referred to as equipment) is an important issue in meat processing factories (**Photo 1**). In these factories, cleaning is performed many times since a lot of the equipment used in the factories is made of plastic, and it is more difficult to wash plastic equipment compared to metal. In addition, since knives are used in procedures in the factories, equipment may have small scratches and dirt in these scratches is difficult to remove. Such factories are characterized by use of many types of equipment, including aprons, arm covers, and alcohol sprayers, in forms that are difficult to clean.

### (3) Four principles of hygiene control and basic countermeasures

The four principles that are important in hygiene control are that microorganisms and foreign materials should *1) not be brought in*, *2) not be attached*, *3) not be increased and expanded*, and *4) be heated*. Cleaning is extremely important from a standpoint of preventing an increase (expansion) of microorganisms attached to equipment. A combination of cleaning and drying should be considered as a countermeasure against microorganisms attached to equipment.

1) Cleaning (and ATP Test after cleaning)

In our Group factories, cleaning is performed (heat sterilization for equipment that is difficult to clean) and then an ATP Swab Test (hereinafter referred to as an ATP Test) is performed concomitantly with a microorganism test to confirm cleanliness after cleaning. However, since it takes a long time to obtain the results of the microorganism test because cultivation is required, it is difficult to provide hygiene instructions on site immediately after the test. However, quantified results from the ATP Test can be obtained in less than one minute. This makes the test highly effective in situations such as checkups before a work and hygiene audit.

2) Drying

It is also important to dry equipment completely after cleaning. In our factories, a thorough visual checkup of dryness is performed before work, as a rule, and drying is an important checkup item in a quality audit in a factory. Our company believes that drying with a gradient is effective, as seen in the cutting boards in **Photo 2**. As an aside, I think you certainly dry dishes with a gradient after washing at home. Although the machine parts are placed upward in **Photo 2**, you never dry dishes placing upward at home. It is important to have the awareness that simple things at home should also be done in a factory.

3) Storage at a low temperature

In microbial control at foods factories, storage at a low temperature after cleaning and drying is effective. Therefore, some factories require storage in a refrigerator after cleaning and drying. This is effective, but I believe that cleaning and drying with a gradient are sufficient.

## Use of an ATP Test for a quality audit and establishment of benchmark values

### (1) Required cleaning level

In a quality audit in a factory, cleaning and drying should be performed, as mentioned above. However, since I have experience in working for a factory, I fully understand that factory workers want to reduce the time and work for cleaning, if possible. In addition, it is important to discuss trimming the costs for cleaning from a managerial standpoint. Perfect cleaning might be suggested, but I think it is sufficient to achieve minimum requirements for cleaning. I believe that it is important to perform cleaning effectively and efficiently by maintaining a balance between the hygiene level and the workforce and costs required for cleaning. Based on my past experiences, an ATP Test is extremely useful for confirmation of whether the required level of cleaning has been achieved. I introduced the idea of setting benchmark values for use of an ATP Test in a quality audit for Group factories, as follows.

### (2) Flow of the audit and ATP Test

The quality audit of the Group factories is usually performed for 2 days (4-5 hours in factories of other companies). On the first day, important points are explained in an opening meeting (for example, an explanation of important tasks based on the results of a previous audit). Then, an interview is performed with an executive officer (the head of the factory in many cases) to confirm the policies and objectives of the factory, responses to suggestions (complaints), and position on education of human resources and capital investment. After the interview, on-site and documentary audits are performed. After the end of work, the methods of cleaning and drying are confirmed. On the second day, visual confirmation and an ATP Test for cleaning and drying are performed 1 hour before the start time of the factory ( performing ATP Tests at about 40 sites in a large factory). As mentioned above, an advantage of the ATP Test is the ability to obtain test results immediately on site. Therefore, we can prepare a report on the ATP Test results and make suggestions that can be shared in the closing meeting.

### (3) Establishment of benchmark values

We fully introduced the ATP Test in the quality audit in FY2013 (with use of a test kit: LuciPac Pen for ATP + AMP Test, Kikkoman Biochemifa Company). Regarding the benchmark values, although Kikkoman Biochemifa has recommended benchmarks (metal: 200 RLU, plastic: 500 RLU), we examined whether the recommended values were appropriate. The following two concepts were used for establishing our benchmark values.

1) Option 1:Use of ATP benchmark values based on microbial standards for products

First, we considered using standards for the ATP Test on equipment based on the voluntary microbial standards for products. Our Group uses a voluntary standard value of $<10^5$/g for the total plate count for pork products (as mentioned above, there are no legal microbial standards for products). However, it was difficult to estimate the benchmark for an ATP Test based on these voluntary standards because we had no accumulated data at that time.

2) Option 2: Use of ATP benchmark values based on microbial standards for equipment.

We then considered estimation of benchmark for the ATP Test for equipment based on the voluntary microbial standards for equipment. Our Group had used the standard of <1,000/100 $cm^2$ for the total plate count for equipment in our pork processing factories. Although stricter voluntary standards may be used in factories for processed food products (for example, <100/100 $cm^2$ and <30/100 $cm^2$), our Fresh Meats Business uses <1,000/100 $cm^2$ because our final products are fresh meats. However, since we had no data on the correlation between total plate counts for equipment and RLU values (RLU = Relative Light Unit, a unit specific to the ATP Test) at that time, we could not estimate the benchmark values. Thus, we decided to collect data on site.

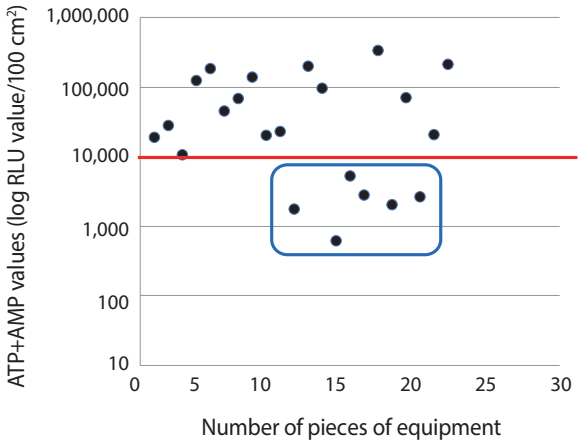



Figure 2:
ATP Test results in a quality audit for a fresh meat processing factory (chicken) (2013)

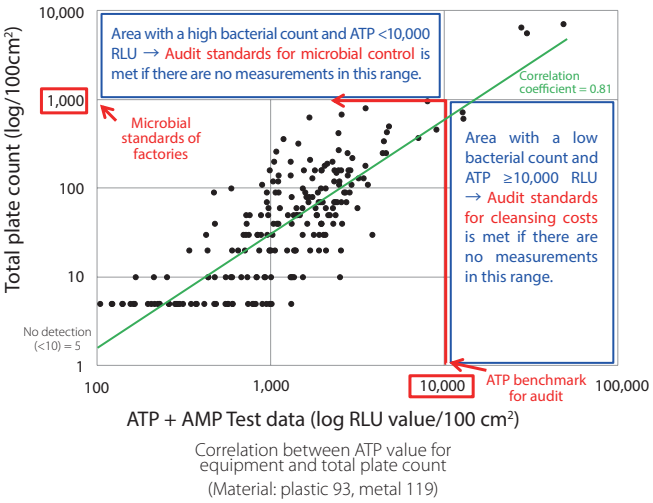



Figure 3: Correlation between an ATP Test and a microorganism test in a fresh meat processing factory

3) Candidates for temporary benchmark values

The three candidates for temporary benchmark values were ① <3,000 RLU/100 cm², ② <5,000 RLU/100 cm², and ③ <10,000 RLU/100 cm². ② was included because we found a case in the literature in which <5,000 RLU/100 cm² was used as the benchmark in a fresh meat factory (although there are few references on the ATP Test in fresh meat factories). ① was selected as a stricter benchmark value than ②. ③ was selected because we had a vague idea of the value as the maximum based on experiences using the ATP Test in past audits.

### (4) Setting of 10,000 RLU as the voluntary benchmark value

In the quality audit (chicken processing factories) in FY2013, we performed the ATP Test by numbering various equipment and obtained the results shown in **Fig. 2**. A total of 73% of the swabbed sites (22 sites in total) gave a result of >10,000 RLU/100 cm², but we did not consider using a benchmark value of 10,000 RLU/100 cm² or higher. Therefore, we concluded only that microbial control could be achieved in 27% of cases using a temporary benchmark of 10,000 RLU/100 cm².

### (5) Correlation between results for an ATP Test and a microorganism test for equipment.

Next, we investigated the correlation between an ATP Test and a microorganism test in a meat processing factory (a fresh lamb meat production factory of an external cooperative company). In this factory, an ATP Test (benchmark value <3,000 RLU/100 cm²) was mainly performed, in addition to performance of a microorganism test (benchmark value for total plate count: <1,000/100 cm²) once every 3 months. The study was performed from July 2014 to April 2017, and we collected a total of 212 values (93 for plastic and 119 for metal equipment). The test was performed immediately after cleaning (before use of a sanitizer) by swabbing for 100 cm². The results are shown in **Fig. 3** (vertical axis: total plate count, horizontal axis: RLU value). Although the detection limit of the microorganism test (number of fungi regarded as "not detectable") is 10/100 cm²*, samples at the detection limit are plotted as 5/100 cm² for ease of explanation in **Fig. 3**.

*In the Swab Test for microorganisms, a 100-cm² area is swabbed with a cotton swab in the kit, and the sample is suspended in 10 ml of water, with 1 ml used for the test. Since it is 10-fold dilution, the detection limit is converted to an area of 1/10 cm² (10/100 cm²).

A result less than the benchmark (10,000 RLU) for the ATP Test, but higher than the voluntary standard (1,000/100 cm²) for the microorganism test (square in the upper left of the graph in **Fig. 3**) is a pass for the ATP Test and a fail for the microorganism test; that is, 10,000 RLU is an inappropriate benchmark for the ATP Test. However, there were no samples with results of <10,000 RLU in the ATP Test and ≥1,000/100 cm² in the microorganism test (**Fig. 3**). On the other hand, a result of >10,000 RLU in the ATP Test and <1,000/100 cm² in the microorganism test (square on the right side of the graph in **Fig. 3**) is a pass for the microorganism test, but stricter cleaning is required. In other words, excessive cleaning and cost are required. Only a few samples gave this result, and therefore we judged that the benchmark value of 10,000 RLU for the ATP Test was appropriate.

### (6) Is the benchmark value recommended by the test device manufacturer appropriate?

Kikkoman Biochemifa recommends benchmark values of 200 RLU and 500 RLU for Lumitester for metal and plastic surfaces, respectively. As shown in **Fig. 4**, for a benchmark of 500 RLU, the maximum total plate count is 100/100 cm² (only the benchmark value differs in **Figs. 3** and **4**). Since 100/100 cm² can be used as

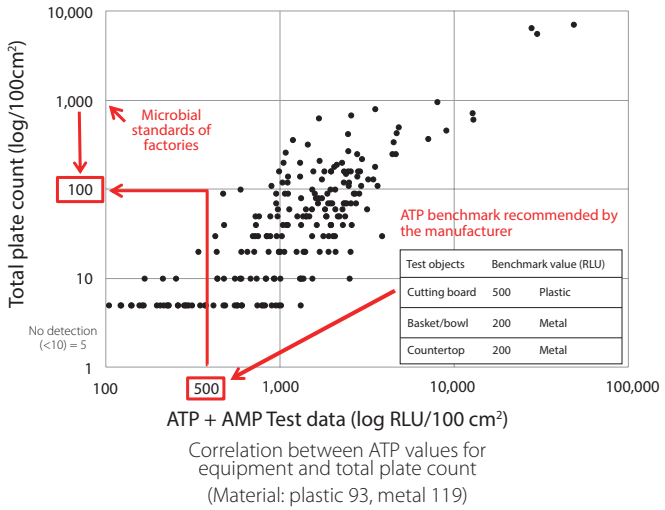



Figure 4: Microbial standard of 100/100 cm2 with 500 RLU used as the benchmark

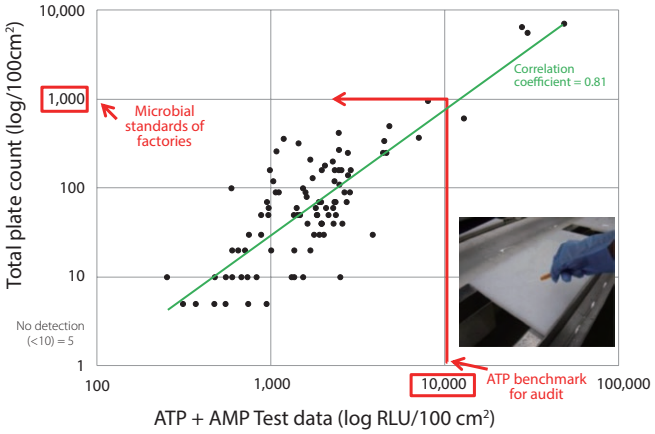



Figure 5:
Correlation between an ATP Test and a microorganism test for plastic equipment

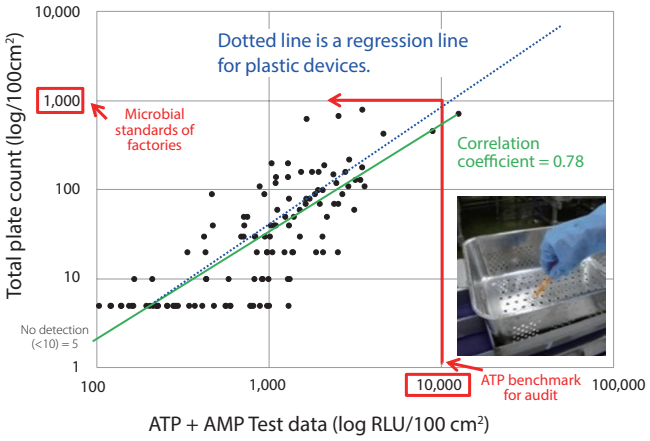



Figure 6:
Correlation between an ATP Test and a microorganism test for metal equipment

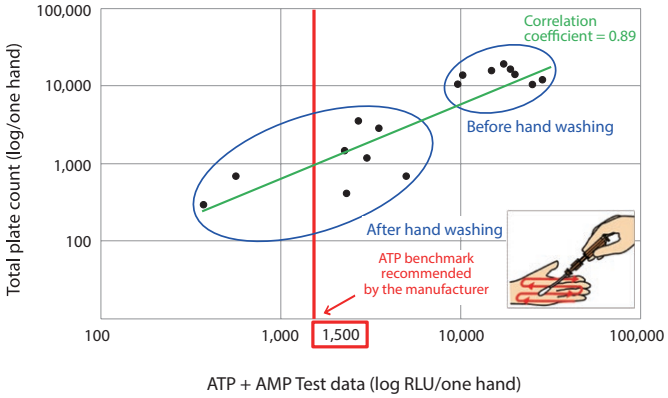



Figure 7: Correlation between an ATP Test and a microorganism test before and after hand washing

the standard for a clean room (clean area) in a processed food factory, 500 RLU can be used for a wide range of foods. In our company, however, 10,000 RLU is used as the benchmark because of the characteristics of fresh food products and expiration date.

### (7) No need to change benchmark values based on materials

Measured values for plastic and metal equipment are shown in **Figs. 5** and **6**, respectively. The data for plastic equipment (**Fig. 5**) tended to be located in the right upper area, compared to those for metal equipment, but both figures show similar regression lines. Therefore, we judged that it was unnecessary to change the benchmark value for different materials.

### (8) Use of an ATP Test to confirm cleaning level after hand washing

The correlation between the results of an ATP Test and a microorganism test before and after hand washing (performed in a factory of a cooperative company) are shown in **Figure 7**. The correlation between these data shows that an ATP Test can be used to confirm the cleaning level after hand washing.

## Effects of an ATP Test in a quality audit: Continual improvement over time

### (1) Changes in the ATP Test over time

As mentioned above, visual confirmation and an ATP Test are performed for cleaning and drying before the start of work in a quality audit, so that the results can be shared at a closing meeting. A sample report of an ATP Test (no information on the swabbing site) is shown in **Table 1**. In the report, sites that did not meet the benchmark value for the ATP Test (10,000 RLU) are shown in

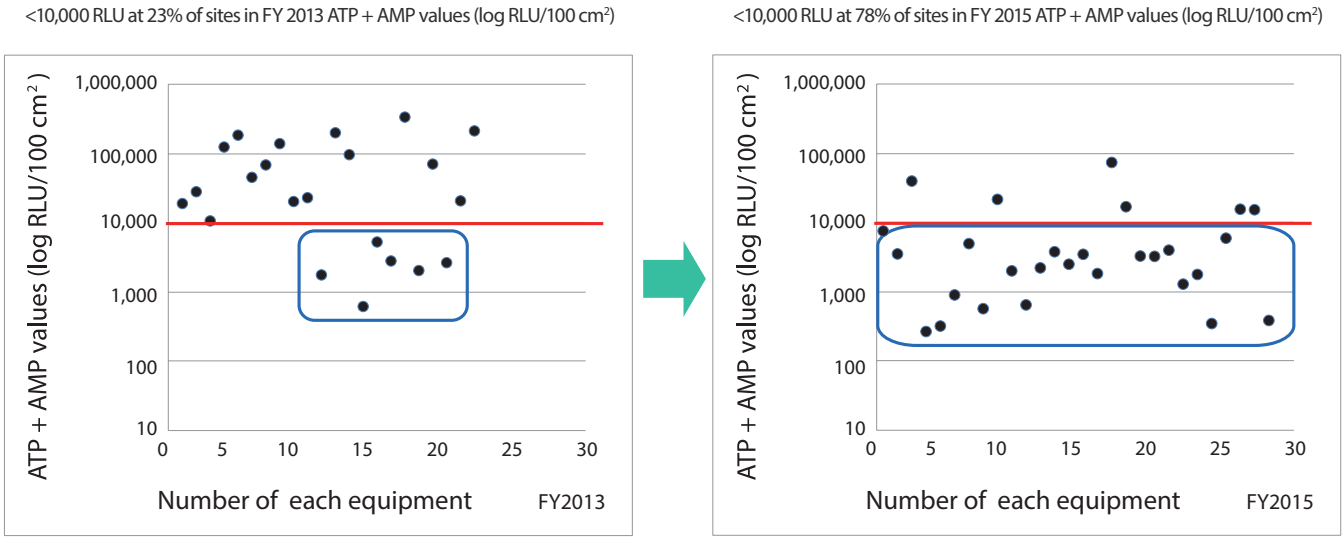



Figure 8: Changes in ATP values over time in a quality audit in a meat processing factory (chicken)

red for easy understanding, along with the increase or decrease in the value compared to the previous audit. Photographs of problematic sites taken during the audit are also included in the report. For the factories in **Fig. 2**, changes in FY2013 and FY2015 are shown in **Fig. 8**. The percentage of samples with lower values than the benchmark (10,000 RLU) increased from 23% in FY2013 to 78% in FY2015, suggesting a steady improvement.

### (2) Future tasks suggested in the audit

The results of ATP Tests suggest future tasks, including reducing variation in hygiene control for personal equipment (for example, an apron and arm cover). Similar variation was observed for hygiene control for materials with a complex form (for example, an alcohol sprayer).

| No. | Testing sites | 2014 | Increase/ decrease | 2015 |
|---|---|---|---|---|
| 5 | | 568 | | 197 |
| 7 | | 13,831 | ↘ | 240 |
| 8 | | 8,939 | ↘ | 740 |
| 9 | | 17,683 | ↘ | 4,734 |
| 10 | | 1,049 | | 450 |
| 11 | | 232,980 | ↘ | 23,512 |
| 12 | | 36,365 | ↘ | 1,769 |
| 13 | | 13,111 | ↘ | 516 |
| 14 | | 563 | | |
| 15 | | 430 | | 1,970 |

Table 1: Results of ATP Tests in a quality audit in a meat processing factory

## Examples of use of an ATP Test in a quality audit in overseas factories

Our Group requests overseas factories to perform regular microorganism tests for their products and a conservation test for setting an expiration day, in addition to a ATP Test for equipment after cleaning and sterilization. I have performed quality audits in factories in Thailand (fresh chicken and heated chicken products), China (heated chicken products), and Australia (fresh beef). Since an ATP Test is not common in these countries, I have to explain the ATP Test before performing the test. For example, I will mention that ATP is an indicator of contamination, and that 10,000 RLU is the benchmark value for meat processing factories.

### (1) Microorganism test for products

A major difference between overseas and domestic factories is the monitoring test for imported foods at a quarantine station. When Enterohemorrhagic *E. coli* is positive in fresh meat (which is not prohibited by the Food Sanitation Act), a quarantine station provides instructions. In addition, since each country has microbial standards and guidelines for fresh meat, it is important to confirm the certificate of analysis, deviation, and continuous detection (refer to samples in **Tables 2** and **3**). Standards for processed foods (meat products and frozen foods) are set by the Food Sanitation Act in Japan, and evaluation must be performed according to the standards. However, the standard for *E. coli* (fecal coliform) is original in Japan (no equivalent overseas standard) and overseas factories are required to fully understand this standard.

| Name | Target level in Japan (Initial bacterial count) | DLD guidelines in Thailand (Initial bacterial count) |
|---|---|---|
| Total Plate Count | $<10^6$/g | $\leq 5.0\times10^5$/g |
| Coliform | $<10^4$/g | $\leq 5.0\times10^3$/g |
| *Escherichia coli* | $<10^3$/g | $\leq 1.0\times10^2$/g |
| *Salmonella* | Negative/25g | Negative/25g |
| *Campylobacter* | Negative/25g | None |
| *Staphylococcus aureus* | Negative/0.01g, $<1.0\times10^2$/g | $\leq 1.0\times10^2$/g |
| *Enterococci* | None | $\leq 1.0\times10^3$/g |

* DLD: Department of Livestock Development, Thailand

Table 2:
Microbial guidelines for fresh chicken in Thailand (field survey, Nipponham, 2014)

| Name | Target level in Japan (Initial bacterial count) | Target level in Australia (Initial bacterial count) |
|---|---|---|
| Total plate count | $<1.0\times10^5$/ g | $\leq 1.0\times10^4$/g |
| Coliform | $<3.0\times10^2$/ g | $\leq 1.0\times10^3$/ g |
| *Escherichia coli* | $<1.0\times10^1$/ g | $\leq 1.0\times10^2$/ g |
| *Enterohemorrhagic E. coli 0157* | Negative/ 25g | Negative/ 25g |
| *Salmonella* | Negative/ 25g | Negative/ 25g |
| *Staphylococcus aureus* | Negative/ 0.01g $<1.0\times10^2$/ g | None |

* It is unclear whether these are national guidelines

Table 3:
Microbial target levels for fresh beef in Australia (field survey, Nipponham, 2016)

### (2) ATP Test for equipment.

In overseas factories, a different method may be used for a microorganism Swab Test, and thus it is difficult to determine whether the benchmark value is appropriate or the results are reliable. However, an ATP Test has the advantage of providing an evaluation independent of the results of a microorganism test in overseas factories, based on the ATP Test having a benchmark of 10,000 RLU for equipment in meat processing factories. The ATP Test has another advantage of quantifying the contamination level. Even if asked to wash an area again if contamintaion is visually confirmed in an overseas factory, the factory workers may not fully understand the request because they do not believe the contamination level suggested by visual checking. However, an ATP Test gives an objective evaluation numerically that the workers can understand easily. Needless to say, promptness of the result is also a major advantage of the ATP Test because the results can be shown immediately on site.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