Middle East Research Journal of Biological Sciences
ISSN 2789-7710 (Print & ISSN 2958-2091 (Online)
Frequency: Bi-Monthly
DOI: https://doi.org/10.36348/merjbs.2024.v04i05.002

Website: http://www.kspublisher.com/
Email: office@kspublisher.com

Ensuring Trust: The Science and Technology Behind Food Authentication and Reliability

Iftear Kazim Rafi[1]*
[1]Department of Pharmacy, Jahangirnagar University, Dhaka-1342, Bangladesh

Abstract: Food authentication of halal food, which includes the manufacturing technique, technical processing, identification of undeclared components, and species replacement in halal food items, has increased rapidly as a result of growing public awareness of food quality and safety. This highlights the need for in-depth investigation into analytical techniques to produce precise and trustworthy data for observing and managing the authenticity of halal food. This study offers a concise, objective summary of current research on the analytical methods applied to the evaluation of the authenticity of halal food.

Keywords: Halal, Food authentication, PCR, Consumption, Metabolomics, Assessment.

REVIEW PAPER

***Corresponding Author:**
Iftear Kazim Rafi
Department of Pharmacy, Jahangirnagar University, Dhaka-1342, Bangladesh

How to cite this paper:
Iftear Kazim Rafi (2024). Ensuring Trust: The Science and Technology Behind Food Authentication and Reliability. *Middle East Res J Biological Sci, 4*(5): 157-163.

Article History:
| Submit: 04.09.2024 |
| Accepted: 03.10.2024 |
| Published: 08.10.2024 |

1. INTRODUCTION

Food authenticity is a major concern for the food industry as well as consumers for a variety of reasons, including legal compliance with religious beliefs, whether or not it is permitted, economic considerations (the right foods at the right price), and the assurance of a consistent, well-defined quality with the use of appropriate ingredients (no harmful substitutes) [1]. Pig derivatives are usually less costly than cow or sheep derivatives. Consequently, pork derivatives are used in a variety of dietary systems. It is standard practice in many countries to adulterate food and feed products by mixing meats and fats from several less costly sources with unclear and incorrect labeling. A major issue for certain customers is deceptive labeling, debasement with less costly species, or violation of rigorous details [2].

Globally, the consumption of halal cuisine, particularly among Muslims, has surged in recent times. The halal food business has enormous potential and is expanding quickly on all continents, including Asia, the Middle East, Africa, Europe, and America. There are around 2 billion Muslims worldwide, and by 2020, it is expected that they would spend US$ 1400 billion on halal food; by 2050, this sum is expected to have increased by more than ten times, reaching US$ 15,000 billion. The Pew Research Center projects that there will be 2.2 billion Muslims worldwide by 2030, which highlights the significance of the halal and pure food industry given that Muslim countries' GDPs are growing faster than those of Western nations [3, 4]. The 21st-century scientific and technological progress, particularly in the food processing sector, has led to the diversification of food components, including gelatin, genetically modified (GM) foods, and medicinal items, among Muslims [5, 6].

Customers, both Muslim and non-Muslim, who buy halal food items due to quality, environmental, and health concerns have broadened the market [7]. Only halal items that satisfy certain conditions are acceptable to Muslims. Products like alcohol and pork, which are strictly forbidden in Islam, are frequently combined with the most popular halal cuisines like chicken and beef. The consumption rate of halal beef and chicken in 2017 was 15.0% and 15.8%, respectively, based on the global consumption rate [8], as well as balanced ideal food sources [9]. Owing to the significance of the halal market, producers and consumers alike need to have a comprehensive grasp of how Islamic Syariah law—which establishes guidelines for Muslims to abide by based on the Holy Quran and Hadith—functions and is administered. Since halal food cannot be determined by taste, texture, or smell, it is difficult to verify. Authenticating the origin of food items can contribute to maintaining food quality, safety, and transparency across the supply chain. Food authenticity and origin testing provide several advantages, however there are still obstacles to be solved. Certain analytical procedures, for instance, are too costly and time-consuming to be useful for field testing on a regular basis. Furthermore, it is difficult to design uniform procedures for food authentication since various goods call for various analytical methodologies and approaches. Nonetheless, improvements in analytical tools and the creation of standardized procedures will keep enhancing our capacity to verify the provenance of food items. By doing this, we may uphold moral and sustainable manufacturing methods, safeguard customers, and advance an open and honest market.

2. METHODS AND STUDY DESIGN

A review design is used in this article. By this, it is meant that the authors gather and examine material and data from a variety of authoritative sources. Information was acquired from several credible international journals and scholarly publications. The literature that the authors chose to review includes earlier research on the identification of pig in food, food adulteration, consumer trust, and different food processing and food analysis methodologies. The authors organize the analyzed information into several categories, such as implication of food adulteration, different methods for food assessment and importance.

3. RESULT AND DISCUSSION

All the finding and impact are categorized by section to section and described below accordingly.

3.1 Foods that Require for Halal Authentication

Certification for halal is necessary for all kinds of food, especially meat items. This is due to the fact that meat products constitute a significant portion and are necessary for human nutrition. As demand grows and prices rise, there is a greater likelihood of unlawful adulteration, substitution, and mislabeling of meat and meat products [10]. For consumers who have religious prohibitions against consuming pork, counterfeit meat products pose a severe risk due to their low cost [11]. In addition to meat, halal cuisine cannot contain alcohol. Alcohol is frequently employed in the creation of food or as a byproduct in the processing of food, especially ethyl alcohol, or ethanol. Moreover, Muslims must eat the flesh of animals that have been killed according to Islamic law and with the correct halal procedures. Industries employ a lot of porcine gelatin, and this product is considered haram and sold not just to Jews and Muslims but also to vegetarians and others who are allergic to swine products.

3.2 Implication of adulteration

Adulteration exposes susceptible people to antigens that may cause particular food allergies. When allergies to particular species are taken into consideration, it is crucial to recognize the various species present in food items [17]. The possibility of contracting infectious transmissible spongiform encephalopathy in humans has deterred many people from eating beef worldwide [18]. The use of ruminant corpses in animal feed for cattle has led to the epidemic-level spread of Bovine Spongiform Encephalopathy (BSE), often referred to as mad cow disease [19]. As a result, one of the most important agricultural issues nowadays is the sensitive identification of ruminant species in animal feed [20].

There have sometimes been serious food poisoning cases in Taiwan as a result of consuming toxic puffer fish or toxic dried dressed fish fillets [21, 22]. The nontoxic puffer fish *Lagocephalus gloveri* has no tetrodotoxin (TTX) in its muscle. Lethal amounts of TTX build up in the muscles of the *Takifugu oblongus* and *Lagocephalus lunaris*. For the manufacture of dried dressed fish fillets, *Lagocephalus gloveri* is therefore more commonly utilized than *Lagocephalus lunaris* or *Takifugu oblongus*. The reason behind the uncertain identification of *Lagocephalus lunaris* and *Lagocephalus gloveri* by both producers and customers is their comparable morphology. Furthermore, *Takifugu oblongus*, a poisonous puffer fish found in Taiwan, is frequently misused as a raw material for the production of dried dressed fish fillet [23].

3.3 Different Methods for Food Assessment

The following parts include both traditional techniques and cutting-edge research on halal food authenticity assessment in several food product categories. Ten years ago, the examination of halal food was done using traditional techniques including electrophoresis and physicochemical approaches. Despite being easy to use and reasonably priced, conventional methods include time-consuming and laborious sample preparation processes. Additionally, the lack of solid datasets makes the results difficult to understand [12]. The results must be confirmed and verified using methods such as molecular spectroscopy and high-performance liquid chromatography (HPLC), which yield validated and trustworthy results. Additionally, the previously described cutting-edge methods might be combined with artificial intelligence (AI), chemometrics, and the Internet of Things (IoT) to further improve the precision, speed, and capacity of multiplexed analyte detection.

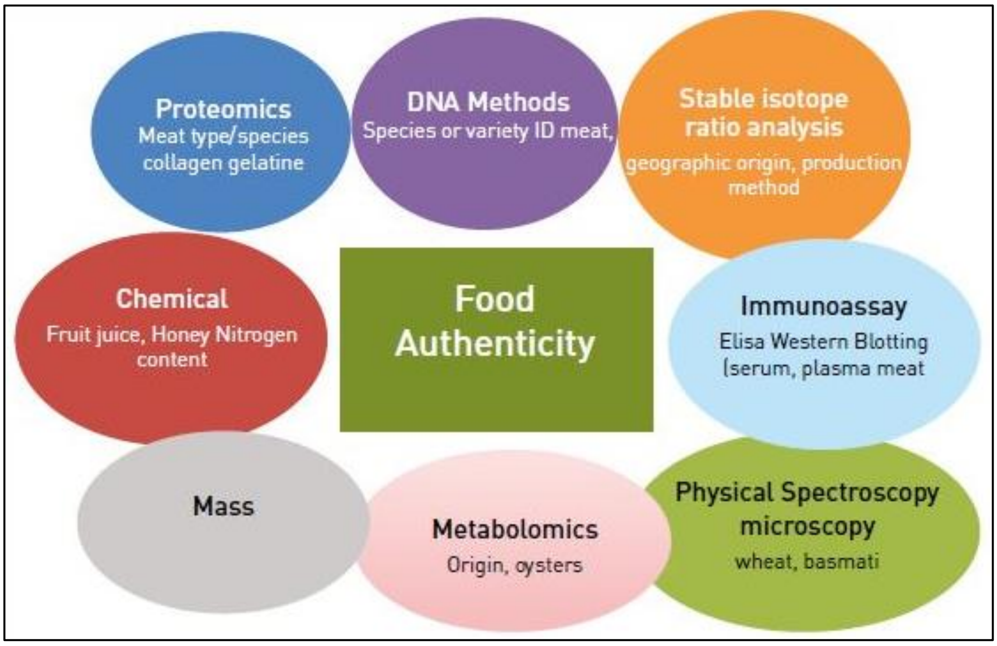

Figure 1: Assessing food authenticity using different methods

The identification and differentiation of species and/or cultivars in food has unquestionably benefited greatly from DNA-based techniques that target nuclear or mitochondrial (mt) markers. The method of choice for authenticating a variety of food commodities is still real-time PCR because of its excellent repeatability, sensitivity, and specificity [24]. This is also true for species authentication in meat products, where one of the most popular DNA-based methods for doing so is real-time PCR, which primarily targets mtDNA [24]. Selecting a DNA marker can be difficult as well, particularly if quantitative analysis is the goal. Although mtDNA has benefits in terms of sensitivity and specificity, its changing copy number poses a challenge for quantitative methods. In order to quantify it in meat products, a TaqMan real-time PCR test was created that targets the roe deer lactoferrin gene [25]. The assay was used to analyze commercial meat products after being internally verified by counting the amount of roe deer in model meat mixes and a model sausage [25].

Plant species verification using real-time PCR was also performed in vegetable oil, a very difficult matrix. Novel qualitative and quantitative PCR tests were presented for the first time in order to validate argan oil. Premium quality, food- and cosmetic-grade argan oil is sold all over the world, albeit it may be tainted with other vegetable oils. In order to tackle this issue, two real-time PCR calibration models were created. These models were then tested internally using blind mixes and estimated probable adulterations of argan oil with olive or soybean oils using the normalized DCqmethod [26]. Another difficult task that has been effectively completed with DNA markers, notably microsatellites or simple sequence repeats (SSR), is the varietal authentication of foods. The olive species served as one example of this. According to a review by Yadav *et al.*, microsatellite markers have been used in cultivar identification, managing olive germplasm banks, characterizing autochthonous olives (old olive trees and oleasters), phylogenetics, diversity analysis, and mapping [27].

Using spectroscopy's non-destructive nature, ease of sample preparation, and ability to be operated by technicians without any training, a number of studies conducted in recent years have shown that it is a feasible method for food verification. However, the creation of appropriate spectrum databases and multivariate analysis are necessary for the efficient use of spectroscopic techniques in food verification. Chia oils tainted with sunflower oil were analyzed using a combination of Raman, near-infrared (NIR), and fluorescence spectroscopy methods [28]. Using edible bug powders (*Alphitobius diaperinus* and *Locusta migratoria*) to enhance doughs and 3D-printed baked snacks, Fourier transform mid-infrared spectroscopy with attenuated total reflection (ATR-FTMIR) was combined with multivariate analysis [29].

An animal's food can be partially reflected in the multi-element composition of its tissues, whereas plants' tissues reflect the soil composition of the environment in which they are grown. Therefore, the accessible nutrients underpinning the soils can directly convey information about the geographical origin of foods [30]. On the other hand, elements found in the tissues of aquatic animals, like fish, are known to originate from the elements in the surrounding environment, the aquatic habitat, and the production premises. This knowledge is especially helpful when attempting to determine the nation of origin of wild specimens [31]. Foodstuffs contain compounds such as amino acids, fatty acids and sugars. NMR is one of the most suitable methods to obtain "highthroughput" spectroscopic and structural information on a wide range of molecular compounds. It enables determination of complex compositional matrices of foodstuffs, with high analytical precision. It is possible to evaluate the concentration of any chosen metabolite in a combination with little sample preparation. NMR's sensitivity was once thought to be its primary drawback, however ongoing advancements in technology have made NMR far more sensitive now. As a result, ΞMR makes it possible to compile extensive metabolic profiles that are useful for food authenticity. Sophisticated Natural Isotope Fractionation (SNIF-NMR) allows strong natural molecular fingerprinting. The EU created SNIF-NMR in 1990 to determine the geographical origin of wine, and this use is well-known (EU rules 2670/90, 2347/91 and 2348/91). Non-targeted 1H-NMR analysis is one profiling technique that has been used to determine the geographical provenance of food [32].

3.4 Metabolomics approach

Among the four "omics" technologies is metabolomics. It is a methodical and scientific technique that looks at the interactions and concentrations of metabolites in organic entities. The method seeks to concurrently identify general metabolite changes in human, plant, animal, and microbe bio-systems. These changes are a direct reflection of the underlying biochemical processes taking place in the cells, tissues, organs, and organisms. Many industries, including food, medicine, and agricultural, employ metabolicomics. Food metabolomics is the application of metabolomics to human diets, food resources, manufacturing, and processing. The change in the food sector has led to a progressive growth and notable advancements in the use of food metabolomics in recent years [33, 34].

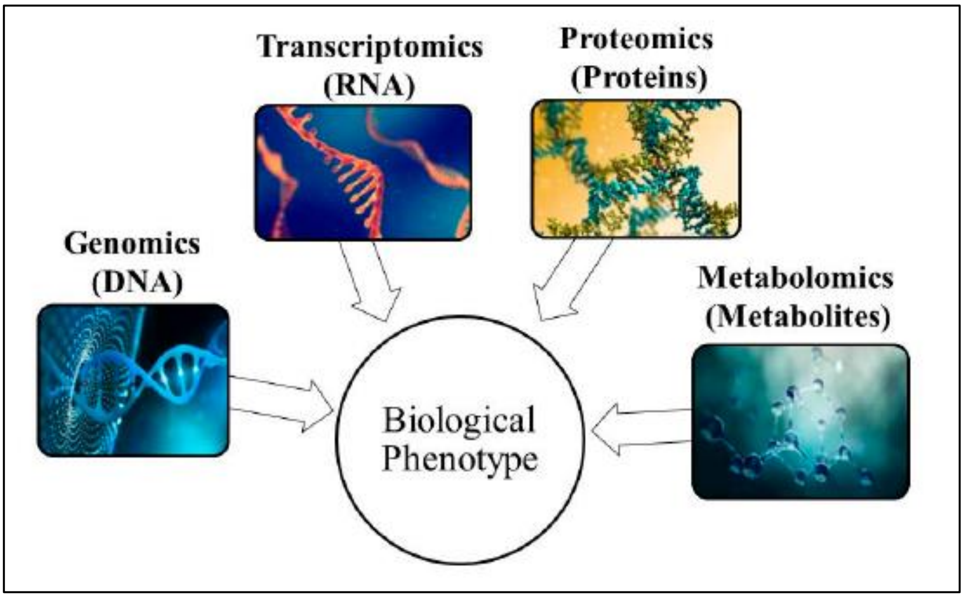

Figure 2: Omics techniques are used to determine the biological phenotype of different biological samples [38]

The majority of the current metabolomics research studies in the food sector employ a variety of reliable technologies and standard analytical techniques to identify food identity markers. The search for metabolic indicators of food authenticity, nutritional quality, and the detection of food adulteration are significantly impacted by these devices [35, 36]. There have been notable results from the use of metabolomics in food commodities for authentication [37]. Although the analysis of the metabolics and mechanisms of diseases may be proven to be effective by the metabolomics approach, some obstacles need to be considered when conducting a metabolomic analysis, such as the sensitivity of metabolites in the existing environment, the choice of the instrument used, and the cost of the analytical instrument. Moreover, the metabolome responds physiologically to a variety of environmental and genetic cues. Metabolites do differ in terms of stability and have wildly varied rates of turnover inside cells. Others could be volatile in the presence of oxygen, light, at different temperatures, or in other analytical situations that might lead to serious issues during the testing. Given that vitamins are photosensitive and may degrade when exposed to direct light, sample preparation for vitamin detection is particularly sensitive.

3.5 Species differentiation or source authentication

In terms of food quality and safety, species distinction and source verification of food items are critical factors to take into account. Food and its products might be tampered with or substituted with subpar goods, resulting in inaccurate labeling and claims. There is a growing demand for accurate and detailed information about what they eat from halal industries, consumers adhering to specific diets, consumers who follow organic lifestyles or are strictly vegetarians, and religious and health concerns regarding the presence of pathogens or allergic substances, among other factors. In order to satisfy these demands, labeling must be precise and unambiguous [39]. Enforcing particular restrictions against deliberate or inadvertent mislabeling, wrong description, and other fraudulent practices performed by manufacturers all in the name of gaining additional profits is the responsibility of concerned (legal) authorities. It is necessary to use extremely sensitive, analytical, and reliable methodologies/techniques to prevent such incidents and their potential negative effects on the economy and public health [40]. It is also possible to verify the origin and species of organic foods and animal products that are thought to be healthier and more nutritious by society [40].

For instance, the meat industry has been linked to a number of dishonest business activities, such as adulterating meats, lipids, and tissues from other species and adding non-meat components [41]. This threat also affects the cattle and fisheries sectors. Since processing destroys all of a fish or poultry bird species' physical and anatomical traits, it becomes extremely difficult to authenticate them, which leads to a rise in fraudulence [42].

Additionally, Rtea and An (2009) used arginine kinase peptide mass fingerprinting (PMF) as a proteomic technique to study species differentiation of economically relevant shrimps. One method used to examine the sarcoplasmic proteome of six distinct species was two-dimensional electrophoresis (2-DE). The examination of the sarcoplasmic proteome across many species revealed variations in arginine kinase's isoelectric point, indicating its potential as a molecular marker [43]. Using matrix-assisted laser desorption/ionization time-of-flight mass spectroscopy peptide mass fingerprinting (MALDI-TOF-MS PMF), the arginine kinase spot was further digested by trypsin. Some results indicated that species-specific peptides were present since the peaks were shared by all specimens belonging to one or more species, while other results revealed that the resultant spectra were distinct.

To find chicken flesh in a combination of meats, a thorough proteomic analysis was done [44]. After myofibrillar proteins were isolated, target proteins were enhanced with the use of OFF-GEL IEF. The breakdown of the myosin light chain by trypsin in solution came next. The resultant peptides were subsequently used in an LC-MS/MS proteomic method protein analysis. According to the study's findings, there was 0.5% of chicken contamination in the pork. Jánosi *et al.*,'s (2007) study, which used PCR to identify fowl meat in a combination of pig, supported this finding.

3.6 Importance of Food Authentication

Food authenticity not only guarantees food safety and quality, but it also helps producers and customers financially. Producers may safeguard their reputation and brand by authenticating items, and buyers can feel certain about the goods they are buying [13]. Food fraud has an effect that extends beyond monetary losses and reputational damage. Food goods that are tainted or incorrectly labeled can seriously endanger public health. Eating foods that aren't authentic can cause allergic responses, foodborne infections, and chronic health problems. Verifying the legitimacy of food is an essential line of defense that lowers possible health risks and prevents dangerous items from reaching customers [14, 15]. Due to food adulteration, a number of sophisticated analytical methods have been assessed recently for their use in food authentication, particularly for halal food items. Panels of qualified human experts have evaluated the authenticity of halal food in the past, but this traditional method has a number of drawbacks, including drawn-out processes, expensive costs, and subjectivity [16].

In the context of Bangladesh, a huge number of confectionery products imported from foreign countries including India, Pakistan, Thailand, Malaysia, Indonesia, Nepal, China, UAE, Vietnam, which comprises of juices, jams, chocolates, beverages, cakes, honey, cosmetics etc. Although all these type of products are manufactured locally. But, the process of production, methods and ingredients may have big differences. Since 2000, Bangladesh's confection food and beverage sector has had the quickest growth since Bangladesh is an agriculturally based nation. This industry alone accounts for 22% of the national GDP and for 2.45% of the labor force. Bangladesh may make a significant contribution to the food and beverage business as an agricultural country with a sizable population. Bangladesh is also having an impact on the global market by exporting food and drink to 90 different countries [45]. There aren't many publications that examine Bangladesh's food and beverage industries, so this one will be important reading for executives in the country's food business as well as foreign investors who want to participate in this market. The potential of Bangladesh's food and beverage business may be of interest to university students, educators, and fresh graduates without jobs. Bangladesh's food sector benefited greatly from the production of bakery goods and confectionery. Bangladesh's food and beverage industries are quite important in both local and global markets. Let's look at some food sales data from Bangladesh.

Table 1: Sales estimation of different food products in Bangladesh [46]

Products	Sales
Edible oils	6%
Fisheries	15%
Other food products	13%
Bakery & confectionery	22%
Grain milling	40%
Fruits and vegetables	4%

4. CONCLUSION

Food authenticity, or the lack of food fraud, is now associated with the local, high-quality, and authentic food movement. Food marketing and branding now have a chance thanks to the improved capacity to identify issues with food fraud and confirm the authenticity of food. Food that isn't authentic might be dangerous and of low quality. Genuine culinary ingredients could cost more due to their greater quality. Foods that aren't authentic should not cost the same as those that are.

Conflict of Interest: Not declared.

REFERENCES

1. Kamm, W., Dionisi, F., Hischenhuber, C., & Engel, K. H. (2001). Authenticity assessment of fats and oils. *Food Reviews International*, *17*(3), 249-290.
2. Nehal, N., Choudhary, B., Nagpure, A., & Gupta, R. K. (2021). DNA barcoding: A modern age tool for detection of adulteration in food. *Critical reviews in biotechnology*, *41*(5), 767-791.
3. Adekunle, B., & Filson, G. (2020). Understanding halal food market: Resolving asymmetric information. *Food ethics*, *5*(1), 13. https: //doi.org/10.1007/s41055-020-00072-7
4. Hoque, M. (2023). Unveiling the silent threat: Food adulteration in Bangladesh. *International Journal of Biological Innovations*, *5*(2), 22-27. https://doi.org/10.46505/ IJBI.2023.5203
5. Rohman, A., Erwanto, Y., & Man, Y. B. C. (2011). Analysis of pork adulteration in beef meatball using Fourier transform infrared (FTIR) spectroscopy. *Meat Science*, *88*(1), 91-95. https://doi.org/10.1016/j.meatsci.2010.12.007
6. Ali, M. E., Razzak, M. A., & Hamid, S. B. A. (2014). Multiplex PCR in species authentication: probability and prospects—a review. *Food Analytical Methods*, *7*, 1933-1949.
7. Olya, H. G., & Al-Ansi, A. (2018). Risk assessment of halal products and services: Implication for tourism industry. *Tourism Management*, *65*, 279-291. https://doi.org/10.1016/j.tourman.2017.10.015
8. Kwag, S. I., & Ko, Y. D. (2019). Optimal design for the Halal food logistics network. *Transportation Research Part E: Logistics and Transportation Review*, *128*, 212-228.
9. Asensio, L., González, I., García, T., & Martín, R. (2008). Determination of food authenticity by enzyme-linked immunosorbent assay (ELISA). *Food control*, *19*(1), 1-8.
10. Chuah, L. O., He, X. B., Effarizah, M. E., Syahariza, Z. A., Shamila-Syuhada, A. K., & Rusul, G. (2016). Mislabelling of beef and poultry products sold in Malaysia. *Food Control*, *62*, 157-164. https://doi.org/10.1016/j.foodcont.2015.10.030
11. Bonne, K., & Verbeke, W. (2006). Muslim consumer's motivations towards meat consumption in Belgium: qualitative exploratory insights from means-end chain analysis. *Anthropology of food*, (5). https://doi.org/10.4000/aof.90
12. Zia, Q., Alawami, M., Mokhtar, N. F. K., Nhari, R. M. H. R., & Hanish, I. (2020). Current analytical methods for porcine identification in meat and meat products. *Food chemistry*, *324*, 126664. https://doi.org/10.1016/j.foodchem.2020.126664
13. Rejeb, A. (2018). Halal meat supply chain traceability based on HACCP, blockchain and internet of things. *Acta Technica Jaurinensis*, *11*(1). https://doi.org/10.14513/actatechjaur.v11.n4.467
14. Rahman, F. S., Jubayer, A., & Hasan, M. J. (2024). Food Authenticity and its Importance for Customer Satisfaction in Terms of Persuasion.https://smsla.global/food-authenticity-testing/
15. Sforza, S., Corradini, R., Tedeschi, T., & Marchelli, R. (2011). Food analysis and food authentication by peptide nucleic acid (PNA)-based technologies. *Chemical Society Reviews*, *40*(1), 221-232.
16. Ng, P. C., Ahmad Ruslan, N. A. S., Chin, L. X., Ahmad, M., Abu Hanifah, S., Abdullah, Z., & Khor, S. M. (2022). Recent advances in halal food authentication: Challenges and strategies. *Journal of Food Science*, *87*(1), 8-35. https://doi.org/10.1111/1750-3841.15998
17. Koh, M. C., Lim, C. H., Chua, S. B., Chew, S. T., & Phang, S. T. W. (1998). Random amplified polymorphic DNA (RAPD) fingerprints for identification of red meat animal species. *Meat science*, *48*(3-4), 275-285.
18. Walker, J. A., Hughes, D. A., Anders, B. A., Shewale, J., Sinha, S. K., & Batzer, M. A. (2003). Quantitative intra-short interspersed element PCR for species-specific DNA identification. *Analytical Biochemistry*, *316*(2), 259-269.
19. Brown, P. (2001). Bovine spongiform encephalopathy and variant Creutzfeldt-Jakob disease. *Bmj*, *322*(7290), 841-844.
20. Comi, G., Iacumin, L., Rantsiou, K., Cantoni, C., & Cocolin, L. (2005). Molecular methods for the differentiation of species used in production of cod-fish can detect commercial frauds. *Food Control*, *16*(1), 37-42.
21. DF, H. (1995). Tetrodotoxin associated food poisoning due to unknown fish in Taiwan between 1988 and 1994. *J. Natural Toxins*, *4*, 307-315.
22. Hwang, D. F., Hsieh, Y. W., Shiu, Y. C., Chen, S. K., & Cheng, C. A. (2002). Identification of tetrodotoxin and fish species in a dried dressed fish fillet implicated in food poisoning. *Journal of food protection*, *65*(2), 389-392.
23. Hwang, D. F., Kao, C. Y., Yang, H. C., Jeng, S. S., Noguchi, T., & Hashimoto, K. (1992). Toxicity of puffer in Taiwan. *Nippon Suisan Gakkaishi*, *58*(8), 1541-1547.
24. Amaral, J., Meira, L., Oliveira, M. B. P. P., & Mafra, I. (2016). Advances in authenticity testing for meat speciation. In *Advances in food authenticity testing* (pp. 369-414). Woodhead Publishing.

25. Druml, B., Mayer, W., Cichna-Markl, M., & Hochegger, R. (2015). Development and validation of a TaqMan real-time PCR assay for the identification and quantification of roe deer (Capreolus capreolus) in food to detect food adulteration. *Food Chemistry*, *178*, 319-326.
26. Amaral, J. S., Raja, F. Z., Costa, J., Grazina, L., Villa, C., Charrouf, Z., & Mafra, I. (2022). Authentication of argan (Argania spinosa L.) oil using novel DNA-based approaches: Detection of olive and soybean oils as potential adulterants. *Foods*, *11*(16), 2498.
27. Yadav, S., Carvalho, J., Trujillo, I., & Prado, M. (2021). Microsatellite markers in olives (Olea europaea L.): Utility in the cataloging of germplasm, food authenticity and traceability studies. *Foods*, *10*(8), 1907.
28. Mburu, M., Komu, C., Paquet-Durand, O., Hitzmann, B., & Zettel, V. (2021). Chia oil adulteration detection based on spectroscopic measurements. *Foods*, *10*(8), 1798.
29. García-Gutiérrez, N., Mellado-Carretero, J., Bengoa, C., Salvador, A., Sanz, T., Wang, J., ... & Lamo-Castellví, S. D. (2021). ATR-FTIR Spectroscopy combined with multivariate analysis successfully discriminates raw doughs and baked 3D-Printed snacks enriched with edible insect powder. *Foods*, *10*(8), 1806.
30. Drivelos, S. A., & Georgiou, C. A. (2012). Multi-element and multi-isotope-ratio analysis to determine the geographical origin of foods in the European Union. *TrAC Trends in Analytical Chemistry*, *40*, 38-51.
31. Varrà, M. O., Ghidini, S., Husáková, L., Ianieri, A., & Zanardi, E. (2021). Advances in troubleshooting fish and seafood authentication by inorganic elemental composition. *Foods*, *10*(2), 270.
32. Longobardi, F., Ventrella, A., Bianco, A., Catucci, L., Cafagna, I., Gallo, V., ... & Agostiano, A. (2013). Non-targeted 1H NMR fingerprinting and multivariate statistical analyses for the characterisation of the geographical origin of Italian sweet cherries. *Food chemistry*, *141*(3), 3028-3033.
33. Clish, C. B. (2015). Metabolomics: an emerging but powerful tool for precision medicine. *Molecular Case Studies*, *1*(1), a000588.
34. Yan, M., & Xu, G. (2018). Current and future perspectives of functional metabolomics in disease studies–A review. *Analytica chimica acta*, *1037*, 41-54.
35. Liang, Q., Wang, C., Li, B., & Zhang, A. H. (2015). Metabolic fingerprinting to understand therapeutic effects and mechanisms of silybin on acute liver damage in rat. *Pharmacognosy Magazine*, *11*(43), 586.
36. Riedl, J., Esslinger, S., & Fauhl-Hassek, C. (2015). Review of validation and reporting of non-targeted fingerprinting approaches for food authentication. *Analytica Chimica Acta*, *885*, 17-32.
37. Erban, A., Fehrle, I., Martinez-Seidel, F., Brigante, F., Más, A. L., Baroni, V., ... & Kopka, J. (2019). Discovery of food identity markers by metabolomics and machine learning technology. *Scientific Reports*, *9*(1), 9697.
38. Selamat, J., Rozani, N. A. A., & Murugesu, S. (2021). Application of the metabolomics approach in food authentication. *Molecules*, *26*(24), 7565. https://doi.org/10.3390/molecules26247565
39. Abd El-Hack, M. E., Khan, M. M. H., Hasan, M., & Salwani, M. S. (2018). Protein-based techniques for halal authentication. In *Preparation and Processing of Religious and Cultural Foods* (pp. 379-391). Woodhead Publishing. Available from: https://doi.org/10.1016/B978-0-08-101892-7.00020-1.
40. Paredi, G., Sentandreu, M. A., Mozzarelli, A., Fadda, S., Hollung, K., & de Almeida, A. M. (2013). Muscle and meat: New horizons and applications for proteomics on a farm to fork perspective. *Journal of proteomics*, *88*, 58-82. Available from: https://doi.org/10.1016/j.jprot.2013.01.029.
41. Ballin, N. Z. (2010). Authentication of meat and meat products. *Meat science*, *86*(3), 577-587. Available from: https://doi.org/10.1016/j.meatsci.2010.06.001.
42. Marrocco, C., D'Alessandro, A., Rinalducci, S., Mirasole, C., & Zolla, L. (2013). Untargeted metabolomic analyses open new scenarios in post mortem pig muscles: Casertana and Large White. In *Farm animal proteomics 2013: Proceedings of the 4th Management Committee Meeting and 3rd Meeting of Working Groups 1, 2 & 3 of COST Action FA1002 Košice, Slovakia 25-26 April 2013* (pp. 270-273). Wageningen Academic Publishers.
43. Ortea, I., Canas, B., Calo-Mata, P., Barros-Velazquez, J., & Gallardo, J. M. (2009). Arginine kinase peptide mass fingerprinting as a proteomic approach for species identification and taxonomic analysis of commercially relevant shrimp species. *Journal of agricultural and food chemistry*, *57*(13), 5665-5672. Available from: https://doi.org/10.1021/jf900520h.
44. Sentandreu, M. A., Fraser, P. D., Halket, J., Patel, R., & Bramley, P. M. (2010). A proteomic-based approach for detection of chicken in meat mixes. *Journal of proteome research*, *9*(7), 3374-3383.
45. Agro- processed industry in Bangladesh. (n.d.). 1st ed. [ebook] Dhaka. Available at: http://www.hortex.org/Employment%20and%20GDP Agroprocessed_171113.pdf
46. Global Halal Foods Industry. Reportlinker, 2020. https://www.reportlinker.com/p05899600/Global-Halal-Foods-Industry.html.