Review On Abattoir Hygiene And Microbial Load Of Meat

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ABSTRACT: Food safety is an issue of paramount concern and of public health importance particularly when the environment in which the food handled is contaminated. Food borne diseases are diseases resulting from ingestion of bacteria, toxins and also cells produced by microorganisms present in food. Meat quality is becoming more important as consumers worldwide and defined by organoleptic evaluation parameters such as tenderness, juiciness, flavor, palatability, color, neatness, pH, water holding capacity, and its proximate composition. The microbial quality and safety of raw meat products can be estimated by the use of indicator microorganisms, including total aerobic plate count, coliform count and Escherichia coli count. Microbial contamination of meat and meat products must not surpass levels which could have negative impacts on the shelf life of meat products and render it unhealthy for human consumption. Food of animal origin tends to deteriorate more rapidly under tropical conditions, thereby becoming an important medium for gastrointestinal infections, inadvertently jeopardizing consumers' health. Sources of contaminations arising from the meat handlers, hides, cutting knives, intestinal contents, chopping boards, containers, meat selling environment and vehicle for transporting carcasses have been reported and weighing scales and wooden boards from meat retail outlets are sources of bacterial contamination, especially *Salmonella*, *E.coli*, *Staphylococcus aureus* and *Shigella species*. Therefore, the modern abattoir hygienic practices, reduced bacterial contamination and risk minimization strategy should be applied along with quality indicators so as to provide safety and hygienic meat in the Abattoir for the society.

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1. INTRODUCTION

1.1. Background

In the developing countries, commercial abattoirs have sophisticated machinery (Gregory, 2005) while most municipal abattoirs have poor handling facilities (Ndou *et al.*, 2011). These differences are thought to have an effect on animal behavior at slaughter and the quality of the product. Slaughtering technology is becoming more important as it has a large influence on meat quality (Swatland, 2000). According to (Kagunyu *et al.*., 2011), in northern Kenya, majority of cattle and other animal slaughtering activities are carried out in the backyard, resulting in poor quality products.

Meat is one of the most nutritious foods that humans can consume, particularly in terms of supplying high quality protein (amino acids), minerals (iron) and essential vitamins like B12, D and K.In Ethiopia, domestic consumption requirements for red meat was arise due to rapidly growing population, increasing urbanization, rising income, increase export of live animal and meat to generate foreign currency (Shapiro *et al*., 2015).

Based on (Kagunyu *et al.*., 2011), cattle and other animals are mainly slaughtered in homesteads during cultural and religious festivals and this, therefore, is scattered and periodic. Slaughter of livestock in rural slaughter slabs is done under very poor conditions. Cattle are mainly slaughtered in poorly equipped slaughter points where the infrastructure is sometimes a slab of concrete, under a tree or using poles for hoisting carcasses. The tools used in these facilities or in homesteads are usually rudimentary and cause damage to the hides during slaughter, resulting in poor prices of the skins (Wayua and Kagunyu, 2008).

In Ethiopia, there are over 300 local slaughterhouses that supply meat for local consumption with different capacities and facilities, however all with low basic hygienic standards (Eshete *et al.*, 2018).

Food safety is an issue of paramount concern and of public health importance particularly when the environment in which the food is handled is heavily contaminated (Soyiri N *et al*., 2008). Raw meat remains an essential and possibly the chief source of pathogenic bacteria in human food-borne infections. There has been difficulty in obtaining food animals free of pathogenic bacteria in spite of decades of control (Wilfred SR and Fairo ZN., 2011).

Meat quality is becoming more important as consumers worldwide are increasingly demanding consistently higher quality meat (Scholtz, 2007). Which is because of beef industry is better in dealing with conversion and processing of live animals to different products and by products (Nebi, 2018). Meat quality can be defined by organoleptic evaluation parameters such as tenderness, juiciness, flavor, palatability, color, neatness (Beriain, 2001), pH, water holding capacity, and its proximate composition (Gusatvesuo *et al.,* 2011).

The microbial quality and safety of raw meat products can be estimated by the use of indicator microorganisms, including total aerobic plate count, *coliform count and Escherichia coli* count (Kim and Yim, 2016).

The microbiological contamination of meat can occur during processing and manipulation, such as skinning, evisceration, storage and distribution at slaughter houses. Fecal matter is a major source of contamination and could reach carcasses through direct deposition, as well as by indirect contact through contaminated equipment, workers, installations and air (Pal, 2007). Healthy animal tissues are normally sterile, but can be contaminated by microorganisms from the exterior of the animal and its intestinal tract during slaughter, dressing and cutting (Akinro AO *et al*., 2009). Microbial contamination of meat and meat products must not surpass levels which could have negative impacts on the shelf life of meat products and render it unhealthy for human consumption. Food of animal origin tends to deteriorate more rapidly under tropical conditions, thereby becoming an important medium for gastrointestinal infections, inadvertently jeopardizing consumers' health (Akinro AO *et al.*, 2009).

Probable sources of contaminations arising from the meat handlers, hides, cutting knives, intestinal contents, chopping boards, containers, meat selling environment and vehicle for transporting carcasses have been reported (Adzitey F *et al*.,2011). Also weighing scales and wooden boards from meat retail outlets are sources of bacterial contamination, especially *Salmonella, E.coli, Staphylococcus aureus* and *Shigella* species (Ali NH *et al*.,2010).

Food borne diseases are diseases resulting from ingestion of bacteria, toxins and also cells produced by microorganisms present in food (Clarences SY *et al*.,2009). The intensity of the signs and symptoms may vary with the amount of contaminated food ingested and susceptibility of the individuals to the toxin. Microbial contamination of meat and products of meat must not extend beyond levels which could seriously affect the shelf life of the product; if it does it renders the meat unwholesome and not fit for human consumption (Fasanmi OG *et al*.,2008). Reduction of risk for human illness associated with raw produce can be better achieved through controlling points of potential contamination in the field, during harvesting, during processing or distribution, or in retail markets, food-service facilities, or the home (Stagnitta PV *et al*.,2006).

In Ethiopia, the consumption of raw meat has associated with cultural practices and widespread raw beef consumption habit that can be a potential source for food borne illnesses (Getaneh *et al.*, 2019). Raw meat is available in open-air local retail shops without appropriate temperature control and purchased by households and served at restaurants as raw, slightly cooked or well cooked (Siddiqui *et al.*, 2006).

1.3. Objectives of the seminar

- To overview the abattoir hygiene.
- To highlight the microbial load of meat.

2. LITERATURE REVIEW

2.1 Abattoir in Ethiopia

An abattoir is defined a place of registered by the controlling authority for hygienic slaughtering, inspection of animals and processing meat product for human consumption (Akpabio *et al.*, 2015).

In Ethiopia, there are over 300 local slaughterhouses that supply meat for local consumption with different capacities and facilities, however all with low basic hygienic standards (Eshetie *et al.*,2018). Although foodborne bacteria have been reported from cattle at slaughterhouses and beef in the retail shops as reviewed by (Abayneh *et al.,* 2014), little information is available concerning beef hygienic handling practices along the beef production and distribution continuum in Ethiopia.

A standard abattoir should have qualified personnel, state of the arts equipment, lairage, adequate and portable water supply, good drainage and efficient sanitation system. In its nature animal source food is easily contaminate. The increasing demand meat is not only quantity wise but also quality wise. The main actors that contribute for meat quality are producers, traders, cooperatives, abattoirs, butchers, processors, and consumers in Ethiopian (Kefyalew, 2011).

2.2. Abattoir Hygiene and Sanitation

In order to uphold the meat demand sanitation of abattoirs and providing quality meat has significant value. Cleaning and sanitation are an integral part of slaughtering and handling of meat and should already be taken into consideration at the planning and construction stage of slaughter facilities. Meat production and storage areas need to be constructed with materials that are readily and thoroughly cleanable. In addition butchers should be trained and aware the sanitary precautions. Meat is potentially subjected to contamination from a range of sources within and outside animal during the slaughter of animal and during its sale. In fact, tissues from healthy animal are sterile however, bacterial pathogens associated with meats can pose risks with food poisoning; and contamination may be associated with the animals themselves, or be introduced to a clean carcass through cross contamination (FSA, 2015).

Contamination during slaughter, dressing and cutting, microorganisms came chiefly from the exterior of the animal mainly from the hide of the animal and the feces and its intestinal tract but that more added from knives, cloths, air, carts and equipment in general (Pal *et al.*, 2013) ; place of slaughter, the environment of the slaughter house (Sofos, 2014); the floor of the retail outlet, the air in the outlet and the vehicle used for the transport of the meat from the slaughter house to the retail outlet act as the external sources for the contamination of the meat (Behandare *et al.,* 2008). On the other hand, foodborne diseases are an important cause of morbidity and mortality in worldwide but the full extent and cost of unsafe food (WHO, 2007-2015).
Contamination also results from poor hygiene practices in small and medium-scale slaughterhouses in Kenya (Carron *et al.*, 2017). The unavailability of gloves and of soap and disposable towels for hand washing, and inadequate cleaning of processing equipment, are common, increasing the risk of carcass contamination and further cross-contamination (Wambui *et al.*, 2017). In addition, (Carron *et al*., 2017) found low government control and enforcement of hygiene standards by meat processors of Nairobi.

Abattoirs are regulated by laws to ensure good standards of hygiene to prevent the spread of disease and to minimize needless animal cruelty (Grandin and Smith, 2000). The methods of slaughtering and handling of carcasses play an important role in product quality and shelf-life of meat and meat products. (Adzitey and Huda, 2012) reported that poor carcass quality reflects in poorer meat quality. Meat quality has been identified as the most critical factor in a highly competitive meat industry in which its profit lies (Robles *et al.*, 2009). Most researchers define it based on conformational and functional qualities (Muchenje *et al.*, 2008). Important technological meat quality attributes include colour, marbling, pH, tenderness, juiciness, and flavour (Muchenje *et al*., 2009). Should these be affected, profitability would also be influenced negatively (Grunert *et al.*, 2004).
According to the World Organization of Animal Health, OIE, the veterinary service of the exporting country has ultimate responsibility for the certification of slaughtered animals (Thomson *et al.,* 2004). But this is still a critical problem in Ethiopia. Most commonly, animals were delivered to the lairage, from different markets to the center of Addis Ababa "Kera"(abattoir) where there was no shelter, which in turn keeps them from sun or heavy rain and where food and water provision depends on the costumer's request without consent of veterinarian. Throughout the slaughter, the animals were observed expressing stress-related behaviors, such as vocalization, head swings, and moving forward. The environment inside the slaughter hall is stressful for farm animals with high volume and lots of activity by humans and animals (Gronvall, 2013).

During slaughter, the use of wet and slippery floors due to a constant water and blood flow was challenging and could be observed as a hygiene problem (Gronvall, 2013). The reported that water in Ethiopia is contaminated with lots of bacteria's and shall not be in contact with the carcass (Gronvall, 2013). Use of water during slaughter can also be a health risk in itself, since wet slaughter has been shown to have a higher risk of letting bacteria's grow in the wet environment on the carcass. To avoid this, slaughter should be done in a dry environment, unfavorable for bacteria's growth. Another hygiene and health problem is step in which the carcass is divided into two, by using an axe and cut directly on the bone marrow. As soon as the bone marrow is touched, the risk of spreading possible Bovine Spongiform. As a result of faulty practice during slaughter, large amounts of bruises could be detected in clotted blood collected as darker areas on the carcass in the back areas, around the upper back and on the hind limbs. The duration of slaughter is imperative in many aspects and can be an important factor for meat quality. Providing a very sharp knife and having competent personnel cutting of the carotid arteries are essential during the slaughter process (Gronvall, 2013).

Post-slaughter carcass handling begins at the abattoir just after exsanguination and continues through to processing of meat, transportation to the market, and finally to consumers (Adzitey and Huda, 2012). Many irreversible quality losses, especially with regard to the hygienic quality, originate from improper slaughtering and carcass handling (FAO, 1990). Faulty meat handling, besides affecting the quality and shelf-life of meat and processed products, may endanger the health of consumers. Therefore, good hygiene during slaughtering and meat handling is of great importance for the quality of the final product because the higher the initial contamination, the faster the meat deterioration, especially under high ambient temperatures (NDA, 2007).

2.2.1. Waste disposal

Waste disposal is considered as a social and political issue all around the globe. Recycling is a major section of waste disposal and could be considered as a valid response to a critically catastrophic environmental crisis (Beal, 2012). More than 90% of municipal solid waste (MSW) in Indian cities, disposed of, unscientifically in open damp and landfilling method (Sharholy, Ahmad *et al.,* 2008).In order to earn sustainable conversion of MSW to useful products, improving recycling process. However, after considering the externalities, recycling could be presented as economically efficient (Lavee, 2007). Affluent countries (mostly developed countries) provide substantial financial and supervisory capitals for recycling waste fractions, such as metals, glass, plastics, and paper. In contrast, for developing economies, recycling is an economic activity in certain sectors of the society(Sanneh; Hu *et al.,* 2011).

Survey results for population estimation of the cyclists in various slums shows that, in 90,000 population area 1500 cyclists are there(Agarwal, Singhmar *et al.*, 2005) and their income is sufficient for food and accommodation for a day. In developed countries or some parts of developing countries, social charity groups are working on recycling in living complex (Council and Hawkins, 2014).

There are different reports on recyclable percentage of municipal solid waste such as 25% (Metin, Eröztürk *et al.*, 2003), 50% (Holloway 1989) and based on a questioner study carried out by (Lavee, 2007) shows that recycling ranges from 10% to 80%. In the light of this, prediction of the recyclable component should be made by studying the percentage composition of each material in MSW, such as plastic, paper, metals and glasses (Saeed, Hassan *et al.*, 2009). Normally, Volume % of recyclable material in MSW is many times higher than weight %. This could be a fundamental reason of importance for recycling in waste disposal especially on the medium and large sized municipalities (Lavee, 2007). Electricity consumption in material recovery facility ranges from 4.7 to 7.8 kWh for each metric ton of solid waste imputes (Pressley, Levis *et al.,* 2015). Consequently, in any site with comparing global price of raw materials and recovery cost, efficiencyof recycling can be calculated. International standard organization (ISO) published two specific environmental standards (Standardization, 2006) for life cycle assessment, which are widely applied for MSW management process(Diaz and Warith, 2006).

2.2.1.1 Solid waste management practices

Sources of solid waste in abattoirs include animal holding areas, slaughterhouse and processing areas, waste treatment plant, unwanted hide or skin pieces and unwanted carcasses and carcass parts. Solid waste should be kept separate from wastewater streams via the use of bucket Burial: Burial is a commonly used option for farmer's traps and skips. This decreases the volumetric andorganic load on the wastewater treatment stream (Adedipe, 2002).At each slaughter house adequate tools should beprovided for de-hiding of the animals and also hides andskins should be immediately transported out of theslaughtering area in a closed wheel barrow or similar otherdevices. In no case, the hides and skins should be spreadon the floor of the slaughtering area for inspection. Legs, bones, hooves etc. should also be removed immediately from the slaughtering area through a spring load floor chute or closed wheel barrow (RMAA, 2010).

Burial

Burial is a commonly used option for farmersalthough, if used for all slaughter waste, valuable nutrients are discarded. The SRM component is suitably contained for long-term on the farm using burial methods. The primary regulatory restrictions relating to burial of SRM are that the landfill must be covered immediately after use, it must have a means of keeping out wild life and records must be kept of the locations and volumes buried (Adedipe, 2002).

Gaseous Waste

The tropical climate enhances the process of degeneration of any tissue material remaining as a waste in the premises of the slaughter houses. Therefore, the slaughter house premises always give a particular stink. In order to avoid this stinking odor proper ventilation of slaughtering halls, washing of the floors with non-poisonous disinfectants and when needed, the use of aerobic deodorants must be provided at each slaughter house. Odor control may be a significant issue, particularly when the abattoir is located near residential areas or in a hot environment (Bello and Oyedemi, 2009). All chemical storage areas and chemical-based odor control equipment must be located on impermeable concrete floors with bending capable of containing 100 per cent of any spillage (GDARD, 2009).

Composting

Composting is natural biological decomposition process where aerobic organisms break down materials in the presence of oxygen, (air). For environmental and sanitation reasons, the composting of should be done in pits or bunkers instead of stacks and heaps. Both structures must be roofed or provided with sheds for security against rain (GDARD, 2009). Many farmers and an estimated 15 to 20 abattoirs are currently composting waste. The cost to compost has been estimated to be approximately one-third the cost of rendering. However, the composting process for full carcasses or significant quantities of waste takes several years is labor intensive and may be ineffective in disposing of hides and bones. The permissible uses of the final product – the compost – are still uncertain and may depend on the nature of the compost. The compost process is effective to break down the waste, kill some pathogens and produce final compost which is relatively safe (Juhasz and Mihelic, 2007).

2.2.2. Liquid waste

During the operations in abattoir, the waste generated is of liquid and solid nature. The liquid waste should be washed away by safe potable and constant supply of fresh water at adequate pressure throughout the premises of slaughtering. Waste water or effluent generated from the abattoir is characterized by the presence of a high concentration of whole blood of slaughtered food animals and suspended particles of semi-digested and undigested feeds within the stomach and intestine of slaughtered and dressed food animals (Coker *et al.*, 2001). The waste water from slaughter house is heavy in pollution, therefore, it should not be allowed to mix with the municipal drain system without treatments like anaerobic treatment which means the effluent is digested in the absence of oxygen in an enclosed digester; aerobic treatment in which oxygen assists bacterial action to reduce biochemical oxygen demand level and filter press for dewatering of the sludge (Massé and Masse, 2000).

2.3 Status of Abattoir Hygiene

B. Akinyera1 *et al*. (2018) in Jos Municipal Abattoir reported that, workers working in the abattoir in most cases in developing countries are untrained and thus, they pay no attention to the hygienic standards and as a result contribute immensely to bacterial contamination. This might be the reason for the meat contamination and with a good number of the respondents in the abattoir (44.1%) don't use disinfectants for washing of floor, 34% make use of Dettol, and 3% make use of ethanol. The floor is a major depositing point of microbes as workers match in and out; packing microbes on the way and depositing them on the floor were the slaughtering takes place. These findings are similar to those reported by Adzitey F *et al*.(2011) that 65% of abattoir workers dressed carcasses on bare floor in the abattoir, 16% dressed carcasses on unclean slaughter slabs and 19% on both the slaughter slabs and bare floor, whereas most of these slaughter floor and slabs were smeared with blood, rumen contents and other wastes from previously dressed animals which increased the risk of contamination of subsequent carcasses.

Adeyemo OK *et al*.(2009) found that animals were often slaughtered and eviscerated on the floor because of the absence of mechanical or manual hoists, a factor which contributed to a major source of contamination. The sanitation and hygiene status of the butcheries was generally poor as most of them did not meet the sanitary requirements for operation as stipulated in (The public health (meat) rules, 2000). Meat hygiene was not properly observed as factors that directly affect it such as discarding wastes; sufficient drainage system and hand washing practices were not adhered to. Additionally, practices such as use of protective wear were low and other requirements such as medical examination of meat handlers and hand washing after toilet was neither consistent nor verifiable.

Table 1. Hygienic condition of abattoir workers

Activity	**Yes**	**No**	**undecided**
Discard Water Waste Close to Abattoir	32	11	0
Wash hands before slaughtering	39	2	2
Sufficient drainage to carryout waste product	12	24	7
Butchers wear protective cloths	16	27	0
Wash hands after toilet	38	3	2
Toilet close to abattoir	12	22	9

(B. Akinyera1 *et al*., 2018)

Table2. Disinfectants used by various respondents to wash floor, hands and containers in the Abattoir

Disinfectant used	Number of respondents (Percentage)
Dettol	15 (34.9%)
Ethanol 3 (7.0%	Ethanol 3 (7.0%)
Formaldehyde	6 (14.0%)
Others	0 (0%)
Don’t use any disinfectant	19 (44.1%

Akinyera *et al*.; AJRAVS, 1(4): 1-9, 2018)

Abebaw *et al*.(2024) in Asossa Abattoir reported that, 67.6% of abattoir workers use of personnel protective equipment (PPE) rarely, while 32.4% of them used PPE always. Majority (50 %) of PPE providers were health officers, while the rest, 17.64%, 3 2.4% of PPE providers were self, and employers respectively. The most 73.5% of abattoirs workers’ wear PPE whereas, 26.5% of workers did not wear. Consistently, Birhanu S and Menda S.(2017) in Gojjam Area, reported that, (18.52%, 81.48%), (31.48%, 68.52%), (7.41%, 92.59%) of abattoir workers had protecting clothes of Apron, hair cover, and boots indicating , ‘as they wear ‘ and ‘did not wear’ respectively.

Abebe B *et al.* (2019) in Bishoftu, Central Ethiopia, stated that, 83.33% of abattoir workers used apron or white coat and 16.67% of workers not used and 33. 33% of hair of butchers were covered and 66.67% did not covered. Similarly, 100%, 71% and 51.6% of overall gumboot, apron and hair coat were protective clothes used for abattoir workers. Muhammed N., and Mulu D.(2021) at Slaughterhouses and Butcher’s Shops in West Hararghe Zone, stated that 57.5% of abattoir workers obtained white coat and head cover and 42.5% of workers not.

Abebaw *et al*., (2023) reported, 64.7% of respondents in abattoir indicated, as there was demarcation between dirty and clean areas in other ways 35.3% of respondents in abattoir said as there was no demarcation between dirty and clean in Slaughter house. In line with this, Muhammed N. and Mulu D. (2021) at Slaughterhouses and Butcher’s Shops in West Hararghe Zone stated that, 83.3% of abattoir workers said as there was demarcation between dirty and clean and 16.7% of workers noted as it was not. So that, in the present study, all slaughterhouses were wiped clean daily, in line with all personnel. Some of the respondents reported the temporary demarcation and availability of meat inspector in slaughterhouses. There was demarcation and meat inspection in the slaughterhouses. In fact, it was reported that many slaughterhouses and slaughter slabs in developing countries are poorly designed and have insufficient slaughter as well as meat inspection amenities. In addition to this, qualified meat inspectors are always in short supply (Komba *et al*., 2012).

Moreover, performing skinning and evisceration on the ground without separating the dirty and clean areas increases the risk of cross contamination during meat processing, putting meat consumers at risk of foodborne illness. .

In Asossa Abattoir, 61.76% of abattoir workers have health certificate for meat handlers while 38.23% of worker have not health certificate for handlers in the abattoir workers (P> 0.05). Ininlinet with this, Abebe B *et al*.(2019) in Bishoftu, Central Ethiopia stated that 58% of abattoir workers obtained health certificate and 42% of workers did not got health certificate in the abattoir. Muhammed N. and Mulu D.(2021) at Slaughterhouses and Butcher’s Shops in West Hararghe Zone stated that 7.5% f abattoir workers got health certificate and 92.5% of abattoir workers did not. Comparable result was reported by Birhanu S and Menda S., (2017) in Gojjam Area, Ethiopia indicated that, 1.85% of worker has health certificate and 98.15% of abattoir worker didn't given health certificate by checking health status of workers.

In consistent with hygienic condition of coat, availability of adequate water in slaughtered house, and washing and sterilizing; 67.64% of respondents has poor hygienic condition of coat while 32.35% has good hygienic condition of coat in abattoir workers ($p<0.05$). Muhammed N. and Mulu D. (2021) at Slaughterhouses and Butcher's Shops in West Hararghe Zone stated that 62.5% and 37.55 of abattoir workers hygienic condition of coat were good and poor respectively.

55.88% of abattoir workers were washing and sterilization of knives after skinning and evisceration while 44.12% of participant noted as there was no washing and sterilizing of knives, $p<0.05$ (Table 11). Muhammed N., and Mulu D., (2021) at Slaughterhouses and Butcher's Shops in West Hararghe Zone , stated that 66.7% of abattoir workers indicated as there was washing and sterilizing of knives after skinning and evisceration and 33.3% of workers did not washed and sterilized of knives after skinning and evisceration. Similarly, 100%, 0.0%, 0.0% of frequency of cleaning and disinfection was done daily, twice week and trice week respectively.

2.4 Microbial Quality Indicators of Beef

Meat quality on the basis of its conformational and functional qualities. Functional qualities as the desirable attributes of a product while the conformance qualities take into consideration producing products that exactly meets consumer's specifications. Meat quality is a function of tenderness, pH, colour, juiciness, flavor and nutritive value (Webb, 2008). Quality attributes primary affected by transport and handling in cattle include pH, colour, tender, texture and moisture and degradation of these variables is collectively referred to as dark firm and dry, high pH, and low glycogen meat (Ponnampalam *et al.*,2017).

2.4.1. Meat PH

The most important meat quality indicator is the pH value, which is related to biochemical processes during the transformation of muscle to meat. Consequently, changes in the pH during the postmortem period influence the organoleptic characteristics of the meat. The pH value of meat closely correlated with many other properties of meat such as water-holding capacity, color, tenderness, flavor and shelf-life (Knox *et al.*, 2008).

The meat pH provides valuable information about postmortem muscle glycolysis, thus enabling to detect quality defects of meat such DFD (Rammouz *et al.*, 2004). The pH of the meat vary due to factor such as pre-slaughter stress, chilling temperature, season and animal factor such as age, breed and sex. The ultimate PH is determined 24 hours post-slaughter using a pH meter. The muscle of a living animal has a pH of 7.1. The pH range of normal meat of an unstressed animal is 5.4-5.7. After slaughtering, some of the glycogen in the meat turns into lactic acid. As a result, the pH value is lowered. The extent to which pH is lowered after slaughter depends on the level of stress induced during transportation and pre-slaughter procedure ,the amount of glycogen in the muscle prior to the animal's death ,and the rate of glycolysis (Ameha, 2008).Rate of post-mortem glycolysis may be too fast, leading to a rapid drop in pH, or too slow, resulting in too high ultimate pH (Knox *et al.*, 2008).

2.4.2. Colour of Meat

Meat color is an important parameter in meat quality. It is an important characteristic of meat that influences consumers purchasing decisions because consumers use meat color as an indication of freshness and quality (Ponnampalam *et al*., 2013). Fresh meat has a bright red color due to the presence of oxymyoglobin which results from the combination of myoglobin with oxygen. It is normal for meat to change color depending on the presence or absence of air. Colour of meat depends upon several individual factors and their interactions, and concentration of meat pigments, essentially myoglobin and the chemical state of myoglobin (Ronsevold and Anderson, 2003).

Differences in meat colour have been associated with variations in intramuscular fat and moisture content, age dependent, muscle-fiber type and changes in muscle myoglobin content. Color is also greatly affected by muscle pH. At a high pH, muscle has a closed structure, and hence, appears dark and the meat tends to be tough (Muchenje *et al.*, 2008). Myoglobin is the basic pigment in fresh meat and its content varies with production factors such as species, animal age, sex, feeding systems, type of muscle and muscular activity (Muchenje *et al.*, 2014) .The color of fresh meat is species-dependent In pork, lighter flesh, which is greyish-pink in color, is considered acceptable to consumers, whereas fresh meat from ruminant livestock (beef, lamb, and chevon) is darker than pig meat, and a bright cherry-red color is deemed acceptable in these species. Meat color differences between species are largely due to the differences in Myoglobin content (Aalhus *et al.*, 2012)

2.4.3. Water Holding Capacity of Meat

WHC of meat is one of the most important factors of meat quality because it influences consumer acceptance and the final weight of the product. It refers to the ability of meat to retain its own water content when subjected to external force during cutting, heating, grinding and pressing (Khastrad *et al.,* 2017). Many physical properties of meat such as colour, texture and firmness of raw meat, juiciness and tenderness of cooked meat are partially dependent on water holding capacity (Joseph *et al.,* 2009).

Meats of adult mammalian muscle contain 70-75% water. Muscle proteins are capable of holding water molecules to their surface. This water exists in three forms; bound water, immobilized water and free water. Bound water is tightly bound to proteins and is not free to move around and cannot be frozen. It is estimated as the amount of water remaining in meat after it has been subjected to some kind of physical pressure. Bound water has been determined to account for the smallest portion of water found in muscle (1-2% or 0.5 g of water for every gram of protein). Immobilized water has a weaker attraction to proteins than bound water and can move away from proteins but not easily. It represents approximately 85% of water in muscle. Free water is the fraction of water that can flow unimpeded from the tissue .The majority of all water held is loosely by proteins and moves easily due to weak attraction force and is therefore an important determinant of WHC (Huff, 2005).

The WHC is determined at 24 h post mortem. The two methods that are in common use for the estimation of water holding capacities are Press method and Centrifugal method. The press or the filter-paper wetness (FPW) method is recognized as the simplest, less cost and fastest technique to evaluate the meat WHC. This method has been used to evaluate the amount of "squeezable" water. The sample is compressed between two glass plates and subjected to a specified pressure for a given time. After compression the free water squeezed out on a pre-weighted filter paper. A number of pre-and post-mortem factors influence WHC of meat. Among pre-slaughter factor age, genotype and stresses on the animal such as fasting, lack of sufficient rest or extreme hot or extreme humid air condition and different stunning methods have been play a large role in influencing WHC of the meat (Lomiwes, 2008) .Chilling, ageing, injecting non-meat ingredients and cooking procedure have been influences water holding capacity in the post-slaughter period. All of these factors have the potential to greatly influence the rate and extent of pH decline, and thus the water-holding capacity of the meat (Joseph *et al.,* 2009).

2.4.4. Tenderness

Tenderness is defined as the ease of mastication, which involves the initial ease of penetration by the teeth, the ease with which the meat breaks into fragments and the amount of residue remaining after mastication.Tenderness is one of the most important meat palatability attributes, and consumers are willing to pay more for beef which is tender (Farzad, 2014). Meat tenderness is the most difficultly predicted trait, but it is very important to meat quality and consumer acceptance. Tenderness is based on ease of chewing that is contributed by many factors. Among them, the fibrous nature of muscle contributes to chewing resistance (Gerrard and Grant 2003).

2.4.5. Flavour

Flavour is the very important components of the eating quality of meat. The flavour of meat, is a combination of its taste and aroma or smell, and influenced by sensations such as mouth feel and juiciness (Robbins *et al.,* 2003). It is a subjective property and difficult to evaluate. Flavour is thermally derived, since uncooked meat has little or no aroma and only a blood-like taste. There are a lot of compounds present in meat which contribute to the flavour, and many of these compounds are altered during storage and cooking. Among these, the proportion of different fatty acids in the fat, and, in particular, the unsaturated fatty acids, which are more susceptible to oxidation to volatile compounds, such as aldehydes, ketones hydrocarbons and alcohols, are the most common. Phospholipids, which are rich in polyunsaturated fatty acids, also play a fundamental role in the flavour of meat (Calkins and Hodgen, 2007).

During cooking, a complex series of thermally induced reactions (Maillard reaction) occur between non-volatile components of lean and fatty tissues resulting in a large number of reaction products. Although the flavour of cooked meat is influenced by compounds contributing to the sense of taste, it is the volatile compounds, formed during cooking, that determine the aroma attributes and contribute most to the characteristic flavours of meat (Mottram, 1998). Breed, sex, nutrition, and post slaughter treatments of the carcass, can all affect carcass fat and hence the flavour of the meat. The flavour intensity increases with increasing age of an animal regardless of the type of animal. Generally, meat from an older animal of the same species exhibits stronger flavour than meat from a young animal (Young *et al.,* 1997).

2.4.6. Juiciness

Juiciness is an important factor in the eating quality of meat and playing a major a role in meat texture. It is a subjective sensory trait which determined by consumers or sensory panels (Robyn, 2017). Meat juiciness is defined as the impression of moisture and lubrication when meat is chewed in the mouth. Meat juiciness can be separated into two components. The first being the impression of wetness during the initial chews, produced by the rapid release of meat fluids, and it related to the water content of the meat. The second component is the impression of juiciness during sustained chewing and is thought to be related to the fat content of the meat (Winger and Hagyard, 1994). Hence, water retained in the meat and lipids or fat determine the juiciness of meat

There are numerous factors which affect meat juiciness. These factors include ultimate pH, fat content, enhancement level, cooking method, and end point temperature or degree of doneness (Montgomery and Lehesk, 2008).The higher end-point temperature, the more the cooking loss and the lower the juiciness (Aaslyng *et al.,*2003) .With Increased amounts of intramuscular fat the meat juiciness also increased (Aaslyng and Bejerholm, 2004) increase juiciness of meat, the most important factor must be to educate consumers not to over-cook the meat.

2.4.7. Cooking loss (CL)

Cooking is a process of heating beef at sufficiently high temperatures that denatures proteins and makes it less tough and easy to consume (Garcia *et al.,* 2006). It can be achieved either by boiling or by roasting (Shilton *et al.,* 2002) and in all cases losses occur. Cooking loss is one of the meat quality parameters that not given too much consideration by meat processors and consumers due to inappropriate cooking time and temperature. It refers to the reduction in weight of meat due to evaporative (volatile) and drip loss during the cooking process (Vasanthi *et al.,* 2006).

Cooking loss affected by many factors such as cooking temperature, time, meat pH, collagen content, ageing and the state of the meat before it is cooked - frozen versus thawed (Robyn, 2017). Meat cooked at high temperature had lower meat yield with more cooking loss, less moisture and less protein content (Nithyalakshmi and Preetha, 2015). This high temperature causes denaturation of myofi-brillar proteins, primarily the actomyosin complex, and consequently results in shrinkage of the muscle fiber which causes loss of meat liquid which results in mass loss (Wyrwisz *et al.,* 2012).

2.4.8. Microbial quality of beef

One of the major and expensive sources of animal protein is beef meat. Its high nutritive values make it an excellent media for bacterial growth. To ensure production of meat of good keeping quality, slaughtering should be in slaughterhouses under veterinary supervision and complete hygienic measures (Zailani *et al.,* 2016). Microbial contamination of meat may affect its quality with a potential of food poisoning or spoilage due to microbial feeding on meat nutrients such as sugars and free amino acids, which liberate undesired volatile metabolites (Bogere and Baluka, 2014).

The microbial quality and safety of raw meat products can be estimated by the use of indicator microorganisms, including total aerobic plate count, coliform count and Escherichia coli count (Kim and Yim, 2016). The microbiological contamination of meat can occur during processing and manipulation, such as skinning, evisceration, storage and distribution at slaughter houses. Fecal matter is a major source of contamination and could reach carcasses through direct deposition, as well as by indirect contact through contaminated equipment, workers, installations and air (Pal, 2007). In Ethiopia, the consumption of raw meat has associated with cultural practices and widespread raw beef consumption habit that can be a potential source for food borne illnesses (Getaneh *et al.*, 2019). Raw meat is available in open-air local retail shops without appropriate temperature control and purchased by households and served at restaurants as raw, slightly cooked or well cooked (Siddiqui *et al.*, 2006).

Microorganisms came primarily from the exterior of the animal, primarily from the hide and feces of the animal, as well as knives, cloths, air, carts, and equipment in general, during slaughter, dressing, and cutting (Pal, 2012). Low sanitary conditions, insufficient quality control procedures, improper meat handling, and no packaging system characterize butcher shops, which are frequently openly exposed stores placed on the road. Butcher shops use abattoirs' slaughtering and transportation services (Brasesco *et al*., 2019).

Contaminated raw meat is one of the most common causes of food poisoning (Bhandare *et al.*, 2007). Some of these microorganisms may contain pathogens, which are responsible for 60% of all foodborne infections that results in hospitalization and two-thirds of all foodborne pathogen-related deaths. According to a study of Buncic (2006), retailed raw meats are frequently infected with hazardous bacteria. Food poisoning and intoxication are caused by these bacteria, as are spoiling bacteria that cause discoloration, unpleasant odors, and slime on meat surfaces. *Salmonella species, Shigella species, Campylobacter jejuni, Campylobacter coli, verotoxigenic Escherichia coli (E. coli), Listeria monocytogenes, Staphylococcus aureus,* and other pathogenic microbes have all been related to contaminated meat and its products (Meyer *et al*., 2010).

2.5 Status of Microbial load of meat

The microbiological condition of safety and hygiene were assayed using the methods recommended by ICMSF (International Commission on Microbiological Specifications for Foods). The total viable counts of raw meat and meat products were determined by standard method. The overall mean Bacterial count and Fungal (yeast and mold) count of meat scrap in the study area were 10,729.5 x10^6 cfu/ml and in Fungus (51.7x10^6 cfu/ml) as indicated Table3.

Asmamaw A., (2024) in Assosa abattoir reported that, the mean *Salmonella, E.coli, Staphylococci, and fungal* count of positive sample were (2.006x10^7, 1.487x10^7, 7.236 x10^7, 51.7 x10^5 cfu/ ml) respectively as indicated in Table 3. Comparable, (Tefera A. and Jerman M, 2021) in Butcher shop in D/Berhan, indicated that, total aerobic mesophilic, *Staphylococci, Enterobacteriaceae, total* coliform, fecal coliform, aerobic spore formers, and yeasts and molds of the butcher shops of 5.47, 4.78, 4.84, 4.88, 4.94, 5.15, 5.07 log cfu/g, of mean microbial counts of afternoon samples respectively.

Firew T *et al*. (2014) reported that, aerobic mesophilic bacteria, total coliforms, enterobacteriaceae, Staphylococci, lactic acid bacteria, yeast and moulds of 8.07, 4.71, 4.45, 6.74, 5.16, and 4.62log cfu/g) of total microbial counts (log cfu/g) of street vended raw beef meat samples respectively, in Jijiga town. Consistently, Mohammed T., (2021) indicated that, mean bacterial counts in beef has, significance. The range count of aerobic mesophilic bacteria at butchers shop and abattoirs was 2.75-7.52 log cfu/g and 2.49-5.16 log cfu/g, respectively. Similarly, the count ranges of *S.aureus* at the butcher shop and abattoirs were 2.74-4.84 log cfu/g and 2.71-4.71 log cfu/g, respectively.

In line with the previous report, Etenesh T. *et al*. (2020) indicated, overall, mean for total aerobic mesophilic bacteria, total coliform, yeast and mold, Staphylococcus spp., Bacillus spp. and psychrophilic bacteria count was 8.34, 4.69, 6.01, 5.36, 5.45, 4.26 log 10 cfu/g, respectively, around Addis Ababa city. The presence of high microbial count in this study might indicate improper meat handling and poor sanitary condition of slaughter houses, personnel, transportation and storage. Thus, to reduce the risks of food borne bacterial infections, there is a need to educate and be aware to practice good sanitation and safe meat handling techniques for butcher shops and personnel.

Table 3: Dilution rate and average result of standard plate count test

Isolated species	N	Mean	Dilution(10^6)	mean ± SD	p-value
E.coli	24	*1594*	*1.594 x10^7 cfu/ml*	*1.594.* ± 0.51	0.001
Staphylococcus spp	24	1013	*1.013 x10^6 cfu/ml*	*1.013* ± 0.46	0.41
Salmonella spp	24	844	8.44 x106 *cfu*/ml	8.44± 0.48	0.25
Yeast	24	38	3.8 x103cfu/ml)	3.8 ± 0.414	0.36
Mold	24	14	1.4 x103cfu/ml)	1.4 ± 0.44	0.16

Source (Asmamaw *et al*., 2024)

Table 4. Distribution of four bacterial meat contaminant isolates

Location (L)	*Sample Size*	Isolates			
		Salmonella spp.	*Shigella spp.*	*E.coli*	*Staphylococcus aureus*
L1	5.00	5	0	4	2
L2	5.00	3	1	2	2
L3	5.00	4	3	5	5
L4	5.00	2	2	0	0
Total	20.00	14	6	9	9

(B. Akinyera *et al*., 2018) in Jos Municipal Abattoir)

Table 5: Means (± SE) of microbial counts (log10CFU/ cm2) meat collected from slaughterhouse and Butcher's shop

Variables With sources	Number of samples (n)	TVBC.	TCC	Enterobacter	*Staphylococcus*
Overall mean	(60)	7.01± 0.25c	6.02 ±0.29c	6.950 ± 0.16c	6.36 ± 0.2b

(Muhammed Nurye and Mulu Demlie.(2021) in West Hararghe Zone, Ethiopia.

Table 6. Bacterial species detected from meat contact surfaces

Sources	**No. of sample**	**Bacterial species detected**			
		S. aureus* *No. (%)	***E. coli O157H7* *No. (%)***	***L. monocytogenes* *No. (%)***	***Camplyobacter* *No. (%)***
Abattoir					
Knives and hooks	15	4(26.67)	1(6.67)	0(0)	0(0)
Surfaces	15	5(33.33)	2(13.33	0(0)	3(20)
Butchers' hands	15	4(26.67)	2(13.33)	0(0)	0(0)
Retail houses					
Knives and hook	15	7(46.67)	0(0)	0(0)	0(0)
Cutting boards	15	3(20)	0(0)	0(0)	0(0)
Butchers' hands	15	6(40)	1(6.67)	0(0)	0(0)
Total	90	29(32.22)	6(6.67)	0(0)	3(3.33

Henok A *et al*., (2015) in study sampled from Jigjiga town municipal abattoir and retail houses.

2.5.1 Food Borne Diseases Related to Beef

Bacterial pathogens contribute to 60% of food borne illnesses that lead to hospitalization and account for nearly two-thirds of the estimated number of food borne pathogen-related deaths. The study revealed that retail raw meats are often contaminated with food borne pathogens (Buncic, 2006) and pathogens associated with beef are as follows:

2.5.1. Escherichia Coli O157:H7

E. coli O157:H7 and non-O157 STEC are mostly associated with raw beef products; it is capable of producing large quantity of toxin (shiga toxin) that causes severe damage to the intestinal lining of human being. Dirt and feces that attached on the hides of cattle can therefore be contaminated with E. coli O157:H7 for long periods of time (Arthur *et al*, 2007).

Research has indicated that the number of hides positive for *E. coli O157:H7* is more accurate predictor for carcass contamination than fecal prevalence (Barkocy-Gallagher *et al.*, 2003). The hide was identified as the primary source of pathogens on beef carcasses, the efficiency of various hide and carcass interventions, and other developments that have led or will lead to even greater improvements in the microbiological quality of beef.

In relation to public health, *E. coli (O157:H7*) strain is the most important *Enterohaemorrhagic E. coli (EHEC)* serotype linked to food borne disease, that resulting in a high incidence of EHEC infections and deaths each year (Mead *et al.*, 1999). In-plant intervention strategies can reduce the spread of E. coli O157:H7 on and between carcasses, enhance the effectiveness of in-plant intervention strategies should reduce the burden of pathogens entering the abattoir should enhance human health (Todd *et al.*, 2010). Therefore, methods that reduce E. coli O157:H7 populations in food animals prior to entry to the food chain have great potential to reduce human illnesses.

2.5.2. Salmonella

Salmonella typhimurium is a pathogenic bacterium which is concentrating in hide and fecal of the cattle, rates of carcass contamination are highest immediately after hide removal and consistently decline during processing as antimicrobial interventions are applied (Koohmaraie *et al.,* 2005). Several species of Salmonella are pathogenic, some producing a severe and often fatal food poisoning. There are mainly two major sources of bacteria in meat causing diseases that are from living animal environment and carcass contaminate; Cross contamination routes involve feces of animals to carcass then carcass to carcass and environment to carcass (Majagaiya *et al.,* 2008). Contamination of food with Salmonella may occur anywhere along the farm-to-table continuum including production, processing, distribution, retail marketing, and handling or preparation (Moon, 2011).

2.5.3. Listeria spp:

Listeria monocytogenes and other Listeria species are widely spread in the environment, the risk of contamination with Listeria in red meat processing industry has to be considered as rather probable, possible Listeria cross-contamination by employees, equipment, and environment surfaces, animal skin, food additives, packing material and many other sources has been reported (Grebenc and Marinšek, 2002). The carcasses and their products may be contaminated during slaughtering and meat processing, thus they can be recognized as feasible transmission routes of Listeria to humans (EFSA, 2006). It could be potentially transmitted by air and colonize various surfaces including raw and ready to-eat meat products (Burfoot, 2003).

3. CONCLUSION

Meat quality can be defined by organoleptic evaluation parameters such as tenderness, juiciness, flavor, palatability, color, neatness, pH, water holding capacity, and its proximate composition. The microbial quality and safety of raw meat products can be estimated by the use of indicator microorganisms, including total aerobic plate count, coliform count and Escherichia coli count. The hygienic standard of the meat outlet and slaughterhouse is below the standard of the general principles of food hygiene (Codex Alimentarius Commission 2020). The microbial quality of meat in the study area was below standard set by WHO and European commission. Therefore, hygienic production and distribution of meat are vital to eliminate or reduce public health risks and prevent zoonotic disease and economic losses due to premature spoilage of meat caused by cross contamination. Besides, the concerned organizations should create awareness among meat handlers and slaughterhouse workers about the importance and ways of hygienic meat processing practices and proper handling. Therefore, the modern abattoir hygienic practices, accepted level of bacterial contamination and risk minimization strategy should be indicated along with quality indicators so as to provide safety and sanitized meat in the Abattoir for the society, and effective implementation of food safety measures through application of hazard analysis and critical control point and, and employ well train butchers so that cross-contamination at slaughterhouse level should be reduced.

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