ATP tests may be Affected by Food Processing and Ingredients

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ATP tests

ATP hygiene monitoring tests are one of the most commonly used methods to verify cleaning effectiveness. This is because they are simple, easy-to-use and provide immediate results. The principle of the test applies the assumption that changes in ATP are proportional to the degree of residual contamination remaining on food processing surfaces or equipment. If cleaning has been ineffective, ATP-containing organic debris from food will be detected on food processing surfaces or equipment.
However, the capabilities of conventional ATP tests are more frequently being questioned and their limitations are becoming more recognized.

How ATP tests operate

Adenosine triphosphate (ATP) is a molecule found in many food materials including plant and animal tissues as well as within microorganisms such as yeasts, molds, and bacteria. In food processing, these same sources – foods, plant and animal tissues, and microorganisms – constitute most residual contamination on food processing surfaces. If high levels of ATP are found, the assumption is that residual contamination remains, as would be the case after inadequate cleaning. The amount of ATP measured strongly correlates with the level of contamination present. In practice, when surfaces are cleaned to the point that assessments of ATP concentrations are below a defined threshold, the surface is declared sufficiently clean and the subsequent processing steps can proceed.[1]

1 **Kikkoman Biochemifa Company**

Importance of monitoring of food residues for food safety

Residual contamination on food production surfaces is recognized as not only an indicator of insufficient cleaning but also a processing hazard that may promote unsanitary, unsafe conditions for the following reasons:

(1) Raw agricultural food commodities, such as fresh meat, fish, dairy, fruit, and vegetables are known sources of both spoilage and pathogenic bacteria.

(2) Food residues can be sources of nutrients that promote or enable the growth of microorganisms including the proliferation of difficult to clean biofilms that serve as a reservoir of those same microorganisms.

(3) Food residues and other soils can deplete the antimicrobial activity of disinfectants in several ways including the reduction of the germicidal effect of the disinfectant through chemical reactions as well as the protection or insulation of microorganisms from contact with the disinfectant. These reasons and others have established that cleaning verification is a prominent part of all robust food safety plans. To meet the need to assess these soils in a timeframe suitable for processing, ATP tests are frequently used to monitor and verify cleaning and sanitation practices in food production and food service operations.

Limitations of conventional ATP tests

Recent research, however, has illustrated some of the limitations of conventional ATP tests. These limitations can lead to the generation of false-negative assessments. In short, because of the unique, unstable behavior of ATP, a conventional ATP test is susceptible to indicating that a surface is clean, when significant soils remain. These false-negative assessments can lead a quality manager in a manufacturing facility to conclude that processing surfaces and equipment are clean, when in fact residual food debris or contamination remains. ATP tests are designed to detect only the ATP molecule. Recent work has demonstrated that ATP readily degrades (hydrolyzes) to the chemical homologues of ADP (adenosine diphosphate) and/or AMP (adenosine monophosphate). When this degradation happens, there is significant reduction in ATP even though the soil remains on the equipment. As a result, the test – or more accurately the assessment – becomes much less sensitive as shown in various studies.

Recent research from the University of Wisconsin – Madison about ATP degradation

Research from the University of Wisconsin – Madison demonstrated that the degradation of ATP within raw meat in typical processing environments can be dramatic even exhaustive in spite of the remaining presence of food soil.[2] This university study showed that ATP degrades quickly into related compounds, ADP then AMP, which become the predominant adenylates, neither of which are detectible by standard ATP-based assays.

A particular study examined the practical implications of ATP degradation by comparing the performance of a conventional ATP assay against an assay that detects all three adenylates (Kikkoman A3)[3] in two licensed, inspected food processing facilities - one a Grade A dairy and the other a meat processing plant.4 A total of 960 data points for each type of assay were collected in parallel over the course of several months and seasons for the purposes of hygiene assessment. The study showed that the Kikkoman A3 assay detected contamination events as frequently as the existing technology, but, more importantly, at significantly higher rates where ATP degradation was likely to occur.

Furthermore, additional research recently published in the Journal of Food Protection[5] demonstrated that ADP generally comprised about 90% (as a mole fraction) of total adenylates across all processing treatments with the exception the final cook step where AMP became predominant (Figure 1). Retail processed meat samples were further evaluated and they followed general trends of most having minimal ATP concentrations with ADP predominant in uncooked samples and AMP predominant in cooked samples (Figure 2).

As a result, the University of Wisconsin-Madison researchers recommend that facilities carefully consider these degradation phenomena when selecting a technology for purposes of hygiene assessment and verification. Kikkoman A3 can be a reasonable approach to avoid the effects of the ATP degradation phenomena, especially in meat processing facilities or where sensitivity to plant hygiene is especially critical.

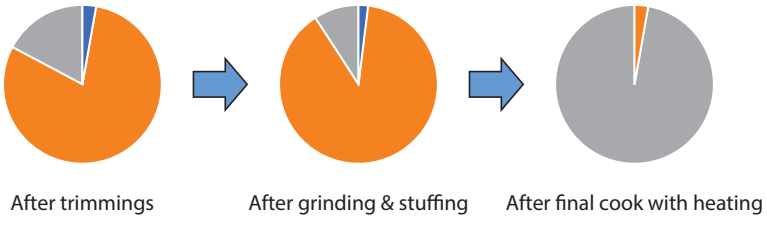

Figure 1: The Change of ratios of adenylates at select manufacturing steps during smoked sausage production in UW-Madison Meat Science and Muscle Biology Laboratory

ATP ADP AMP

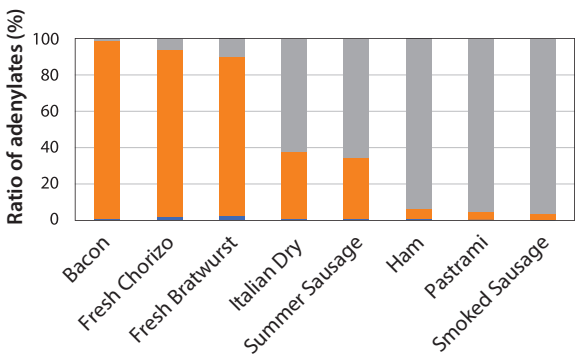

Figure 2: Ratio of adenylate content of selected retail processed meat products

ATP ADP AMP

Kikkoman A3 Test

In 2017, Kikkoman researchers developed the technology used in this University of Wisconsin-Madison study to remedy this shortcoming of current ATP test technologies. Known as "Kikkoman A3" the technology accounts for this demonstrated loss of ATP by simultaneously accounting for and measuring the presence of all three homologues, ATP, ADP, and AMP. As a result, Kikkoman A3 has shown markedly improved sensitivity to ATP depletion.

Swab and get Better results in 10 seconds.

- Tests are collected in the same way as conventional ATP tests – a simple surface swab
- The A3 advantage is able to reverse ATP depletion
- This advantage results in increased confidence in soil detection

Conclusion

Cleaning and sanitation verification practices throughout the food manufacturing environment are critical and form the basis of every food safety plan. Rapid, sensitive verification assays are an important step in such programs and are the reason ATP tests were first developed and continue to be used. Recent studies, however, demonstrate the implications of the depletion of ATP and the increased risk of false negative assessments when using from ATP-only assays. All food processors, especially those who process meats where ATP depletion is prominent, should carefully consider the selection of the appropriate food hygiene verification technology where accurate residual soil detection is critical to process success.[6,7]

1 Mildenhall, K. B, and S. A. Rankin 2020. Implications of Adenylate Metabolism in Hygiene Assessment: A Review. J. Food Prot. 83: 1619–1631. https://doi.org/10.4315/JFP-20-087

2 Smith, N. W., J. J. Sindelar, S. A. Rankin 2019. Quantities of adenylate homologues (ATP+ADP+AMP) change over time in Prokaryotic and Eukaryotic cells. J. Food Prot. 82: 2088–2093. https://doi.org/10.4315/0362-028X.JFP-19-223

3 Total adenylate is ATP+ADP+AMP, known as A3

4 Whyte, C., T. F. Ma, J. Sindelar, and S. A. Rankin 2021. Rapid hygiene assay sensitive to cumulative adenylate homologues exhibits equal or higher frequencies of soil contamination detection than assay limited to ATP detection. J. Food Prot. 84: 1937–1944. https://doi.org/10.4315/JFP-21-028

5 Smith, N. W., J. J. Sindelar, S. A. Rankin 2024. AMP, ADP, and ATP concentrations differentially affected by meat processing, manufacturing, and non-meat ingredients. J. Food Prot. 87: 100287. https://doi.org/10.1016/j.jfp.2024.100287

6 Bakke, M., and S. Suzuki. 2018. Development of a novel hygiene monitoring system based on the detection of total adenylate (ATP+ADP+AMP). J. Food Prot. 81:729-737. https://doi.org/10.4315/0362-028X.JFP-17-432org/10.4315/0362-028X.JFP-19-223

7 Bakke, M. 2022. A comprehensive analysis of ATP tests: practical use and recent progress in the total adenylate test for the effective monitoring of hygiene. J. Food Prot. 85:1079-1095. https://doi.org/10.4315/JFP-21-384

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