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Detection of Fraud in the Type and amount of Meat in Meat Products: A Systematic Review

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ABSTRACT

Introduction: The aim of this study was to identify methods for detecting composition and fraud in meat foods.
Methods: An extensive literature review was conducted in 2022 using the electronic databases: Web of Science, Scopus, SID, and PubMed. The search was limited to articles published in English from 1970 to 2022. Search terms used were "fraud", "meat products", "Iran," " authentleication," "detection," and "adulteration".
Results: Genetic-based molecular tests (PCR) and less use of histological and chemical tests were used to detect fraud and its type in meat products. PCR was used in 30 cases to identify the type of cheating in meat products such as sausages. Histological methods were used in 19 cases to detect type of violation.
Conclusion: Molecular methods for detecting food fraud are highly accurate; therefore, they have the highest detection rate.

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Introduction

Fraud in meat-contaminated foods has been a rising global problem in recent years. Cheat food is defined as the intentional incorporation or replacement of cheaper or inferior components in foods in order to improve their quality and lessen their environmental impact. Because of this, the health of the community has been linked directly to the authenticity of meat. Identifying meat species in various meat products, on the other hand, is particularly crucial in Islamic nations where people only consume halal meat. In the last few decades, PCR-based methods have been used to check the authenticity of meat from different raw, cooked, and cooked food products made from different animal species (1). World consumption of meat and animal carcasses is increasing these days. Because of how much money meat is worth, it is possible that illegal tissue could be used in processed meat. species of animal (2).

Authenticity and traceability of meat are big problems in our modern society. For example, there have been reports of horse meat being added to meat products that were not supposed to have it (3). This exemplifies the widespread demand of consumers for clear and accurate data on the food they consume. This is especially true for processed meat products, where you can't tell the different parts apart as easily by looking at them as you can with whole fresh meat (4). In fact, there

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are substantial underlying reasons behind this allegation. Nowadays, pricing and lifestyle, as well as religious or health considerations, might influence an individual's choice of feed products based on their composition. An excellent example of this is the Muslim community's growing need to certify the halalness of the meat they consume in an expanding global meat market (3).

Major food fraud and contamination occurrences occur with startling regularity and are known to be episodic, raising the question of when, not if, another large-scale food safety and integrity disaster will occur. Indeed, the issue of preserving food security is now widely acknowledged on a global scale. The growing size and complexity of food supply networks can make them much more prone to adulteration and contamination, as well as possibly dysfunctional (5). The deception of flesh products using undeclared or incorrectly stated animal species is a major concern around the world. There are several analytical tools for identifying meat types, but they are time consuming and require highly skilled workers (6). Fraudulent use of meat in processed foods is a serious subject because specific meat species are forbidden in various religions, including Islam and Judaism. Some meats may also be carriers of deadly diseases such as SARS, hepatitis, and anthrax. Furthermore, unintentional eating of some meat may result in an allergic reaction (7). In conclusion, the current study suggests that the real-time PCR-HRM method could be considered a reliable technique for detecting meat authenticity in processed products and distinguishing between halal and haram meat samples. However, some refinements are needed to improve the selectivity of these methods (8).

Materials and Method

Data sources

An extensive literature review was conducted in 2022 using the electronic databases Web of Science, Scopus, and Side, and PubMed. The search was limited to articles published in English from 1970 to 2022. Search terms used were "Fraud", "meat products", "Iran," " authentication," "detection," and "adulteration".

In total, 1050 articles were found in Iran, of which 163 were useful. We had 65 duplicate articles and 48 articles were deleted for the following reasons.No access to full text (6), no percentage and type of fraud (2), livestock gene identification (9), article not original (6), fraud other than meat (7), test except target (9) Once preliminary results matching search terms were obtained, data was extracted in three steps: duplicate articles were identified and removed; remaining titles and abstracts were screened for eligibility against inclusion criteria; and full text articles were retrieved and assessed in terms of their study design and scientific approach. Then, all 50 articles that were found were reviewed critically and added to the overview as needed (Figure 1).

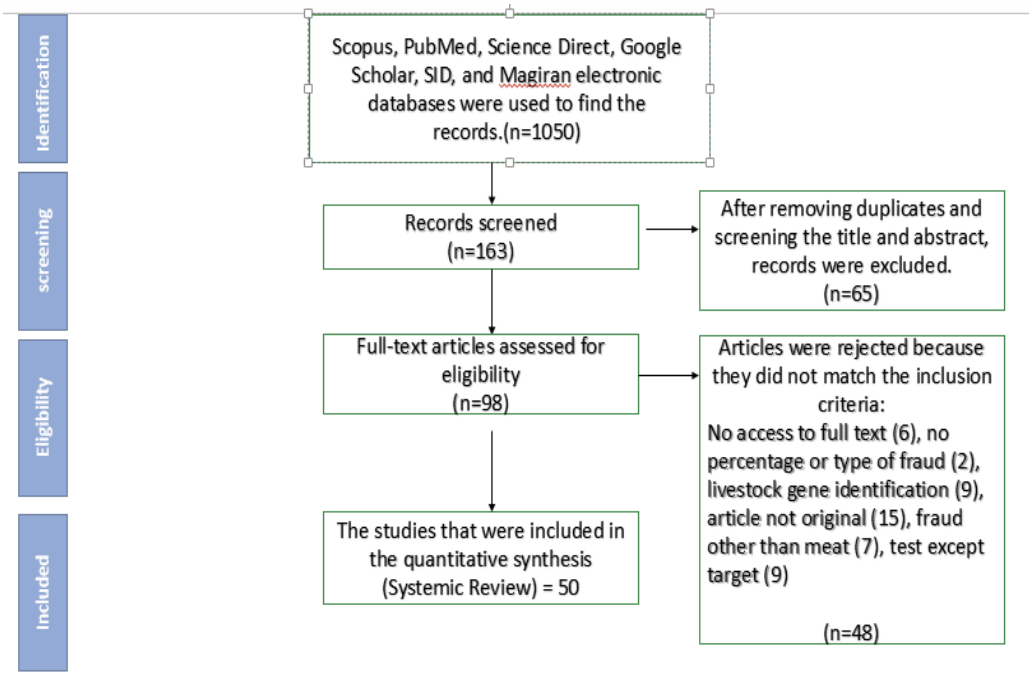

Figure 1: Article flow diagram

Results

The total number of samples are 1944. The following are meat products. In 21 articles on sausages, 3 articles on halal products, a kebab review in 12 articles, gelatin 2, fish, sandwiches, minced meat, 9, hamburger, 17, meat There have been two articles, pointing out that in some articles more than one meat product was reviewed.

Studies conducted in 1993, comprise two studies 2021 (1), 2016 (10), 2012 (2), 2011 (2), 2019 (3), 2020 (6), 2015 (2), 2013 (3), 2014 (5), 2018 (7), 2017 (4), 2009 (1) A study on meat fraud, type of meat and its products was collected.

50 articles collected from Tehran 21, Isfahan 4, Yazd 5, Tabriz 9, Shiraz and Khorasan each one, Khorramabad 1, Kermanshah 1, Urmia 1, North 2, Mashhad 1 and the rest have been done in the whole country.

In this study, looking at the collected articles from all over the country, we came to the interesting conclusion that the amount of unauthorized meat used in meat products is quite interesting. The use of poultry meat as an unauthorized additive and its permitted fat textures such as skin and fat in 21 articles It is mentioned that this issue indicates widespread fraud of this meat, the reason for which in Iran may be its lower price for producers. The use of ruminant meat as an unauthorized additive and its unauthorized tissues such as rumen and by-products are mentioned in (16) articles, in (3) only ruminant articles, in (8) beef mince articles, and in (6) articles. Mutton and goat meat are mentioned in the context of meat fraud. This indicates widespread fraud of this meat. which can have different reasons. The unauthorized use of horse meat and its unauthorized textures, all of which are prohibited, are mentioned in (7) articles that can be used in sausages and other products (Table 1).

Table 1. Methods for detecting food fraud

Journal Year	Location	Fraud	Percentage	Product	Detection Method	Sample Number	Reference
1993	Four factories	Unauthorized texture	7–30%	Hamburger meat	Histology	120	(9)
2021	Markets in Tehran	Mislabeling of cattle, sheep, chicken, turkey, and wild pig	Pos	Raw and cooked mincemeat samples	Real-time PCR	Five species (cattle, sheep, chicken, turkey)	(8)
2018	Markets in Tehran	Chicken and red meat	Pos	Hamburger meat	Simplex and Duplex PCR	10	(2)
2019	Markets, in north-east Iran	Unauthorized tissues	Muscle fiber (100%), fat tissue (100%) and plant material (97.70%).	Sausage	Histological	20	(3)
2016	Yazd	Avian skin and adipose tissue	5-20% avian skin	Mincemeat	Histological	15	(10)
2017	Iran	Bovine, buffalo and porcine	Beef frankfurters (71%) Hamburger meat (85%)	Beef frankfurters and Hamburger meat	PCR	-	(11)
2018	Markets in Tehran	Chicken and red meat	Sausage (60%)	Sausage	Multiplex PCR	114	(12)
2018	Tabriz	Donkey meat	Pos	Mincemeat and bovine	PCR	98	(13)
2009	Factories in the north and south	Chicken and red meat	1%	Fishmeal	(QC-PCR)	30 commercial samples of fishmeal	(14)
2016	Restaurants in Tabriz	Unauthorized tissues	41.4%	Kebabs	Histological and chemical	44	(6)
2018	Markets in Tehran	Unauthorized tissues	54.76%	Hamburger meat	Histological	42	(15)
2020	Markets in Tehran	Mislabeling	67%	Premade kebabs contain 70 and 90% red meat	FTIR	36	(16)
2018	Markets in Tehran	Chicken and red meat	Sausage (60%)	Sausage	Multiplex PCR	114	(12)
2018	Tabriz	Donkey meat	Pos	Mincemeat and bovine	PCR	98	(13)

Table 1. Continue

2009	Factories in the north and south	Chicken and red meat	1%	Fishmeal	(QC-PCR)	30 commercial samples of fishmeal	(14)
2016	Restaurants in Tabriz	Unauthorized tissues	41.4%	Kebabs	Histological and chemical	44	(6)
2018	Markets in Tehran	Unauthorized tissues	54.76%	Hamburger meat	Histological	42	(15)
2020	Markets in Tehran	Mislabeling	67%	Premade kebabs contain 70 and 90% red meat	FTIR	36	(16)
2012	Factories in Iran	Poultry and ruminants	9-25%	Fishmeal	PCR	124	(17)
Control 2014	Restaurants and supermarkets	Chicken and red meat	6-100%	Raw Hamburger meat	PCR	300	(18)
2019	Factories in Iran	Ruminant, poultry, and pork	80% of sausage samples and 90% of cold cut	Sausages, cold cuts and ground meat	PCR	Each -10 samples,	(19)
2016	Tehran, Tabriz, and Isfahan	Horse, donkey, pig, and other ruminants	50.50,60.40% ,% 70.30%	Halal meat	PCR	35 samples	(20)
2020	Supermarkets in Iran	Mislabeling of bovine and chicken	25 cases	Supermarket hamburger meat	PCR-RFLP	31 samples	(21)
2020	Tabriz	Mixing poultry meat	41.38%	Processed, semi-processed products	PCR	58 samples	(22)
2012	Mashhad and Tehran	Sheep, cattle and goat	24 cases	Iranian commercial meat products	PCR-RFLP	30 samples of oil in mincemeat, kebabs, beef burgers and canned meat	(23)
2016	Tabriz	Bone, cartilage and lung tissues	9.1-18.2%	Ground meat used for kebabs	Histological and chemical	33 samples	(24)
2015	Restaurants and supermarkets	Unauthorized tissues	15 cases	Two types of red meat kebabs, sausages, handmade hamburger meat	Morphological	20 samples	(25)
2014	Different companies and food markets	Beef, sheep, pork, chicken, donkey, and horse	58.7%	Hamburger meat, sausages, frankfurters, cold cuts	PCR	224 meat products	(26)
2014	Various food factories	Mislabeling of bovine and chicken	50%	Sausages	PCR	10 sample sausages	(27)
2016	Markets in Tehran	Mislabeling of chicken	Pos	Hamburger meat	Multiplex PCR	10 samples of specified brands	(28)
2018	Tehran	Bovine and chicken	43%	Hamburger meat (60-90%)	PCR	10 samples of specified brands of hamburger meat	(2)
	Tehran	Unauthorized texture	Pos	Sausages	Spectrophotometric	60 sample sausages	(29)
2020	Markets in Tehran	Amount meat		Industrial kebabs and sausages	Histological	5(3)	(30)
2018	Markets in Urmia	Unauthorized tissues	Transparent bone and cartilage frequency 41.7% and 54.2%	Sausages	Histological	24	(31)

2019	Markets in Tehran	Unauthorized tissues(chicken)	Pos	Sausages (30 & 90%), industrial kebabs (70%)	Histological	5	(32)
2016	Markets in Yazd	Unauthorized tissues (destruction and viscera)	50%	Mince meat	Histological	20.3	(1)
2017	Tehran, Isfahan, Tabriz	Horse, donkey	(17%)	Sausages, mincemeat, hamburger meat	PCR	35	(33)
2014	Tehran	Chicken and meat	Pos	Sausages55%))	PCR method	10	(34)
2017	Kermanshah	Unauthorized tissues	Muscle or skeleton was not observed in 96.2% and 30.8% of adipose tissue samples. Organ or heart was found in 19.2% of the samples. Mature cartilage and bone were found in 96.2% of the samples. In 57.6% of samples, immature employment were found.	Sausage	Histological	720	(34)
2020	Yazd	Quantitative detection of meat	Low	Sausages (30%, 50%, 70%, 90%), kebabs (70)%	Histological	5	(30)
2020	Factory in Tabriz,	Donkey meat adulteration	Varied	Sausages	PCR	3	(39)
2013		Detection and quantification of chicken	5-90%	Sausages	PCR	4	(40)
2019	Yazd	Unauthorized tissues (chicken skin and bone)	5-20%	Kebab (70%) and cold cuts 90% & 30%	Histological	5	(32)
2014	Yazd	Unauthorized tissues (avian skin and adipose tissues) of chicken	5-20%	Mince meat	Histological	5	(10)
2016	Tehran	Unauthorized Tissues/ chicken	5-20%	Mince Meat	Histological	10	(41)
2017	Isfahan, Tabriz, and Tehran	Horse (11%), pork and donkey (6%)	17%	Sausages, kebabs, and hamburger meat	PCR	35	(42)
2013	Iran	Bovine, ovine, and caprine	100%, 50%, 10%, 5%, 1%, 0.5%, 0.1%	Pure and binary mixtures and heat processed meats	PCR	-	(35)
2016	Markets	Chicken paste in meat products	Sausages 84%, hamburger meat 26%-(10-50%)	Sausages, hamburger meat	PCR	150	(36)
2011	Khorramabad factory	Collagen	0.02-0.13 g/100	Sausages	Histological	30	(37)
2018	Tehran	Unauthorized tissues	57.48%	Handmade hamburger meat	Histological	35	(15)
2016	Various restaurants	Unauthorized tissues	-	Red meat sandwich products	Applying light, histochemical and scanning histological methods	105	(7)

2016	Isfahan, Tabriz, and Tehran	Horses, donkeys, pigs, cows, sheep	17%	Hamburger meat, sausages, mincemeat, kebabs	histological methods	35	(38)
Journal Year	Location	Fraud	Percentage	Products	Detection Method		
2015	Super-markets in Tehran	Pork	0.1%	Gelatin-	PCR	16	(43)
2013	Super-markets in Tehran	Incorrect labeling	11%	Fish species	PCR	3 Alaska Pollack samples	(44)
2020	North Khorasan province	Beef, lamb, pork, chicken, donkey, and horse	Beef (100%), lamb and chicken (83%), and horse (10%)	Kebab	TaqMan real-time PCR	150	(45)
2011	Tabriz, Iran	Pork		Halal meat products	PCR	20	(4)
2016	Shiraz	Chicken and red meat mislabeling	10-50%	Sausages	PCR	100	(5)

The study of donkey meat added to meat products has been done in 9 articles. Also, pork and its products were collected in 8 studied articles. In the continuation of the study, it was found that the use of unauthorized tissues such as skin and livestock in 18 The article has been in the country. Among them, the use of buffalo meat in meat products has been studied in 1 article. Also, collagen 1 and hair 1 and the least amount of tissue added to meat have been studied. The use of incorrect labeling and labeling has been studied in six articles. Among these violations were the use of buffalo meat, as well as collagen and hair, which were added to fewer meat products (Figure 2).

But in the meantime, the use of poultry waste as well as other meat waste accounted for the highest rate of meat fraud, with added to meat products that should not have been added.

Genetic-based molecular tests (PCR) and less use of histological and chemical tests were used to detect fraud and its type in meat products. PCR was used in 30 cases to identify the type of cheating in meat products such as sausages. And histological methods were used in 19 cases to detect the type of violation, in one case using histological and chemical methods to detect counterfeiting of meat products (Figure 3 and 4).

Discussion

Regarding the economic value of meat, use of unauthorized animal tissue is not impossible in meat products. Meat fraud generated a huge outrage amongst customers in 2013 in Europe due to the horsemeat scandal. (4). In this regard,

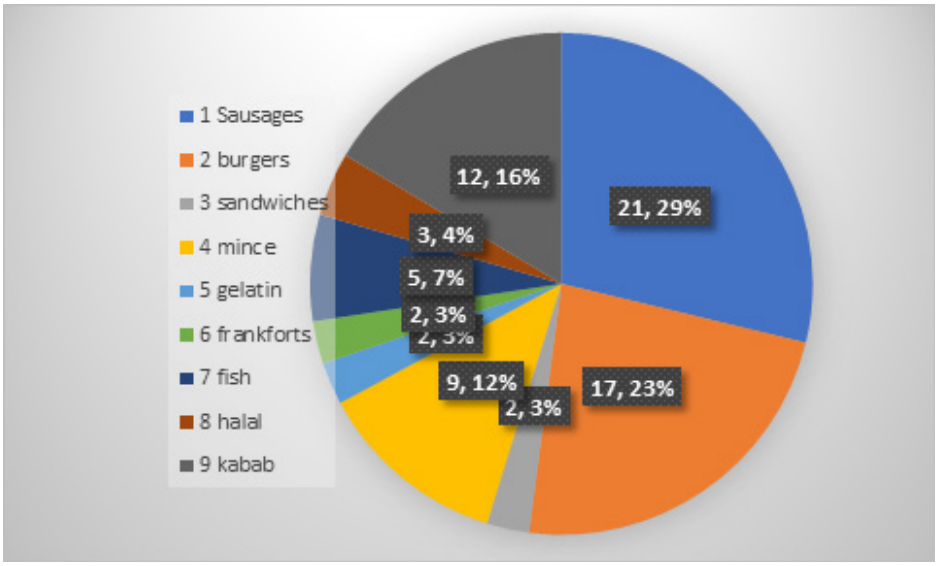

Figure 2. The number of studies conducted according to the type and amount of fraud in meat products

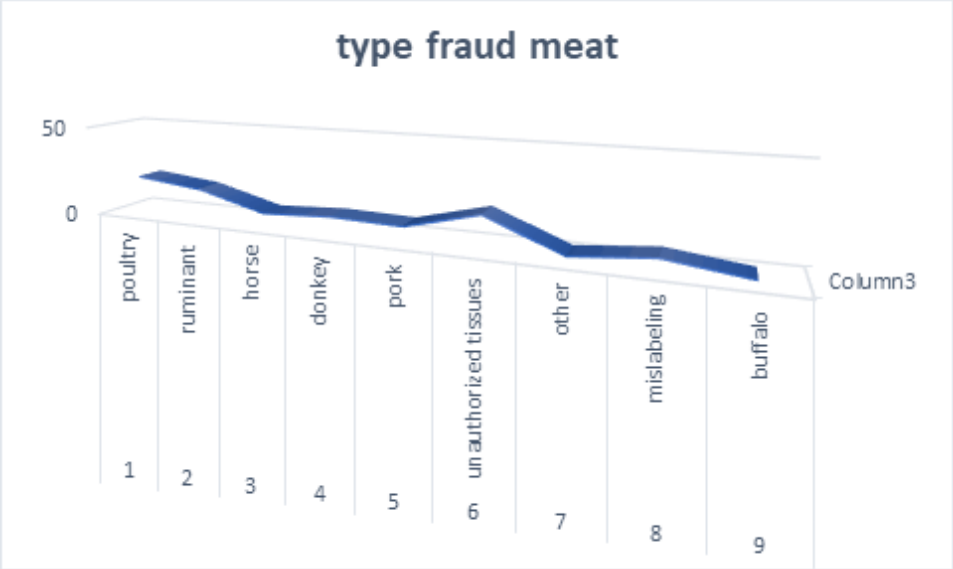

Figure 3. Number of fraud investigation articles

honest and accurate food labeling is essential to ensure consumer safety and food selection (12).

There is a requirement in meat products to specify the amount of each ingredient providing the nutrient, which is known as a Quantitative Declaration ((QUID) Quantitative Declaration). There is a requirement in meat products to specify the amount of each ingredient providing the nutrient, which is known as a Quantitative Declaration. (9). So it implies that each animal in the merchandise is depicted and determined separately. Furthermore, mechanically recycled meat ((MRM (mechanically recycled meat)and other components, such as the liver, lung, heart, or tongue, are not considered meat and must be separated (2).

A variety of 105 distinct meat sandwich items (Kufta, Havashi, and Shawarma sandwiches, 35 sandwiches of each type of product were collected in 2016 and from New Valley City of various sorts) was reviewed. A scanning electron microscope was used to detect meat theft by analyzing scanning and light. Select half of every group's samples for optical and histochemical microscopic inspection, and the remaining samples for electron microscopic investigation. Hematoxylin and eosin, PAS, trichrome, Garrett and Crossman, bromophenol blue, and ATPase were used to stain these sections (7).

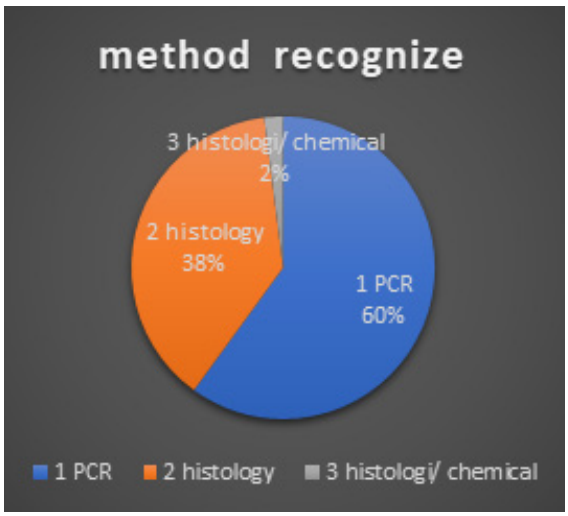

Figure 4. Method of fraud investigation articles

Histological examination indicated that skeletal muscle contains a variety of tissues, including connective tissue. lungs, ruminant stomach, enormous elastic blood vessels, cardiovascular system, adipose tissue, cartilage (hyaline and white), spongy bone, lymphoid system (spleen), plant material, mostly on sand particles Embryonic tissue in Hawawshi meat with flying muscle fiber (shrinkage) relative to light might be suspected using the enzyme ATPase Staining (rapid shrinkage). The discovery of muscle fibers in the study points to histology as a possible method of improving the quality of market meat sandwiches (7).

The identification of species in meat products is important to ensure the health of consumers. PCR amplification and species-based- Dedicated primers were used to identify horses, donkeys, pigs, and other ruminants in their raw form, and meat products. Processed: Oligo nucleotid primers were designed and patented for amplification of species-specific mitochondrial DNA sequences of each species, and samples were prepared from binary meat mixtures.

The findings revealed that the meat kinds in all chemicals were precisely determined multiplex - (PCR (polymerase chain reaction)), This product's

sensitivity was 0.001 ng, making it available to you and acceptable for usage in industrial meat products. Based on the results, the least volume of fraud was found in chicken products compared to other meat products (20). The results showed that the types of meat in all compounds were precisely determined multiplex. On 12S rRNA chicken mitochondrial genes, dedicated primers are created. On DNA isolated from 150 sausage samples, conventional PCR and SYBR Green RT-PCR were recruited. Results The presence of mislabeled chicken in sausages was discovered to be 84%, with Q-PCR technology able to reduce the load, detecting 10% to 50% chicken in products. Your method's recognition limit could be Meat authorities commonly use this method to control the quality of meat products (9). Specific analysis methodologies, sensitivity, and dependability are necessary for detecting counterfeit chemicals in food products. Some methods have defined reasons for their placement, whilst others do finger printing across the sample without a specific aim. The goal of this study is to give an overview of both targeted and non-targeted approaches developed in previous studies that focused on food quality, especially beef authentication (2).

Consumption of food from pig sources is strictly forbidden in Islam. Gelatin, taken mostly from beef and pork sources, it has many uses in food and medicine Industries to ensure the compliance of food products with solvent regulation, valid and reliable development Analytical methods are much needed. In this study, a specific polymerase chain reaction is specific Method (PCR) using mitochondrial DNA protected region (cytochrome b gene) for study- Eat the solvent origin of gelatin. After separation of DNA from gelatin powders of specified origin, Ventional PCR was performed using a specific zinc type primer on the extracted DNA. Boosted Expected PCR products of 212 and 271 DNA structure were observed for pig and bovine gelatin, respectively. Zinc sensitivity method for binary gelatin mixtures containing 0.1%, 1%, 10% and 100% (w / w) pork gelatin in cow gelatin and vice versa. If more DNA is destroyed Due to the intense processing of gelatin production, the minimum level was 0.1% by weight on the weight of both pigs and bovine gelatin was detected. In addition, eight labeled foods containing cow gelatin and Eight capsule shells were subjected to PCR. The results showed that all samples were present Bovine gelatin, and the absence of porcine gelatin were confirmed. This method is very original It is useful to check that gelatin and gelatin-containing foods are derived from solutes (43). Meat cheating is a worldwide problem Violates diet, health and religious care. Bottom Measuring the prevalence of meat scams is difficult and used Various methods have been used for this topic.

The histometric analysis demonstrated that additive bone, especially in mincemeat kebab, and skin texture did not differ significantly from the actual result in adulteration detection (6).

The detection of porcine DNA in meat extracts is critical for the halal certification of meat products. To address this issue, the creation of a true green SYBR was effective for the pig PCR method. Successful DNA isolation from meat samples had been proven to be deleterious when using particular primers for porcine mitochondrial DNA. The research indicated that green SYBR real-time PCR, could be considered a reliable method for meat solvent authenticity (4).

Conclusion

In conclusion, this study demonstrated that real-time PCR is a reliable method for recognizing fraud in meat products. However, certain improvements are required to develop these approaches. These useful tests and approaches are recommended for quality control companies.

Strict supervision of industrial meat products is necessary for quality assurance for consumers. For this quality assurance, molecular methods for detecting food fraud are highly accurate, and they have the highest detection rate.

Conflicts of interest

The authors declare no competing interests.

Authors' contributions

Drafting of the manuscript and screening the article was done by (Nourozi A). Conception and design was done by (Hashemi M). Critical revision of the manuscript for important intellectual content and double review to minimize bias was conducted by authors (Hashemi M, A. Afshari, Erfani A).

Ethics approval and consent to participate

This is a systematic review article and all ethics approval and consent of used articles was checked.

No aspect of this article was related to laboratory animals, special human illnesses, and/or the use of people's information.

Consent for publication

Our work did not include any personal data ("Not applicable").

Availability of data and materials

All data from this study are included in the published article and its supplementary files.

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