Meat product adulteration and contamination: how do we know?

There is increasing scrutiny of what we are eating, especially with regard to meat and its provenance. Consumers want to know where their meat has come from, that it was raised and produced ethically and that it complies with their cultural or religious demands. This is a perfectly reasonable expectation, particularly if a premium product commands a premium price. Legislators and other authorities apply appropriate constraints on labelling of produce and ask for evidence of compliance from the producers.

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It is the evidence of compliance that is the subject of this article. Data are produced to support claims of labelling compliance from analytical testing but how do laboratories monitor the quality assurance of the data? This is where proficiency tests (PTs) play an important role by providing an externally-controlled reference point for laboratories to be assessed against.

Proficiency testing

Any laboratory process should have some sort of quality control checks in place. Increasingly, this is formalised via accreditation to a recognised international standard, typically ISO 17025. Legislators might make this a requirement, usually mandatory for official control laboratories, which has been the case in the EU for many years now.

In the US, the Food Safety Modernisation Act is also mandating compliance to the international standard. It is widely acknowledged that the best mechanism for demonstrating competence is via the use of an external quality control, for example, one that is generated outside the laboratory.

Usually this is interpreted to mean taking part in a PT scheme, generally provided by a professional PT provider such as Fapas. Compliance to international standards of testing is best supported by a PT provider with a wide international reach.

PT involves the production of a standard test material which is dispatched to all the participants in the test against a defined timeframe. The participant laboratories have to undertake their routine analysis on the test sample and return the results of that analysis to the PT provider. After the deadline for submission, all participants' data are analysed by the PT provider who then issues performance assessments to each participant.

This performance assessment can then be used by the laboratory as evidence that their analytical process is compliant with their accreditation (or other authority). The outcome of the test might also indicate that the laboratory has not performed satisfactorily and the onus is on the laboratory to investigate what went wrong. For a food or meat producer this is invaluable in providing confidence that their supply chain is operating effectively or might indicate where a problem lies in compliance with traceability.

Adulteration or contamination?

In the food industry, there are separate issues of deliberate adulteration versus contamination.

Adulteration occurs for reasons of economic gain, that is to say diluting a product with an undeclared cheaper ingredient. Adulteration therefore tends to be at significant levels to make an economic impact, typically at concentration levels of several percent.

This is enough to make the exercise financially worthwhile but not quite enough to make the consumer suspicious. The obvious example is the horse meat scandal.

Contamination on the other hand is due to poor handling practices of ingredients, with contamination levels at sub-percent concentrations. This is particularly important for the control of allergenic ingredients in food production, for example, or the transfer of veterinary medicines from a dosing feedstock to a general feed. There is also the question of authenticity or provenance of a product, such as basmati rice, olive oil or beef with defined country of origin.

For the meat industry, there is the possibility to produce proficiency tests for both the adulteration and contamination scenarios, despite the large difference in concentration levels. The difficulty is in the production of the test material.

A good PT material must be appropriate for its purpose, to resemble as closely as possible the kind of sample that the laboratory would ordinarily receive in its routine work.

The test material must also be equivalent for each participant (and there might typically be up to 100 laboratories taking part in any one PT). Hence, the test material will be a homogenised item and the PT provider has to ensure that each

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item is the same as all the others.

For the adulteration scenario, producing a beef mince material containing about 5% horse meat presents little difficulty for an experienced PT provider.

The contamination scenario is very different. Meat is a very heterogeneous material containing different structures of proteins, fats and membranes even in a lean cut of meat. In order to contaminate a beef mince material with sub-percent levels of pork and make it homogeneous presents a unique challenge but one that Fapas has overcome.

Why is this contamination scenario for a meat test material important? The demand for such a PT comes from laboratories involved in testing for Halal compliance (although the principle applies to other religious or cultural decrees, this was initiated for Halal purposes).

Just to be clear on the requirement, Halal abattoirs receive approval or certification for the correct slaughter of the animal. Compliance with the method of slaughter is not the purpose of the PT. At any point in the meat production chain, there is a risk of contamination from pork and it is this that laboratories are testing for. Therefore, the Fapas PT is not a Halal PT but a Halal compliance PT.

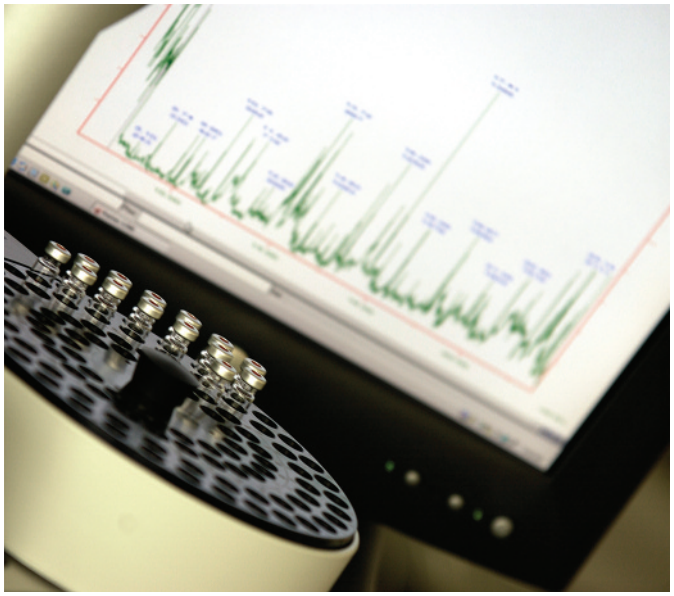
Meat adulteration and contamination PT in practice

Both types of PT are qualitative PTs in which the base matrix is known to participants (for example beef).

Participants return results of 'detected' or 'not detected' for the added species of interest. In the case of the adulteration PT, a list of potential added species is provided (lamb, pork, chicken, horse) and the base matrix will have one or more of these potential species added to it, typically between 2 and 5% w/w.

Participants can also state which other species they analyse for that are not on the potential list (for example ostrich or goat).

The correct detection of a known adulterant is assessed as 'satisfactory' performance, supported by the consensus of all participants' responses. Failure to detect a known adulterant is assessed as 'not satisfactory' performance, again supported by the consensus of all participants' responses.



Detection of a species that was not deliberately added to the base matrix (false positive) is compared to the consensus of all participants' responses and assessed as 'disagrees'. This allows for possible cross-contamination of the base matrix at its retail (uncontrolled) source.

The contamination (Halal compliance) PT is run slightly differently. In this scenario, there is only one contaminant species of interest, pork.

Hence, there is no target list of potential species to identify. To add challenge to the PT, two or more test samples are provided to each participant, one of which might be the blank (uncontaminated) base matrix. However, given that the objective of the exercise is to detect low level contamination, how do we control adventitious cross-contamination of the base matrix?

The answer is to apply the same principles that a Halal testing laboratory does, i.e. ensure physical segregation of 'clean' samples and equipment from those being used to handle the contaminant. This necessarily requires a degree of investment on the part of the PT provider, in terms of capital expenditure as well as staff training to ensure that the implications of cross-contamination are fully comprehended. The base matrix is also sourced from an approved Halal meat supplier and undergoes testing before dispatch.

Outcome of the PTs

Two examples are provided here, one each of the two types of PT. The summary results for the adulteration PT 2971 are provided in Table 1. The base matrix was beef to which was added chicken, lamb and pork but not horse. Results were returned by 67 laboratories within the timeframe of the PT (a few weeks).

All the laboratories that submitted results for chicken and horse detections agreed that chicken was present and horse was absent. This also agrees with the known preparation of the material. However, two laboratories failed to detect the presence of lamb or pork.

Many participants additionally submitted confirmation that beef was present in the base matrix and there was also a range of other species that were included in participants' screens. These included goat, turkey, dog, deer, fish and duck.

A majority of participants used DNA methods, either PCR or DNA testing kits. Non-DNA methods used by participants were ELISA kits of various manufacturers.

The summary results for Fapas PT 3102 (Halal compliance) are provided in Table 2. With this PT, two beef test materials were distributed to participants, one of which was contaminated with pork. Results were returned by 29 participants for the detection of pork.

All participants agreed that pork was absent from test sample A. One participant, however, failed to detect pork in test sample B. This PT was specifically aimed at the detection of pork DNA so the only appropriate method to use is PCR. Given the low level of contamination, participants were advised to increase the number of PCR cycles but this was the only method advice provided. In the majority of PTs, no advice on methods will be provided.

Additional outcomes from the PT exercises

With many PTs, there is an excess of materials produced. These have uses beyond the PT as quality control samples or reference materials. This benefits participants who need to investigate their unsatisfactory performance in a PT. However there are also benefits for ongoing quality control trending purposes, staff training or method validation exercises. The materials are characterised by the PT exercise itself and so provide a very high degree of confidence in the 'correct' result. Meat proficiency test materials are no exception in this respect and post-PT samples were made available to any interested party, not just the participants in the PTs.

Summary

The provenance of food, especially meat products, is a sensitive topic but there are tools available to support producers in demonstrating compliance with legislators and other authorities. The confidence in analytical data provided to producers can be enhanced through proficiency testing. This provides clear evidence from an independent source that the laboratory supplying the analytical service is competent. PT exercises, such as those run by Fapas, exist to support detection of both adulteration and contamination of meat products for purposes of unscrupulous economic gain or for Halal compliance. ■

Table 1. Summary results for Fapas PT 2971. The assignment is the known preparation of the material.

Analyte	Assignment	Consensus results	Total results	Results agreeing with assignment (%)
Chicken	Present	61	61	100
Horse	Absent	58	58	100
Lamb	Present	48	50	96
Pork	Present	64	66	97

Table 2. Summary results for Fapas PT 3102. The assignment is the known preparation of the material.

Sample	Assignment	Consensus results	Total results	Results agreeing with assignment (%)
A	Absent	29	29	100
B	Present	28	29	97