Meat value chain losses in Iran

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Abstract

To stop hunger reducing food losses is a potential movement towards saving food. A large portion of these losses could be avoided and reduced through the improved food chain in many countries. Raising awareness on how and where food losses occur will help recovering foods such as meat by identifying solutions and convincing people to implement those solutions. This, in turn, will lead to private and public efforts to recover meat that might be otherwise wasted. After highlighting the importance of food saving benefits and relevant statistics, this paper explains the possible ways to reduce meat loss and waste in abattoirs and presents a framework for prevention according to the estimates of meat losses in Iran meat supply. The current article answers the questions of where do we have the meat loss in Iran and what approaches are most successful in reducing losses in the meat industry. The national average loss and waste in meat production are about 300 000 metric tonnes (about 15 %). Many segments and players are involved with this huge amount of losses in the meat value chain, a large portion of these losses could be avoided and reduced by about 25 % through using by-products with the mechanization of design and manufacturing. The production amount of mechanically deboned meat (MDM) is 105,091,000 kg, concluding the major waste (88.33 %) of total poultry losses. Ensuring appropriate actions by exploiting the full potential of engaged Iranian associations and institutes is considered to reduce the losses.

Keywords: Loss, waste, meat value chain, meat consumption, mechanically deboned meat

Introduction

The food wastage contributes to 30 % of world's agricultural land area (1.4 billion hectares of land), in which 78 % of the land occupation of food wastage contributes to meat and milk wastage (Sawaya, 2017). In Iran, the livestock is mainly produced in moisture regions and the big area of concentration is near the Caspian Sea with higher rates of rainfall. The Iran total surface area which suites for farmland is about 1/3, but is restricted by lack of water and poor soil, resulting in the cultivation of 12% total land area (Najafi et al., 2009). In 2016, the global production of carcass weight was 330 million tonnes, in which the EU accounted for approximately 15 % of total production. Of 534 million tonnes of feed consumed by livestock husbandry, 70 million tonnes of live animals were processed to 35 million tonnes of meat (Aan den Toorn et al., 2018). In Iran, the production of single-propose animals (product-species) is preferred to multi-propose types and there has been a raised trend for industrial commercial production than grazing or mixed farming systems. The diet changes, population growth, and raised meat consumption enforce higher needs for meat production. In the EU markets including UK, Sweden, Denmark, Germany, and the Netherlands, there has been a great trend for alternative protein products (Aan den Toorn et al., 2018). In Iran, livestock provides employment for small-scale stakeholders and is in line with providing jobs and new sources of income. Livestock production as the backbone of the Iran agricultural economy employs 70 % of the agricultural labor force (Rezvanfar et al., 2009). Approximately 40% of the agricultural gross domestic product is allocated for the livestock sector, this sector accounts for 1.3 billion of job opportunities and offers one-third of protein's intake (Steinfeld et al., 2006). The agricultural sector which comprises the livestock subsector contributes 11 percent of the gross domestic product (GDP) and employs a third of the labor force in Iran, which is about 328,000 people or 16.1% of the entire industry sector’s workforce (Noorivandi, 2013). Currently, there is an increasing trend to eat meat and seafood-based diets in developing countries. By 2020, developed countries produce 63% of world meat (Delgado et al., 2003) and consume 107 million metric tonnes (36 kg per capita) more meat than they did in 1996/1998 (25 kg per capita) (Delgado, 2003). In Iran, per capita, meat consumption is around 35.5 kg/year, comprising of 12.5 kg of red meat and 23 kg of poultry meat. Given that in many developed countries a large amount of meat losses occur due to defects in supply organization, packaging and standardization of expiration dates, in Iran, a major amount of meat is distributed and sold in meat markets, “Gasabi”, which present non-packaged fresh meat without further processing and labelling. To the best of our knowledge, there is no study about national meat loss and waste outlook in Iran. In this article, sources of loss and waste in meat value chain including slaughterhouses as well as possible ways to reduce meat loss and waste is mentioned. Moreover, this article presents a framework for the prevention of meat loss and waste according to the estimates of meat loss and waste in the Iranian meat supply.

Materials and Methods

To gather information on meat loss and waste, training workshops on "Meat value chain losses in Iran" was launched by the Ministry of Jihad-e-Agriculture, Food and Agriculture Organization of United Nations and in collaboration with the National Nutrition and Food Technology Research Institute. The main objective of workshops was to familiarize the involved professionals with the importance of saving food by reducing losses; how to reduce waste and loss in meat production and assist the meat industry in saving food together with money. The work steps done for the gathering of information were as follow:

Four workshops were held for assessment, monitor, and analysis of the meat value chain in four important provinces.

A meat value chain report was developed of the sector weakness, inefficiencies, and opportunities to build capacity to improve the meat value chain .

A technical curriculum was obtained for a 4 days' workshop for preventing waste and loss in the meat chain.

The training materials were prepared by focus on management strategies for improvements in meat value chain in terms of quality and safety.

A comprehensive technical workshop was held for the training of 30 trainers, in 4 days base on needs assessment for prevention meat losses in meat value chain stakeholders and technical persons in Karaj, Iran, Ministry of Jihad-Agriculture.

More than 600 persons have been trained in a series of provincial workshops for preventing waste in the meat value chain.

In Iran, conducting 17 workshops on preventing waste in the meat value chain ensured the transfer of the acquired knowledge to stakeholders. These serial workshops helped the implementation of effective control of loss in the meat industry. Finally, we divided participants into 4 groups to explore the three issues in Iran as (1) how does the industry play a role in waste and loss of food? (2) What approaches are most successful to reduce loss in meat industry? (3) Where do we have the loss? Participants reported their implications at the end of the workshop and later by noting down workshop reports. Hence, the relevant information and literature on the meant value chain and loss were obtained from participants from various government departments, academics, research and development institutions, ministries, and NGOs.

Results and Discussion

Meat value chain losses

Figure 1 shows the results of meat loss and waste estimates in meat supply in Iran. Our investigation indicates that 300 000 tonnes of meats are lost and wasted in Iran. In Iran, the amount of meat loss and waste is 15 % and is less than the global rate. Globally, 20 percent of meat for human consumption is lost and wasted in the meat value chain. This amount equals 1.3 billion tonnes or 190 kilograms/person of food which equals to 750US$ billion to 1.0 trillion of economic cost, whereas 870 million people go hunger (Gustavsson et al., 2011). Of total global food loss and waste (32 %) which is equal to 24 % of all food calories produced, only 7 % is contributed to meat, however, reducing the meat loss and waste has an important role in economic costs and environment (Sawaya, 2017). Cold storage capacity in Iran is about 20 kg per capita per year, which is a little less than France, the Netherlands, and Brazil (Gustavsson et al., 2011). In most provinces of Iran, there are good cold storage facilities; however, there might be some shortage in some deprived regions. In developing countries, lack of proper storage facilities is a major cause of post-harvest losses (Gustavsson et al., 2011).

Please insert Figure 1 here.

Abattoir meat losses

Transportation and Distribution

Mortality rates of animals during transport significantly differed due to species, travel distances, and welfare levels. For example, fattened cattle are more resistant to transport stress compared to calves and dairy cows (Malena et al., 2007). The reasons for Iran meat loss and waste in slaughterhouses as well their solutions are summarized in Table 1. The reasons to meat loss and waste including empty shackle or missed assignment, excessive or unnecessary trimming, maladjusted equipment, etc. can be prevented through appropriate actions. As shown in Table 1, due to improper technical practices a part of meat and meat products could go out of the value chain. In brief, the meat loss and waste occur due to improper condition of machines, poor management, weak work system, unqualified or inexperienced workers, defective materials, and methods of production. Applying hygienic and technical principles in meat processing reduces meat losses and wastes. All livestock should be insensible by mechanical (compression stunner) electrical and chemical methods to pain before being hung and stuck for bleeding. In Iran, a major amount of meat is distributed and sold in meat markets, "Gasabi", which presents non-packaged meat. Meat loss among these vendors is higher than other parts of the meat chain in Iran. The fresh-cut of meat products are tending to discoloration, spoiling and dehydration due to damaged and exposed tissues and lack of protective cover.

Please insert Table 1 here

The number of distribution centers is listed in Table 2.

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Inspection and microbial losses

In Iran, veterinarian inspectors evaluate livestock before, during and after processing and approved meat receives a stamp. If the carcasses possess the presence of specified risk material (SRM), fecal, milk contamination or other pathological condition, the carcass is retained and reworked or condemned and deemed inappropriate for use as a food product (Scanga, 2005). SRM such as the spinal cord and brain tissues that are considered to possibly contain bovine spongiform encephalopathy (BSE) infectivity are banned for human consumption. Inevitable meat losses related to abattoir condemnation are most attributed to parasites infections. (Borji and Parandeh, 2010) reported parasites as responsible for nearly 420 dollars of lost value due to carcass condemnation. *Echinococcus granulosus* and *Dicrocoelium dendriticum* contributed to approximately 52 and 30 percent of condemnations, respectively that are not recoverable for human consumption. This is in contrast with pre-weaning lamb losses that most happen in first 15 days due to non-parasitic disease mainly pneumonia followed by malnutrition (Mandal et al., 2007). On the other hand, a small portion of meat is usually trimmed due to quality defects that can be prevented.

The main microbial hazards associated with livestock slaughter should be considered including *Salmonella enterica*, *E. coli* O157:H7, Campylobacter spp., Listeria spp. and *Yersinia enterocolitica* and, also the prion agents for application of by-products in different industries (Hosseini et al., 2004).

Over the last decades, meat safety scares such as bovine spongiform encephalopathy (BSE) and foot and mouth disease (FMD) outbreaks have had significant short-term and long-term impacts on price and consumption of meat products (Lindgreen and Hingley, 2003). Consumers show temporary reactions to food safety scares immediately after BSE and FMD discoveries. Therefore, strategies concerning educating consumers and differentiating products should be taken to reduce the detrimental effects of consumer overreactions (Saghaiana & Reed, 2007).

By-products

In 2016, 35 million tonnes of meat and 14 million tonnes of by-products were produced by slaughtering of 70 million tonnes of livestock in the EU (Aan den Toorn et al., 2018). In Turkey, the bone and blood wastes were estimated to be 41,121,380 kg and 17,990,604 kg, respectively in 2020 (Kayikci et al., 2019). Of 706.5 kg of bones as animal product, approximately 759 kg of heat and 155 kg of fertiliser can be produced which can reduce the CO_2 emissions by more than 446 tons in 3 months (Bujak, 2015).

Raising awareness on the issue of using a by-product is a part of a comprehensive approach to reduce the loss and to assist the meat industry to comply with saving food. Offal including liver, brain, kidney, heart, and other parts are collected and used for a variety of products such as (1) Bones and skin for animal feed, gelatin, button, piano keys, glycerin, cellophane tape, adhesives, dice, and shampoo, (2) Collagen and bone for plastic surgery, ice cream, and pharmaceutical products, (3) Tissues, hormones and fats for soap, medicine, wax, tire, antifreeze, hair conditioner, solvents, chewing gum, oleomargarine, and candle, (4) Wool for Lanolin, (5) Hide hair and pelts for leather, sports equipment, clothing, saddles, hide glue, textile, paint, luggage, footwear, and upholstery, (6) Intestine for sausage casings, instrument strings, surgical sutures and tennis racquet strings (Ockerman et al., 2017; ur Rahman et al., 2014; Prieto and García-López, 2014; Leoci, 2014).

Nutritional and quality point of view

Losses in quality might have an impact on the safety of the product, consumers' acceptability, and its nutritional value (Kader and Rolle, 2004). As stated in Figure 2, one of the critical places for the loss to happen is in a slaughterhouse, where the rigor mortis is induced at inappropriate moisture and temperature (Hannula and Puolanne, 2004). In normal rigor mortis, lactic acid accumulation results in pH reduction and it is followed by shortening and changes in the water holding capacity (WHC), color and flavor. Poor WHC results in high drip and purge loss and this factor is of significant industry concern (Huff-Lonergan and Lonergan, 2005). Physical/biochemical factors in the muscle that affect water-holding capacity are: net charge effect, genetic factors, steric effects, and leaky' membranes (Pearce et al., 2011). As pH decreases during post mortem, the meat color becomes pale. The drip losses occur by pH changes to an ultimate value around 5.4 through fall in WHC of proteins in isoelectric point (Figure 2). The extent of the cooking loss is influenced by quality and cooking conditions. Low pH value followed by low WHC results in a higher amount of cooking losses (Aaslyng et al., 2003). To reduce meat loss it is important to control abnormal rigor, meat discoloration, and both protein and lipid oxidations (Naseri et al., 2010; Afshari et al., 2017; Afshari et al., 2015). In abnormal rigor mortis, meats are lost due to quality changes in the forms of dark firm dry (DFD), pale soft exudative (PSE), cold shortening, thaw, and heat rigor (Lesiów and Kijowski, 2003; Adzitey and Nurul, 2011; Swatland, 2002). Ruminant products such as milk and meat are important and readily available sources of polyunsaturated fatty acids (PUFA) and conjugated linoleic acid (Raes et al., 2004). Diets containing higher contents of alpha-linolenic acid and lipids rich in PUFA result in increased contents of the same fatty acids in beef muscle or tissue and meat, respectively (Vargas-Bello-Pérez and

Garnsworthy, 2013; Vargas-Bello-Pérez and Larraín, 2017). Changing animal feed to grass improves color shelf life because of vitamin E (Scollan et al., 2006). Usually, cardiovascular diseases are linked to fatty acids available in red meat. However, some epidemiological studies totally ignore the connection between lipids and cardiovascular diseases (Siri-Tarino et al., 2010). Red meat contains L-carnitine. L-carnitine converts to trimethylamine followed by trimethylamine oxide. The latter two compounds are responsible for reduced reverse transport of cholesterol from tissues to the liver that is linked with atherosclerosis (Koeth et al., 2013). However, the quality of meat and meat products can also, in order to mitigate the losses. In conclusion, to reduce meat loss it is important to control abnormal rigor mortis, meat discoloration, and oxidation.

Please insert Figure 2 here.

Climate change perspective

In Iran, the drought has led to substantial consequences on livestock feed and production, affecting over 50 percent of the country's total population and about 2.5 billion USD of livestock sector losses (Ghaffari, 2010). In Iran, Annually, 600 thousand hectares of farmland are destroyed and 1.65 million hectares are added to deserts (Chizari et al., 2003). This results in the cultivation of only 12% of the total land area (Najafi et al., 2009). A large amount of freshwater, agricultural land, and fertilizers are allocated to compensate for the food wastes and losses (Kummu et al., 2012). One of the biggest problems facing most countries in the future is related to climate change. Food loss and waste (FLW) is a major contributor to climate changes. FLW accounts for around 8 % of total global greenhouse gas emissions (about 3.300-5600 million metric tonnes), which arises from the land, livestock and energy inputs needed in food systems as well as from waste disposal (Lipinski et al., 2013b). Although in comparison to cereals with 30 % loss of production or root crops with 40-50 % production loss, meat loss (20 %) is not a high amount, but the meat share for carbon print is 21 % and meat waste has the highest impact on greenhouse emissions (Sawaya, 2017). Making efforts to avoid meat waste and improve the use of resources are of important solutions to meats availability without any extra agricultural production (Hodges et al., 2011). Meat loss and waste among these vendors are higher than other parts of the meat chain in Iran. Therefore, the importance of presenting relevant experiences acquired in loss assessments and sharing further information on meat loss reduction is highlighted by many Iranian stakeholders in order to comply with saving foods. In Iran's agricultural sector, more than 90% of the total water resources are consumed for irrigating farmlands (Nabizadeh et al., 2018). The highest Iran livestock production is associated with small ruminants (63%) with approximately 52 million sheep with 27 breeds (Kamalzadeh and Aouladrabiei, 2009). The current state of Iranian livestock production and capacity is shown in Table 3.

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In contrary to the Iranian livestock production, the cattle contributes to 88 % of total Turkey red meat production (3602115 tonnes in 2018), which may be due to its higher economic value and milk production compared to small ruminants such as sheep and goat (Kayikci et al., 2019). Livestock farming causes further environmental problems including greenhouse gas (GHG) emissions and global warming (Veysset et al., 2010). A chicken product contributes less to GHG emissions and generates less CO_2 equivalent per kilogram of food in comparison to cattle or pig (Michaelowa and Dransfeld, 2008; Birisci and McGarvey, 2016). The livestock sector accounts for 18, 80, and 70% of GHG emissions, the use of agricultural land, and grazing lands, respectively (Stehfest et al., 2013).

Strategies and solution to reduce food loss and waste

Policy level

To save food, all stakeholders, chain actors, support organizations needed for meaningful results should take part. Policymakers and stakeholders are investigating ways to eliminate food waste across the supply chain. In 2015, the size of the meat market was about 1050 million metric tonnes for red meat and 1750 million metric tonnes for chicken meat, totaling about 2800 million metric tonnes for both. In 2016, 12 % of available meat was exported in the EU, which consisted of 64 % swine, 25 % chicken, and 9 % cattle (Aan den Toorn et al., 2018). In 2016, the import quantity was 2 % in the EU. In Iran, meat importation quantity was 120, 230, 110, 60, and 98 (thousand tonnes) during 2011-15. Iran's meat export quantity in 2015 is shown in Table 4.

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The meat importation quantity can be minimized by reducing meat loss and waste. A value chain analysis studied how to terminate waste at intra and intercompany levels. Ten points of action plan released by the red meat industry forum (RMIF) in the United Kingdom. Some of them are (1) Plan schemes in order that farmers can identify how their business can be improved through realizing weaknesses and reducing cost. (2) Attract talented and skilled job seekers to the meat industry and equip abattoirs with tools for better performance. (3) Be in collaboration with retailers and suppliers to get feedback from customers (Simons et al., 2003).

Infrastructure level

There are 391 slaughterhouses in Iran for cattle and sheep. 308 slaughterhouses out of 391 are not mechanized, so potentially there could be meat loss because of lack of technology, or emergency systems. Conversely, almost 96% of the 252 poultry slaughterhouses are well equipped and mechanized. In Iran, there are about 150 active meat processing factories that are well-equipped and approved GMP by the Ministry of Health. There are also 391 cattle and 252 poultry slaughtering and packaging sites which are approved by the veterinary organization. Of the 150 companies which are active in the production of different meat products, it is estimated that 101 units are currently registered as members of Iran Meat Producer's society and Units employment is about 9,000 person. Figure 3 shows the trends of Iranian meat production value and employment by 2006-15.

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Processor level

Livestock slaughterhouses in Iran are not mostly mechanized or partly mechanized, thereby, there could be a potential meat loss due to lack of technology, or recovery systems. The majority of raisings in meat wastes that originate from those by-products and prepared products have not been sold should be organized in order to reduce losses. Processing of meat and meat products contributes to 34000 tonnes of wastes in Denmark, however, some of this waste is inedible and should be converted to by-products (Halloran et al., 2014).

In Iran, the application of by-products is a solution to the major poultry meat waste and losses. For example, in poultry slaughterhouses, the major waste is associated with improper usage of mechanically deboned chicken meats (MDCM). MDCM is a raw material produced by crushing tissues with specific mechanical deboning equipment after the removal of meat. The MDCM is obtained from cheaper parts of the chicken such as the neck, the back, and meat clinging to the bones (Akramzadeh et al., 2020). As a result of the current study, the production amount of mechanically deboned meat is 105,091,000 kg, concluding the major waste (88.33%) of total poultry losses which are shown in Table 5.

Please insert Table 5 here.

Implementation of sanitary conditions during meat processing and production are key points to reduce contamination and assuring the final product is fit for human consumption. Given that there is much information on where meat losses occur, actions should be taken in order to focus stakeholders on possible ways to reduce waste and loss in their meat plants (Kantor et al., 1997). Many segments and players are involved with this huge amount of losses in the meat value chain, a large portion of these losses could be avoided and reduced by about 25% through using by-products with the mechanization of design and manufacturing.

Farmer level

Many programs have been designed regarding agricultural production in order to protect natural resources and eliminate food shortages. The behavior of farmers can affect how calves respond to unloading and transportation. Where farmers have positive behavior, calves show lower stress and fear during loading onto vehicles and the unfamiliar slaughterhouses with negative behavior toward calves have resulted in more traumatic incidents, changes in heart rate, and higher cortisol contents (Lensink et al., 2001). In line with this study, automated farming systems in less human contacted calves have worsened handling by familiar and unfamiliar people (Lensink et al., 2000). Hence, the farmers, processing/distribution centers, retail/food service, and consumers play a role in food safety and must be closely monitored.

Supply level

Of 263 million tonnes of global meat is lost or wasted which is equal to 75 million cows (FAO., 2014). Reducing losses requires development and investments in capacity building and varies by the stage of the supply chain across countries. The major part of meat loss is dedicated to consumption and processing in the region and European countries, respectively (Gustavsson et al., 2011). In Europe and North-America, per capita, food waste by consumers is 95-115 kg/year, whereas in South/Southeast Asia is 6-11 kg/year (Halloran et al., 2014). As estimated in Denmark as a high-income European country, 34 000 tonnes of meat and meat products is wasted and this occurs at retail and consumer level (Halloran et al., 2014). But, in Iran, the food losses occur at storage, transport, and processing level. As shown in Table 6, the Iran consumption level of ham and sausages is less than in other countries such as the USA with an estimate of seven billion hot dogs in the summer of 2000 (Essien, 2003). As reported by a British survey, 82 % of consumers do not consider the breakfast complete without sausage consumption. The sausage consumption was estimated to be 197000 tonnes for total retail of pork and beef sausages in 2007 (Raud, 2017).

Please insert Table 6 here.

The stakeholders should pay special attention to the relevance of chemical, microbial, and physical causes of meat losses. The fresh-cut of meat products are tending to discoloration, spoiling and dehydration due to damaged and exposed tissues and lack of protective cover. Raising awareness on how and where meat losses occur will help to recover meat that is otherwise wasted.

The existence of relevant information on date labeling might be misunderstood by consumers that the food approaching the label date is unsafe or disqualified. This perception leads to excess inessential wastes of food by consumers. Value-based labels indicate the quality and safety of meat and meat products from the consumer's point of view (Schröder and McEachern, 2004).

An open dating system ensures consumers about the freshness of the product and reduces unnecessary food wastes. The reduction of food waste by an open dating system might be due to the prevention of sorting products by dates on supermarket shelves. Sorting food products causes that consumers buy the freshest product which results in food wastes of the oldest product that are still suitable for consumption (Labuza and Szybist, 1999). Buying excess food products due to discounts, buying for a specific recipe or occasion, and unknowing how much they need can result in food wastes (Graham-Rowe et al., 2014).

Efforts should be taken to influence the shopping routines of purchasing food (Stefan et al., 2013). It is suggested to determine the uniform format for sell-by dates as a mandatory law for perishable foods such as meat. Definitions and conceptions for a better understanding of consumers are published (Nist, 2013). "Best before" and "use by" dates and other concepts labeled on food products should be well defined to avoid unnecessary food discards for safety or quality concerns (Wilson et al., 2017). Quality and quantity changes in fresh products before the expiration date have led researches to optimize the price and replenishment time due to quality changes and price sensitivity of demand. When rates of deterioration are large, prices and orders can be increased in order to enhance the profit (Qin et al., 2014).

Consumer level

Food waste occurs in consumer level and producer level in an approximate ratio of 2:1 (Buzby et al., 2014). As shown in Figure 1, of 15% of total meat loss and waste, 0.5 % and 2-3 % of meat is wasted at market/retail and consumption level, respectively. In the EU, 14.5 % of meat is wasted at the retail and consumption level (Aan den Toorn et al., 2018). In the USA, 22 % meat loss and waste occur at the retail and consumer stage (Buzby et al., 2014). Measuring meat loss at the consumer level seems inaccurate when it reaches to households. Behavior changes in discarding meat could occur in the survey period, and excess meats are fed to pets and animals. In this case, those surveys conducted in restaurants detail plate waste at the consumer level.

Many studies have documented the possible ways to prevent waste at the consumer level rather than earlier stages (Amani et al., 2015). A solution to feed more people is changing diet from meat and meat products to grains and expanding aquatic productions (Godfray et al., 2010). Plate waste as a non-ethical event rises in restaurants compared to households due to over servings. Therefore, leftover foods can be collected and consumed later or recovered and donated rather than being discarded. Retailers can distribute foods to charities and be further delivered to homeless people. In this way, food poverty, as well as food waste, is reduced, and poor people can eat luxury foods such as meat.

Unfit foods for consumption are usually discarded in a landfill or diverted to the animal sanctuary (Alexander and Smaje, 2008). Leftovers can be even composted aerobically in bins in combination with desired microorganisms and cooking process. However, it has not been the best way to use food wastes due to the long time and severe cares needed for maturation of composts (Shahudin et al., 2011). The type and ratio of leftovers differ greatly. In restaurants, meat is rarely wasted compared to potatoes or rice (Engström and Carlsson-Kanyama, 2004). On the contrary, a higher rate of wasted meat than wasted potato has been reported from households (Engström and Carlsson-Kanyama, 2004). Household waste is most related to over preparation of food. The amount of waste differs between household in terms of family income, size, habits, beliefs, tastes, and type of lifestyle. Food waste significantly rises in convenience lifestyles (Parizeau et al., 2015). Apart from preferences in convenience lifestyles, changes in meat-eating patterns and asking for organic foods may play a role in the formation of meat waste and losses.

Conclusion

The meat has a high "diet impact ratio", i.e. the meat consumption patterns show severe consequences for environmental sustainability. One of the biggest problems facing most countries in the future is related to climate change. The hunger situation further worsens when the susceptible countries are not prepared to cope with climate disasters including loss of lives resulted from lack of food in advance. There has been a unanimous consensus that the loss of food and lack of food are interlinked and extreme hunger can be eradicated by tackling food waste and loss mainly attributed to pre and post-harvest losses. In conclusion, to achieve substantial savings further actions and regulations should be undertaken to familiarize the involved professionals with the basic concepts and principles of the issue. This could be possible by highlighting the role of saving benefits, statistics, and the importance of saving food by reducing loss and developing a meat value chain report of the sector weakness, inefficiencies, and opportunities to build capacity to improve the meat value chain.

Conflict of Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Ethics approval and consent to participate

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Figure legends

Figure 1 Estimates of meat losses in meat supply in Iran

Figure 2 Losses due to post mortem/rigor mortis

Figure 3 Annual production value and employment by meat industry

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746 Table 1. **Reasons and solutions of meat losses in different stages.**

Stage		**Reasons**	**Solutions**	**Reference**
Transportation	Livestock	Fear, fatigue, stress, dehydration, and hunger during transportation and prolonged truckling leads to PSE (pale, soft and exudative) and DFD (dark, firm and dry) meats and quality loss.	Proper handling and loading of livestock. Optimal environmental and vehicle conditions. Avoiding prolonged travel times.	(Knowles et al., 2014; Cockram, 2014; Knowles and Warriss, 2007; Broom, 2008; Weeks, 2014)
	Poultry	Long distances with unsuitable vehicles in poor conditions, heat prostration, overcrowding and dehydration.	Huge fans should rotate to reduce the temperature. Transportation cars should be parked in shadow and sheltered place and animals should be refreshed with water.	

Unloading	Poultry	Bruising and broken bones. Vehicular crowding. Slaughter and processing areas are overcrowded and noisy. Stressful operations, unloaded chickens, glycogen reduction and higher pH prior to slaughter. Chicken with injury, leg/hip breaks or crippled thrown chickens.	Minimize conveyor distance to avoid chicken fall. Avoid roughly manual uploading. Designing waiting salons for animals. Uniformity of birds or adjusted machines between birds. Chicken should not be hung by only one leg. Suspending conditions should be improved to reduce the pain of being stretched by feet.	(Harford, 2014; Weeks, 2014; Smith, 2014; Chao et al., 2014)
	Poultry	Improper electrical immobilization results in blood splash, incomplete bleeding and torturing chickens.	Splashing conditions including voltage and water temperature should be monitored for a better feather removal and avoiding consequences of improper stunning.	

Sticking	Livestock	Sticking severs blood loss: 3-3.5% of live weight and 50% of blood.	This is an unavoidable loss which is necessary for meat quality and to be palatable. Sticking allows maximal blood removal.	(Cockram, 2014; Fernando, 1992)
	Poultry	Cross contamination.	Separate baskets washing area from slaughter.	
Scalding	Poultry	Drowned alive chickens in blood or in scalding hot tunnel. Low standard quality meat. Cross contamination and high bacterial load. Blood loss. Short shelf life.	Reduce the line speed of slaughter to avoid presence of feather in further process. Coordination of carcass flow and production lines so that adequate birds are present to make maximum use of personnel and equipment. Special bleeding rails and channels for collecting blood free from admixture with feather.	(Smith, 2014; Pedersen et al., 2016; Sams and McKee, 2001)

Skinning	Livestock	Cattle are laid in a cradle for mechanical skinning by hide pullers.	The animal should not be in contact with the floor. Hide should be removed such that be folded, preventing cross contamination.	(Small et al., 2005; Tan, 2008)
Evisceration	Livestock	Contamination by faecal and abdominal pathogens, dirty feet and skin.	Pre-evisceration water washes with acetic acid (1.6–2.6 %). Clean butchers tools such as knife and axes and sanitation of carrier, floor and walls frequently.	(Bacon et al., 2000; Wagude, 2007)
	Poultry	Cross contamination. Skin tears in the thigh and breast regions, broken wing, leg and rib bones. Loss in offal and defects in feet such as dark pigmentation or food pad lesions. Rework.	Picking machines should not be adjusted too close to the bird. Do not manually transfer birds to evisceration line. Washing and avoiding intestine cut resulting in fecal and bacterial contamination	

Chilling	Livestock	Weight loss. Toughening.	Monitor temperature and moisture. Avoid immediate chilling after slaughter to prevent toughening.	(Devine et al., 1999; Yu et al., 2005; Sams and McKee, 2001)
	Poultry	Washing and chilling effects. Dark color which is usually taken as a sign of thawed and slow refrozen poultry meat. High bacterial load.	Regulate water absorption by time and temperature. Use limited amount of chlorine as an antimicrobial agent in product contact water such as chiller.	
Packaging	Poultry	Toughening. Aging. Weight loss or spoilage.	Proper aging for at least 4 hours after death or 3 hours after exiting the chiller under refrigeration. Using oxygen scavengers, moisture absorbers, temperature compensating, antimicrobial packaging, aseptic packaging and sous vide.	(Rouger et al., 2017; Zhu et al., 2014)

Table 2. **Number of distribution centers for different kinds of meat**

Super butchers (ghasabi)	**Fish and chicken distribution centers**	**Chicken distribution centers**	**Major chicken distribution centers**	**Meat and by products distribution centers**	**meat distribution centers**	**Major red meat distribution centers**
7515	8.296	20.549	921	9.306	18.929	434

Table 3. **Iranian livestock industry**

	Annual production (tonnes)	Average carcass weight (kilogram)	Annual production capacity (tonnes)	Daily production capacity (tonnes)
Bovine	495000	150	3300000	11000
Sheep	522000	20	26100000	87000
Total	1017000			

Table 4. **Meat export quantity in Iran**

	Chicken	Ostrich	Sheep	Cow	Camel	Total Export quantity
Weight (kg)	24,605,000	60,000	12,330,000	555,000	139,800	37,689,800

Table 5. **Estimates of total meat loss in Iran**

	Potential production capacity of mechanically deboned chicken meat	**Loss in chicken slaughterhouse**	**Loss in production, distribution and storage**	**Loss in livestock slaughterhouse**
Weigh/Kg	105.091.000	7.013.476	4.887.500	1.975.486
Total/tonnes	118.967 Meat loss and MDM	13.876 Meat loss		
Loss/%	88.33	11.67		

Table 6. **Sausage and ham consumption per capita in Iran**

Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Sausage and ham consumption per capita (Kg)	3.5	3.8	4.0	4.3	4.9	5.0	5.1	4.5	5.0	5.2

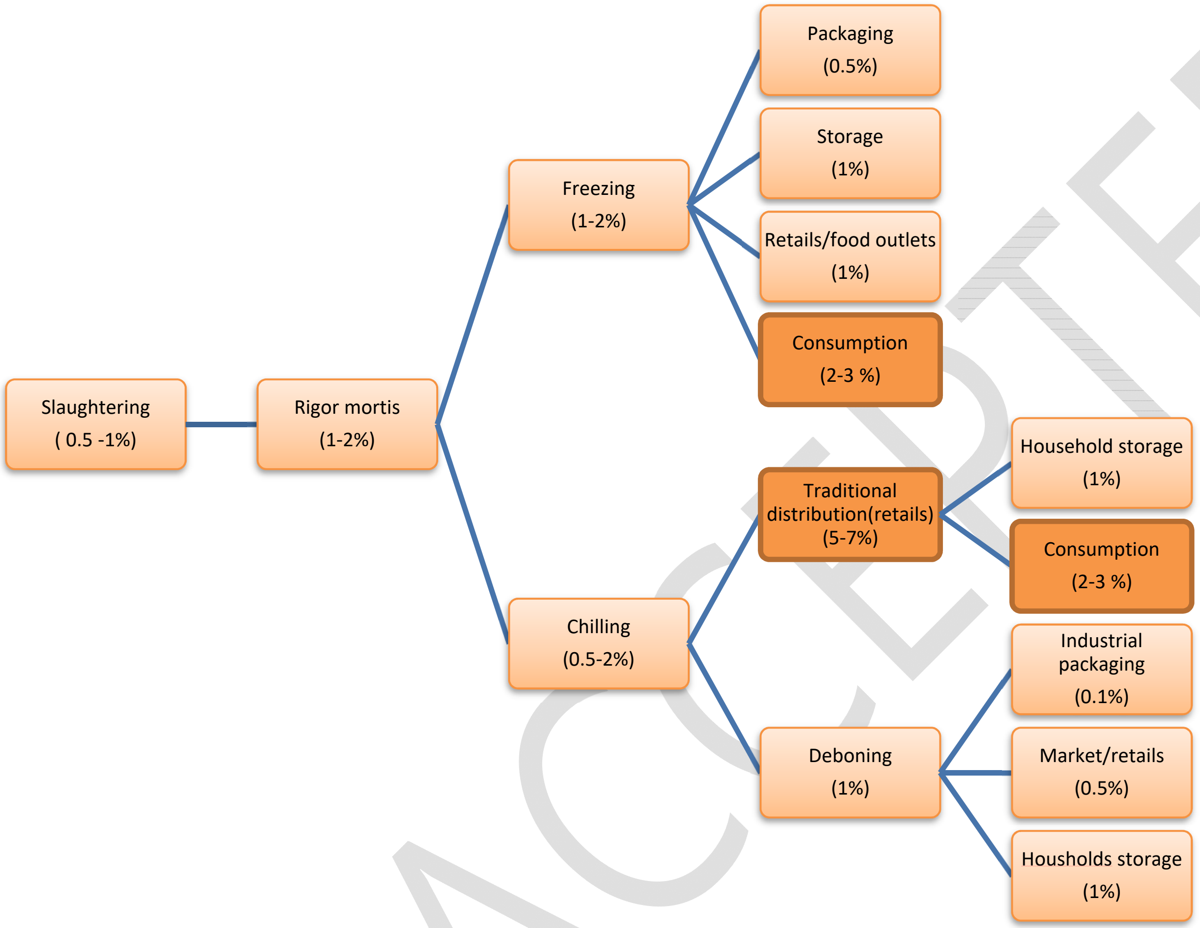

Fig. 1 Estimates of meat losses in meat supply in Iran

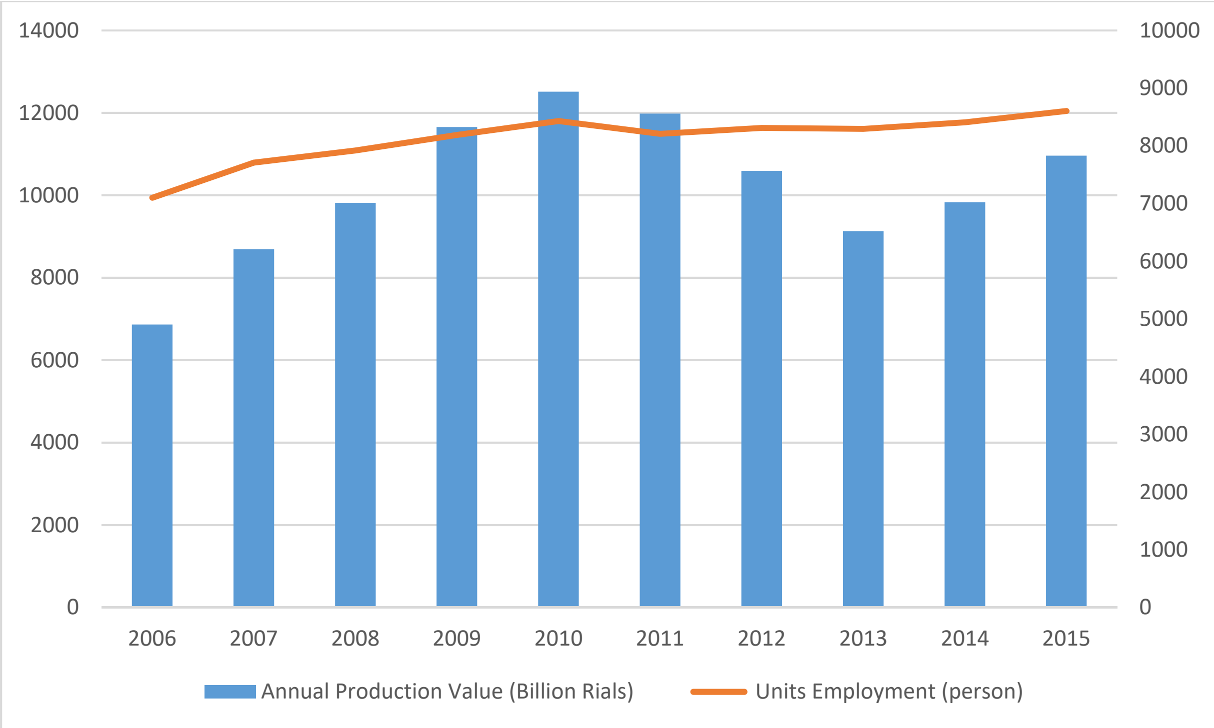

Fig. 2 Annual production value and employment by meat industry

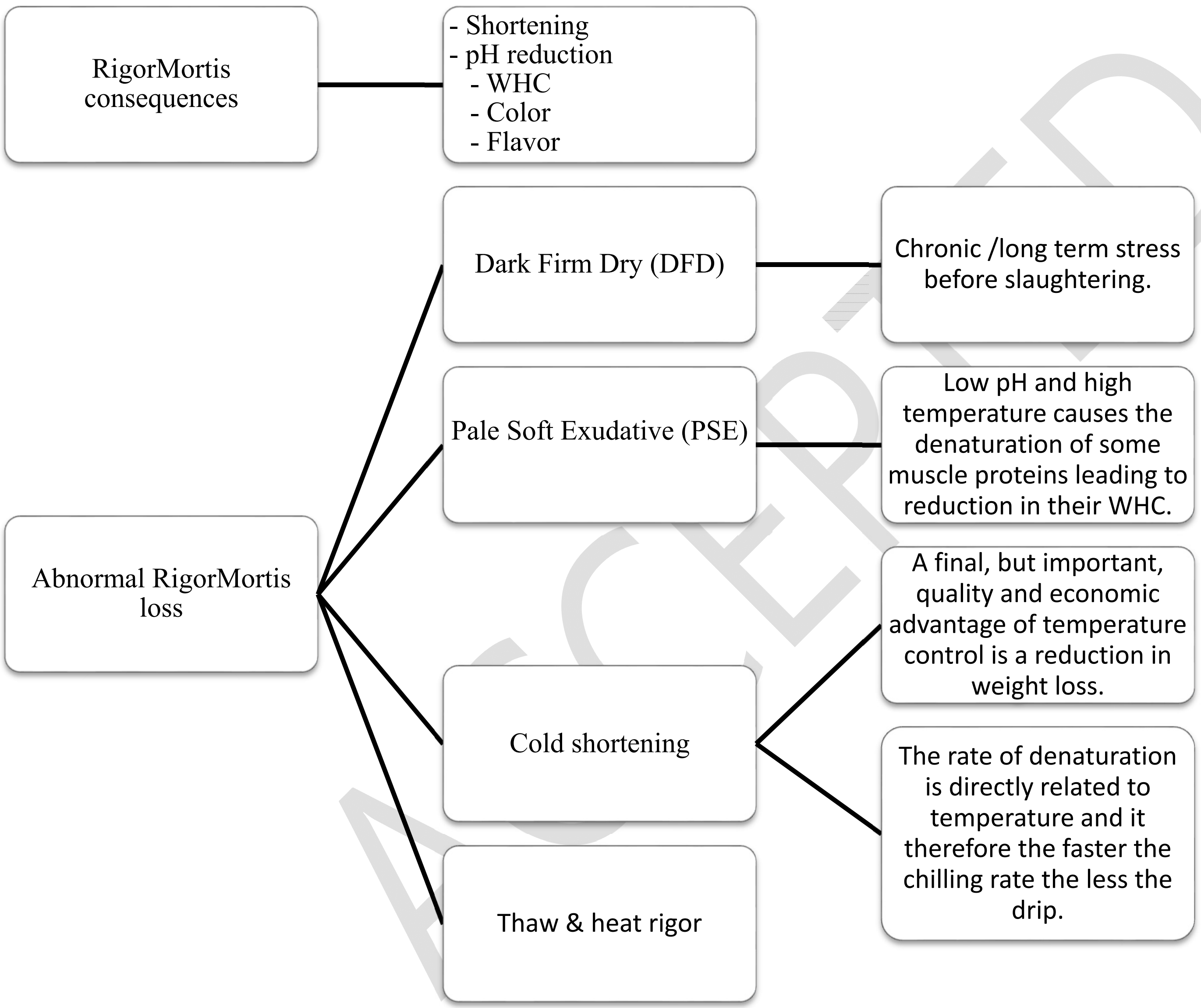
RigorMortis consequences
- Shortening
- pH reduction
- WHC
- Color
- Flavor
Abnormal RigorMortis loss
Dark Firm Dry (DFD)
Chronic /long term stress before slaughtering.
Pale Soft Exudative (PSE)
Low pH and high temperature causes the denaturation of some muscle proteins leading to reduction in their WHC.
Cold shortening
A final, but important, quality and economic advantage of temperature control is a reduction in weight loss.
The rate of denaturation is directly related to temperature and it therefore the faster the chilling rate the less the drip.
Thaw & heat rigor

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Fig. 3 Losses due to post mortem/rigor mortis.