World Journal of Dairy & Food Sciences 15 (2): 78-87, 2020
ISSN 1817-308X

DOI: 10.5829/idosi.wjdfs.2020.78.87

Red Meat Processing and Preservation Technologies: A Review

[1]*Yohannes Shona Yuma,* [2]*Agegnehu Mekuria Beta and* [3]*Biruk Alemu Basore*

[1]Aletawondo Town Administration Urban Agriculture Office,
Aletawondo, Sidama Regional State, Ethiopia
[2]Livestock and Fishery Agency, Sidama Regional State, Hawassa, Ethiopia
[3]Ethiopian Veterinary Drug and Animal Feed Administration and Control Authority, Hawassa, Ethiopia

Abstract: Processing of red meat is a segment of the manufacturing industry that transforms animal material into intermediate or finished value-added food products that are safer to eat. Red meat processing and preservation aim to prevent red meat from getting spoilt and to extend the period in which meat remains wholesome, providing (supplementing) nutrients required for health, providing variety and convenience in diet and adding value. Red meat processing technologies include both technical and chemical processes such as cutting/chopping/comminuting, mixing/tumbling, salting/curing, utilization of spices/non-meat additives, stuffing/filling into casings or other containers and drying heat treatment and smoking. Methods of red meat preservation include drying, smoking, salting, curing, freezing, refrigeration, canning, irradiation, use of acids (vinegar or citric acid) and hurdle technologies. The color, taste and nutritive value of meat are also preserved. A range of synthetic materials suitable for meat packaging is available mainly in the form of plastic films or foils. Packaging preserve spoilage of color, flavor, odor and texture, prevent contamination by hazards, prevent loss or absorption of water and oxygen, prevent tampering, communicate information with ingredients/nutrition facts and facilitate marketing. The red meat labeling scheme aims to assist consumers to make informed food choices, to encourage red meat manufacturers to apply sound nutrition principles in the formulation of red meat and to regulate misleading or deceptive labels and claims. Although Ethiopia has a huge livestock population, red meat processing is largely traditional with most of the slaughtering taking place in the back yard especially for shoats and butcheries still retailing red meat in a non-chilled, often openly exposed shop. Therefore, red meat processing and preservation technologies should be encouraged in Ethiopia.

Key words: Meat Packaging and Labeling · Red Meat · Red Meat Preservation · Red Meat Processing

INTRODUCTION

There are two types of meat; red meat and white meat. White meat is lighter-colored meat of poultry (breast part) and other animals. Red meat contains myoglobin that transports oxygen to muscles in the bloodstream. An example of red meat is beef. Red meat is a highly perishable product and soon becomes unfit to eat and possibly dangerous to health through microbial growth, chemical change and breakdown by endogenous enzymes [1].

These processes can be curtailed by reducing the temperature sufficiently to slow down or inhibit the growth of micro-organisms, by heating to destroy organisms and enzymes (cooking, canning), or by removal of water by drying or osmotic control (binding the water with salt or other substances so that it becomes unavailable to the organisms). It is also possible to use chemicals to inhibit growth and, very recently, ionizing radiation [2].

Red meat processing is a procedure in which meat is prepared for consumption. People often use this term to refer specifically to making packaged foods, but technically anything which transforms raw ingredients into something else is a form of food processing. There are several purposes for red meat processing. The most basic goal is to prepare red meat which is palatable. This can include processing ingredients that are not safe to eat raw, flavoring red meats to make them more interesting and making dishes that comply with cultural and religious norms surrounding food, in addition to addressing issues such as allergies [3].

Corresponding Author: Biruk Alemu Basore, Ethiopian Veterinary Drug and Animal Feed Administration and Control Authority, Hawassa, Ethiopia.

Processing of red meat is also usually intended to make meat which is nutritious and can include activities such as red meat fortification, in which vitamins and minerals are added to red meat during processing to increase the nutritional value. Safety is also a major concern in red meat processing, especially industrial processing to create packaged red meats that are sold commercially. These facilities can be easily contaminated and the contamination can quickly spread, causing widespread illness. Part of making red meat safe includes processing it to remove any potential risks, such as bacteria in meat, in addition to maintaining strict safety procedures to reduce the risk of introducing harmful organisms during processing [4].

The term red meat preservation refers to any one of several techniques used to prevent the meat from spoiling and extend product shelf life. The general methods of red meat preservation include the application of heat, such as canning and preserving, evaporation, sun drying, dehydration and smoking, application of cold, as ill cold storage, refrigeration and freezing, the use of chemical substances such as salt, sugar, vinegar, benzoic and lactic acids, fermentation, examples being acetic, lactic, alcoholic, etc., such mechanical means as vacuum and devices or agents for preventing chemical deterioration or bacteriological spoilage and combinations of two or more of the above [5].

The various red meat preserving methods are all designed to reduce or eliminate one or more red meat spoiling agents. For example, a simple and common method of preserving red meat is by heating it to some minimum temperature. This process prevents or retards spoilage because high temperatures kill or inactivate most kinds of pathogens. The addition of synthetic compounds known as BHA (butylated hydroxyanisole) and BHT (butylated hydroxytoluene) to foods also prevents spoilage in another different way. These compounds are known to act as antioxidants, preventing chemical reactions that cause the oxidation of red meat resulting in its spoilage [6].

In general, the major aims of the meat processing and preservation activities are to extend the shelf-life of meat, increase the organoleptic (flavor, color, texture) quality of meat that provide meat with the nutrients required for enhancing good health and help build communities and generate income for the farmers and manufacturers [7] whereas, there are no enough literature available to strengthen the awareness of the community on red meat processing technologies and basic principles of red meat processing and preservation. Therefore, the objectives of this review paper are to overview of the basic principles of red meat processing and preservation and to review the currently available literature on the red meat processing and preservation technologies.

Literature Review

Composition of Red Meat: To understand some of the meat processing and preservation procedures and principles, we must first understand the composition of red meat and how this and meat additives affect the water holding capacity (WHC), color, deterioration and properties of red meat and red meat products [8]. Meat is composed of water, fat, protein, minerals, vitamins and a small proportion of carbohydrates [9, 10]. The most valuable component from the nutritional and processing point of view is protein. Protein contents and values define the quality of the raw meat material and its suitability for further processing. The protein content is also the criterion for the quality and value of the finished processed meat products [10].

Water: Water is by far the largest component of meat, comprising 65-80% of the lean tissue. Water exists in red meat as bound (restricted or immobilized) water and free or bulk water. One type of bound water often called restricted or immobilized water is attracted to the protein, forming loosely ordered associations. Free or bulk water in meat is held only by weak forces such as capillary action. Free water is readily available to microorganisms for growth. The water holding capacity (WHC) of meat is one of the most important factors of meat quality both from the consumer and processor point of view. Muscle proteins are capable of holding many water molecules [11].

Protein: The function of proteins in red meat is for nutrition, texture, color and water holding capacity. Protein can be categorized into three types namely myofibrillar (contractile) proteins, salt soluble, sarcoplasmic (plasma) proteins, water-soluble and Stromal (connective) proteins, relatively insoluble. The myofibrillar (or contractile) proteins form the largest structure and bulk of muscle (e.g., actin and myosin). The plasma (or sarcoplasmic) proteins are found inside the muscle cell. The connective tissue (or stromal) proteins transmit the movement generated by contraction of the myofibrillar proteins to the skeleton of the body (e.g., collagen) [12].

Fat: Fat (crude lipid) is the most variable component in red meat. It functions for flavor, texture and juiciness. Animal lipids are generally triglycerides, which are glycerol molecules with fatty acids attached. There are many different fatty acids. They differ in the number of carbon atoms in the carbon chain, ranging from 12 to 20 and the number of unsaturated double bonds [13].

The pH of Red Meat: The pH of normal muscle at slaughter is about 7.0 but this will decrease in red meat. In a normal animal, the ultimate pH (expressed as pH 24 = 24 hours after slaughter) falls to around pH 5.8-5.4. The degree of reduction of muscle pH after slaughter has a significant effect on the quality of the resulting red meat. The typical taste and flavor of red meat are only achieved after a sufficient drop in pH down to 5.8 to 5.4. From the processing point of view, red meat with pH 5.6-6.0 is better for products where good water binding is required (e.g. frankfurters, cooked ham), as red meat with higher pH has a higher water-binding capacity [14].

Vitamins: As with other animal foods, red meat is an excellent source of bioavailable vitamin B_{12}, providing over two-thirds of the daily requirement in a 100g serve. The liver is an excellent source of vitamin A and folate [15].

Minerals: Beef and lamb meat are among the richest sources of the minerals iron and zinc, with 100g providing at least one-quarter of daily adult requirements. The iron (Fe) in meat is mostly haem-iron which is well absorbed and meat protein also appears to enhance the absorption of iron from meat. Red meats are also good sources of selenium. The copper (Cu) content in raw lean cuts range from 0.055 to 0.190 mg/100g in beef and veal, 0.090 to 0.140 mg/100g in lamb and 0.190 to 0.240 mg/100g in mutton [16].

Processing Technologies of Red Meat: Red meat processing technologies comprise the steps and procedures in the manufacture of processed meat products. Meat processing involves a wide range of physical and chemical treatment methods, normally combining a variety of methods. The aims of red meat processing could be considered four-fold: (1) extending the period during which food remains wholesome (microbial and biochemical), (2) providing (supplementing) nutrients required for health, (3) providing variety and convenience in diet and (4) adding value [17, 18].

Meat processing technologies include on the one hand purely technical processes such as cutting/ chopping/comminuting (size reduction), mixing/tumbling, stuffing/filling of semi-fabricated meat mixes into casings, synthetic films, cans, etc. and heat treatment. On the other hand, chemical or biochemical processes, which often go together with the technical processes, are also part of meat processing technology such as salting and curing, utilization of spices and additives, smoking, fermentation and drying [10, 19].

Technical Processes: In modern red meat processing, most of the processing steps can be mechanized. The major items of red meat processing equipment needed to fabricate the most commonly known red meat products are listed and briefly described hereunder [18, 20].

Cutting/Chopping/Comminuting (Size Reduction): There are five methods of red meat cutting. These are mincing (grinding) of lean and fatty animal tissues, chopping animal tissues in bowl cutter, chopping animal tissues in emulsifying machines, frozen meat cutting and cutting of fatty tissues. Mincing (grinding) of lean and fatty animal tissues: - Larger pieces of soft edible animal tissues can be reduced in size by passing them through meat grinders. Some specially designed grinders can also cut frozen meat, others are equipped with devices to separate "hard" tissues such as tendons and bone particles from the "soft" tissues [21]. A red meat grinder is a machine used to force meat or meat trimmings through a feeding worm (auger) under pressure through a horizontally mounted cylinder (barrel). The smallest type of meat grinder is a manual grinder [22].

Chopping animal tissues in bowl cutter: - Bowl cutters are used to chop and mix fresh or frozen lean meat, fat with water (often used in form of ice), functional ingredients (salt, curing agents, additives) and extenders [23]. A bowel cutter is the commonly used meat chopping equipment designed to produce small or very small ("finely comminuted") lean meat and fat particles [24]. Chopping animal tissues in emulsifying machines done by pre-mixed the animal tissues to be emulsified with all other raw materials, functional ingredients and seasonings and pre-cut using grinders or bowl cutters. Thereafter, they are passed through emulsifiers (also called colloid mills) to achieve the desired build-up of a very finely chopped or emulsified meat mix [25].

Frozen meat cutting: - Boneless frozen meat blocks can be cut in slices, cubes, or flakes by frozen meat cutters or flakes. The frozen meat particles (2-10 cm) can be directly chopped in bowl cutters without the previous thawing thus avoiding drip losses, bacterial growth and discoloration which would happen during thawing [26]. Cutting of fatty tissues:- Back fat is cut in cubes of 2-4 cm on specialized machines to facilitate the subsequent chopping in cutters/emulsifiers [27].

Mixing: Mixing is the process of blending red meat and spices, or coarse and finely chopped meat for the development of desirable product color and texture [28].

Stuffing/Filling into the Casing or Other Containers: In this process, meat is filled into other containers for chopping to produce small or very small ("finely comminuted") lean meat and fat particles [29].

Chemical or Biochemical Processes: The chemical or biochemical processes are part of meat processing technology which includes salting and curing, utilization of spices and additives, smoking, fermentation and drying [10]. Salt (sodium chloride NaCl) can be added to the final product. The content of salt in red meat is normally 1.5 - 3%. The water holding capacity of meat can be increased with the addition of salt up to a concentration of about 5% in red meat [30]. The most important spices used in processed red meat products are pepper, paprika, nutmeg, mace, cloves, ginger, cinnamon, cardamom, chili, coriander, cumin and pimento. The most common natural spice in sausage-making is pepper. Spices are mainly used in the ground form with particle sizes from 0.1 to 1 mm [31].

Smoking of the product, whether using either natural smoke or liquid smoke, can produce desirable effects for red meat products. Smoking provides color and flavor as well as an antioxidant (phenols) and antimicrobial (phenols + acids) properties to the product [32]. Fermentation and drying are also commonly used types of nontechnical meat processing technology to prepare different types of processed meat [33].

Preservation of Red Meat: Red meat processing and preservation are two techniques that are used to maintain the quality and freshness of red meat. In terms of how they are performed, red meat processing and preservation are different; red meat preservation is just part of the entire procedure of processing red meat. Red meat processing mostly involves both packaging and preservation, while red meat preservation is concerned with the control and elimination of the agents of meat spoilage. Additionally, red meat processing is performed to turn red meat into something more palatable and convenient to eat [34].

Principles of Red Meat Preservation: Meat preservation has different principles. (1) Prevention or delay of the growth of micro-organisms by avoiding invasion of micro-organisms e.g. by aseptic techniques, removing micro-organisms, inhibiting the growth and activity of micro-organisms e.g. freezing, refrigeration, drying, anaerobic conditions, chemicals or antibiotics and killing the micro-organisms e.g. heat or irradiation [35]. (2) Prevention or delay of self-decomposition by destruction or inactivation of inherent enzymes naturally existing in red meat e.g. by blanching and prevention or delay of chemical reactions e.g. prevention of oxidation by using antioxidant [36]. (3) Prevention of damage from insects or animals by using suitable chemicals to kill insects or animals from destroying the red meat and by storing red meat in dry, airtight containers to prevent the insects or animals from destroying red meat [37].

Preservation Technologies of Red Meat: Preservation of red meat delays product spoilage extends the life of the product and improves product quality. Types of preservation techniques include freezing, Heating, Dehydration, chemical, Fermentation, Hurdle technology, etc [38].

Freezing: Optimum temperature (0°F or lower) and works by completely stopping enzyme activity and inhibiting spoilage microorganisms like bacteria, yeasts and molds. Frozen red meat lasts for Beef – 12 months, Pork – 6 months, Lamb – 6 up to 9 months and Poultry – 3 up to 6 months. Changes in red meat during freezing include re-crystallization, freezer burn (dehydration) and residual chemical (lipid oxidation) and enzymatic reaction (proteolytic and lipolytic enzymes. Freezer burn is the loss of moisture from red meat to the storage environment, characterized by lighter color (microscopic cavity previously occupied by ice can change the wavelength of reflected light), red meat with the large surface area/volume ratio and minimized by packaging [39].

Heat Treatment: Heat is the most commonly used media for preservation by killing micro-organisms. Heat treatment can be cooking, sterilized cooking and canning [40].

Cooking: Works by heating products to high temperatures to kill microorganisms. There are two types of cooking namely Pasteurization and Sterilization. Pasteurized cooking products are cooked to 150-170°F and kills most (but not all) microorganisms [41].

Sterilized Cooking: Products are cooked under pressure to 250°F, all microorganisms are killed and products are shelf-stable [42].

Canning: Canning is an important, safe method for preserving red meat if practiced properly. The canning process involves placing red meat in jars or similar containers and heating it to a temperature that destroys micro-organisms that cause red meat to spoil. During this heating process air is driven out of the jar and as it cools a vacuum seal is formed. This vacuum seal prevents air from getting back into the product bringing with it contaminating micro-organisms. There are two safe Canning methods of red meat namely the boiling water bath method and the pressure canner method. In the boiling water bath method, jars of red meat are heated completely covered with boiling water (212°F) and cooked for a specified amount of time and in the Pressure canning method, Jars of red meat are placed in 2 to 3 inches of water in a special pressure cooker which is heated to a temperature of at least 240° F [43].

Chemical Treatment: Chemicals inhibit microbial growth, add flavor to the product, improve product shelf life and develop a pink cured- red meat color. Examples are Salt, Sodium Nitrite and Sodium Lactate. It is known that salt binds with water molecules and thus acts as a dehydrating agent in foods. A high level of salinity may also impair the conditions under which pathogens can survive. Sugar appears to have effects similar to those of salt in preventing spoilage of food. Meats can be submerged in a salt solution known as brine, or the salt can be rubbed on the meat by hand. The injection of salt solutions into meats has also become popular [44]. The use of acids (vinegar or citric acid) lowers the pH and thus inhibits the growth of many micro-organisms. It is more effective against yeast and bacteria than moulds [45].

Table 1: Summary of common preservative chemicals

Preservatives	Target organism(s)	Action
Sulfites	Yeasts and bacteria	Antioxidant
Sodium nitrate	Bacteria	Antimicrobial
Propionic acid	Moulds	Antimicrobial
Sorbic acid	Moulds	Antimicrobial
Benzoic acid	Yeasts and moulds	Antimicrobial

Source: Nadeem *et al.* [44]

Fermentation: It's the process of using microorganisms, such as bacteria or yeast, to convert carbohydrates to organic acids under anaerobic conditions [46]. *Creating anaerobic condition:* Anaerobic condition means a conditioned lack of or containing the only minimum amount of air or oxygen. It can prevent the surviving bacteria in red meat from growing in the container. The container is filled with food and air in unfilled space is removed or replaced by nitrogen or carbon dioxide [47].

Use of Salt and Sugar: Sugar binds moisture and thus can preserve red meat by preventing the growth of microorganisms if a high concentration (65% or above) is used [48].

Irradiation: Red meat absorbs and is heated up by radiant energies. Radiant energies can kill microorganisms without a marked increase in temperature as well as marked changes like meat. Gamma rays, x-rays and electromagnetic, ultra-violet radiations are commonly used for food preservation [49].

High-Pressure Processing: High-pressure processing, also referred to as "high hydrostatic pressure processing" or "ultra-high pressure processing, " uses elevated pressures (up to 600 MPa) with or without the addition of external heat, to achieve microbial inactivation or to alter red meat [50].

Microwave Heating: Microwave energy (300–300, 000 MHz) generates heat in dielectric materials such as foods through dipole rotation and/ ionic polarization. In microwave heating, rapid volumetric heating could reduce the time required to achieve the desired temperature, thus reducing the cumulative thermal treatment time and better preserving the thermolabile red meat constituents [51].

Pulsed Electric Field Processing: During pulsed electric field (PEF) processing, a high voltage electrical field (20–70 kV/cm) is applied across the red meat for a few microseconds. Several process parameters including electric field strength, treatment temperature, flow rate or treatment time, pulse shape, pulse width, frequency and pulse polarity govern the microbiological safety of the processed red meat [52].

Ultrasound: High-power ultrasound processing or sonication is another alternative technology that has shown promise in the red meat industry, in inactivating spoilage microorganisms. Ultrasound is a form of energy generated by sound waves of frequencies above 16 kHz; when these waves propagate through a medium, compressions and depressions of the medium particles create micro-bubbles. The antimicrobial action of ultrasound arises mainly from the acoustic cavitations and the physical and chemical effects propagated thereof. Ultrasound is known to enhance several mass transfer processes, including the bringing of meat [53].

Hurdle Technology (HT): HT (also called combined methods, combined processes, combination preservation, combination techniques, or barrier technology) advocates the deliberate combination of existing and novel preservation techniques to establish a series of preservative factors (hurdles) to improve the microbial stability and the sensory quality of red meat as well as their nutritional and economic properties [54].

Presently, several new red meat processing technologies, including microwave and radiofrequency heating, pulse-electric field treatment, high-pressure processing, ultrasonic applications, irradiation and oscillating magnetic fields, is being investigated to improve, replace, or complement conventional processing technology. Meat processing involves a wide range of, normally combining a variety of methods [18, 55].

Packaging and Labeling of Red Meat

Packaging of Red Meat: Packaging of meat is to surround or wrap meat products with suitable protective material. A range of synthetic materials suitable for meat packaging is available mainly in the form of plastic films or foils. Packaging preserves spoilage of color, flavor, odor and texture, prevent contamination by biological, physical, chemical hazards, prevent loss or absorption of water and oxygen, prevent tampering (neckbands/shrink-film sleeves), communicate information with ingredients/ nutrition facts and facilitate marketing [56].

Packaging films must be/have flexible, mechanical strength, lightweight, odorless, hygienic (clean and toxicologically harmless), easy recycling, resistance to hot and cold temperatures, resistance to oil and fats, good barrier properties against gases, sealing capability and low-cost. Films laminated with aluminum foil are very effective [57]. A packaging method commonly used in larger red meat industries is skin packaging. For this method, the products are placed in the packaging machine, usually on a rigid film, which serves as the bottom layer of the final packaging. The skin-like coverage of the product takes place in a sealing station in the packaging machine, where the top and bottom film are sealed around the edges [58].

Useful technology is the Modified Atmosphere Packaging (MAP) of red meat and red meat products. Packaging a perishable product in an atmosphere which has been modified so that its composition is other than that of air is termed as MAP [59]. The main purposes of MAP of meat and meat products are twofold: to ensure the (i) microbiological shelf life and (ii) the sensory quality of the product, including the color, odor and palatability. MAP addresses both these objectives, by using combinations of gases in the production environment that limit or reduce the growth of spoilage and pathogenic microflora of meat and stabilize the color of the meat [60]. The packaging materials used are gas-proof multi-layer films. A flexible lid foil is then sealed on [61].

Labeling of Red Meat Products: The red meat label is a systematic way of presenting nutrition information of red meat products. The nutrition information on red meat labels is an important public health tool to promote a balanced diet, hence enhancing public health. This information assists consumers to better understand the nutritional value of red meat. It enables consumers to compare the nutritional values of similar food products and then make healthy food choices based on relevant nutrition information [62].

Red meat labeling scheme is needed because the red meat labeling scheme aims to assist consumers: to make informed food choices, to encourage red meat manufacturers to apply sound nutrition principles in the formulation of red meat and to regulate misleading or deceptive labels and claims. Consumers can use the information on the nutrition label in many ways: to compare nutritional content among different red meats for a healthier choice, to understand the nutritional content of red meat and estimate their contribution to the overall diet and to meet individual's dietary needs [63].

Current Status of Red Meat Processing and Preservation in Ethiopia: Ethiopia owns the largest livestock populations in Africa and the tenth in the world. The country had 59.5 million heads of cattle, 30.70 million heads of sheep, 30.20 million heads of goats, 56.53 million of poultry and 1.21 million heads of a camel [64]. Meat processing in Ethiopia is by large traditional with most of the slaughtering taking place at the back yard especially for shoats and butcheries still retailing meat in a non-chilled, often openly exposed shop [65]. The illegal or informal killing of animals is highly practiced for domestic consumption at the backyard of practically all households especially for shoats whereas for cattle-killing at the village level to share among a group of neighbors or close families is common which is called "Kircha" [65, 66]. In Ethiopia, people use different traditional red meat preservation methods such as drying to prepare "quanta", application of salt on the surface of red meat (salting), application of honey and other spices [65].

Even though Ethiopia has the tenth largest livestock population in the world, the processing and preservation of red meat is still low and contributed only about 0.2 percent of the world's total red meat production, of which most is sheep and goat meat. This ranked Ethiopia as the 55th largest meat-producing country in the world. The reasons behind the low rate of meat processing and preservation in Ethiopia are multiple including low off-take rates owing to low domestic consumption of meat (9 kg/head/annum), large numbers of live animals that by-pass abattoirs and are exported on foot, low supply of animals owing to lack of commercial orientation of animal producers as a result of which they sell only in need of cash or when draught animals get too old and limited capacity of red meat processors in meeting international market requirements and limitation in fulfilling international industry standards [67].

Recently, the Ethiopian Government is perusing Agricultural Development Led Industrialization (ADLI) strategy as agriculture is the major economic sector of the country owing to over 80% of the population engaging in agriculture one way or the other. Hence the economic development growth direction that the government of Ethiopia chose is more of a value addition on agricultural products through industrial processing. The meat processing industry is on the rise in Ethiopia even though the sector is still much less than it should be given the resource potential. Currently, there are about 15 export slaughterhouses including 8 under establishment and more than 29 abattoirs serving the local market. Municipal level domestic abattoirs are growing from time to time with the growth of urbanization whereas modern slaughterhouses are mainly established for exporting purposes [65].

CONCLUSION AND RECOMMENDATIONS

Red meat processing and preservation methods can be chosen from several approaches (heat addition or removal, acidity, water activity, pressure, electric field, among others) to transform raw red meat to produce microbiologically safe, to delay red meat product spoilage, to improve red meat product quality, extended shelf life, to meet consumer-desired, convenient and value-added foods. The type of red meat processing operation chosen can influence the extent of changes in product quality (color, texture and flavor) and safety attributes. Various chemicals such as Nitrite can be safely used in tiny concentrations for food preservation and coloring purposes. Packaging of red meat can preserve promote the safety and quality attributes of meat. The nutrition information on red meat labels is an important public health tool to promote a balanced diet, hence enhancing public health. This information assists consumers to better understand the nutritional value of red meat. Thus, there are economic, dietary and sensory aspects that make meat processing and preservation is one of the most valuable mechanisms for adequately supplying animal protein to human populations. Although Ethiopia has the largest livestock resource, the processing and preservation of red meat are still traditional and very low. Recently, the meat processing industry is on the rise in Ethiopia even though the sector is still much less than it should be given the resource potential. Based on the above conclusion, the following recommendations are forwarded:

- Safety and quality issues should be addressed during the processing and preservation of red meat.
- The processing and preservation of using chemicals should strictly control to prevent chemical hazards.
- Red meat processing and preservation technologies should be encouraged in Ethiopia.
- Traditional processing and preservation mechanisms of red meat in Ethiopia should be studied and promoted.

REFERENCES

1. Henchion, M., M. McCarthy, V. Resconi and D. Troy, 2014. Meat consumption, trends and quality matters. Meat Science, 98: 561-568.
2. Koutchma, T., A. Le Bail and H. Ramaswamy, 2006. Modeling of temperature profiles under continuous tube-flow microwave and steam heating conditions. Food Process Engineering, 23: 1-24.
3. Harper, J., 2000. Food extrusion. Critical Reviews in Food Science and Nutrition, 11: 155-215.
4. Zottola, E. and K. Sasahara, 1994. Microbial biofilms in the food processing industry. International Journal of Food Microbiology, 23: 125-148.

5. Cheftel, J., 1995. Review: high pressure, microbial inactivation and food preservation. Food Science and Technology International, 1: 75-90.
6. Floros, J., R. Newsome and W. Fisher, 2010. Importance of Food Science and Technology. An IFT Scientific Review. Comprehensive Reviews in Food Science and Food Safety, 9: 572 599.
7. Graham, W., M. Stevenson and E. Stewart, 1998. Effect of irradiation dose and irradiation temperature on the thiamin content of raw red meat. Journal of the Science of Food Agriculture, 78: 559-564.
8. Williams, P., V. Droulez, G. Levy and T. Stobaus, 2006. Nutrient composition of Australian red meat 2002. 1- Gross composition data. o Food Australia, 58: 173-181.
9. Pearce, P., R. Purchas and S. Rutherford, 2004. Concentrations in beef and lamb of taurine, carnosine, coenzyme Q10 and creatine. Meat Sci., 66: 629-637.
10. Heinz, G. and P. Hautzinger, 2007. Meat Processing Technology for Small- To Medium Scale Producers. Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific, Bangkok, 32: 1-50.
11. Cobiac, L., V. Droulez and P. Leppard, 2003. Use of external fat width to describe beef and lamb cuts in food composition tables. Food Composition Analysis, 16: 133-145.
12. Schaafsma, G., 2000. The Protein Digestibility-Corrected Amino Acid Score. Meat Science, 130: 1865S-1867S.
13. Sinclair, A. and K. Dea, 1987. The lipid levels and fatty acid compositions of the lean portions of Australian beef and lamb. Food Technologies, 39: 228-231.
14. Droulez, V., P. Williams and G. Levy, 2002. Nutrient composition of Australian red meat. Fatty acid profile. Food Science, 58: 335-341.
15. Purchas, R., M. Zou and P. Pearce, 2007. Concentrations of vitamin D3 and 2- hydroxyl vitamin D3 in raw and cooked New Zealand beef and lamb. Food Composition Analysis, 20: 90-98.
16. Purchas, R.W. and J.R. Busboom, 2005. The effect of production system and age on levels of iron, taurine, carnosine, coenzyme Q (10) and creatine in beef muscles and liver. Meat Sci., 70(4): 589-96.
17. Garriga, M., N. Grebol, M. Aymerich, J. Monfort and M. Hugas, 2004. Microbial inactivation after high-pressure processing at 600 MPa in commercial meat products over its shelf life. Innovative Food Science & Emerging Technologies, 5: 451-457. Agriculture, 78: 559-564.
18. Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific. Meat processing technology for small- to medium scale producers. Bangkok, 2007.
19. Balny, C., 2001. High pressure and protein oligomeric dissociation. In Proceedings European High-Pressure Research Meeting, 37: 16-19.
20. Boye, J.I. and Y. Arcand, 2013. Current trends in international technologies in food production and processing. Food Eng., 5: 1-17.
21. Hamilton, W. and A. Sale, 1967. "Effects of high electric fields on microorganisms: Mechanism of action of the lethal effect". Biochimica et Biophysica Acta (BBA) - General Subjects, 148(3): 789-800.
22. Sastry, S., 2008. Ohmic heating and moderate electric field processing. Food Science and Technology International, 14: 419-422.
23. Rivas-Cañedo, A., E. Fernandez Garcia and M. Nuñez, 2009. Volatile compounds in fresh meats subjected to high-pressure processing: Effect of the packaging material. Meat Science, 81: 321-328.
24. Zheng, L. and D. Sun, 2006."Innovative applications of power ultrasound during food freezing processes. Trends Food Sci. Techn, 17: 16-23.
25. Gola, S., P. Mutti, E. Manganelli, K. Dazzi, N. Squarcina and M. Ghidini, 2000. The behavior of pathogenic *E. coli* in a model system and raw minced meat treated by HP: microbiological and technological aspects. Industria Conserve, 75: 13-25.
26. Gentry, T. and J. Roberts, 2005. Design and evaluation of a continuous flow microwave pasteurization system for apple cider. Lebensm.-Wiss. Utilization of Technologies, 38: 227-238.
27. Jung, S., M. Ghoul and M. Lamballerie-Anton, 2003. Influence of high pressure on the color and microbial quality of beef meat. Lebensmittel Wissenschaft and Technologies, 36: 625-631.
28. Knorr, D., M. Geulen, T. Grahl and W. Stitzman, 1994. Food application of high electric field pulses. Trends in Food Science Technologies, 5: 71-75.

29. Knore, 2004. Applications and potential of ultrasonic in food processing Livestock marketing in Ethiopia: A review of the structure, performance and development initiatives (Socio-Economics and Policy Research Working Paper 52) Nairobi, Kenya: International and Technology, 15: 261-266.
30. Beaufort, A., M. Cardinal, A. Le-Bail and G. Midelet-Bourdin, 2009. The effects of super-chilled storage at -2 degrees C on the microbiological and organoleptic properties of cold-smoked salmon before retail display. International Journal of Refrigeration, 32: 1850-1857.
31. Diez, A., E. Santos, I. Jaime and J. Rovira, 2009. Effectiveness of combined methods to extend the shelf life of Morcilla de Burgos. Meat Science, 81: 171-177.
32. Bertrand, K., 2005. Microwavable foods satisfy the need for speed and palatability. Food Technol., 59: 30-34.
33. Vogel, R., A. Molina-Guiterrez, H. Ulmer, R. Winter and M. Ga¨nzle, 2001. Sublethal injury of bacteria in high-pressure treatments. In Proceedings European on Advanced Technology for Safe and High-Quality Foods, 3(45): 5-7.
34. Lambert, A., J. Smith and K. Dodds, 2011. Shelf-life extension and microbiological safety of fresh meat: Food Microbiology, 8: 27–67.
35. Andersen, M.B., Å. Rinnan, C. Manach, S.K. Poulsen, E. PujosGuillot, T.M. Larsen, Arne Astrup, Lars O. Dragsted, 2014. Untargeted metabolomics as a screening tool for estimating compliance to a dietary pattern. J. Proteome Res., 13(3): 1405-18. doi:10.1021/pr400964s
36. Tassou, S., J. Lewis, Y. Ge, A. Hadawey and I. Chaer, 2010. A review of emerging technologies for food refrigeration applications. Applied Thermal Engineering, 30: 263-276.
37. Gupta, P.G., 1997. Consumers' Perceptions of the Ethics and Acceptability of Product Placement inMovies: Product Categories and Individual Differences. Journal of Current Issues and Research in Advertising, pp: 37-50.
38. Aymerich, T., P. Picouet and J. Monfort, 2008. Decontamination technologies for meat products. Meat Science, 78: 114-129.
39. De Mey, E., H. De Maere, H. Paelinck and I. Fraeye, 2015. Volatile N-nitrosamines in meat products: potential precursors, the influence of processing and mitigation strategies. Crit Rev. Food Sci. Nutr.
40. Ledward, D. and H. Ma, 2004. High pressure/thermal treatment effects on the texture of beef muscle. Meat Science, 68: 347-355.
41. Sikes, A., E. Tornberg and R. Tume, 2010. A proposed mechanism of tenderizing post- rigor beef using the high pressure-heat treatment. Meat Science, 84: 390-399.
42. Brosnan, T. and D.W. Sun, 2004. Improving quality inspection of food products by computer vision: a review. Journal of Food Engineering, 61: 3e16.
43. Hugas, M., M. Garriga and J. Monfort, 2002. New mild technologies in meat processing: high pressure as a model technology. Meat Science, 62: 359-371.
44. Nadeem, S., U. Chattopadhyay, A. Sherikar, V. Walker, A. Paturkar and C. Latha, 2003. Chemical sprays as a method for improvement in microbiological quality and shelf-life of fresh sheep and goat meats during refrigeration storage (5-7 degrees C). Meat Science, 63: 339-344.
45. Farkas, D. and D. Hoover, 2000. High-pressure processing. Journal of Food Science, 65: 47S-64S.
46. Rahman, M., 2007. Handbook of Food Preservation. Meat Science Technologies, 476: 635-665.
47. Jeong, S.H., D. Kang, M.W. Lim, C.S. Kang and H.J. Sung, 2010. Risk assessment of growth hormones and antimicrobial residues in meat. Toxicol. Res., 26(4): 301-13. doi:10.5487/TR. 2010.26.4.301.
48. Pawar, D., S. Malik, K. Bhilegaonkar and S. Barbuddhe, 2000. Effect of Nisin and its combination with sodium chloride on the survival of *Listeria monocytogenes* added to raw buffalo meat mince. Meat Science, 56: 215-219.
49. Vogel, R., A. Molina-Guiterrez, H. Ulmer, R. Winter and M. Ga¨nzle, 2001. Sublethal injury of bacteria in high-pressure treatments. In Proceedings European on Advanced Technology for Safe and High-Quality Foods, 3(45): 5-7.
50. Carlez, A., T. Veciana-Nogues and J. Cheftel, 2007. Changes in colour and myoglobin of minced beef meat due to high pressure processing. Lebensmittel-Wissenschaft and Technologie, 8: 528-538.
51. Ramaswamy, H. and J. Tang, 2008. Microwave and radiofrequency heating, Food Science and Technology International, 14: 423-428.
52. Yousef, A. and H. Zhang, 2006. Microbiological and safety aspects of pulsed electric field technology. Advances in Microbiological Food Safety, 66: 152-166.

53. Piyasena, P., E. Mohareb and R. McKellar, 2003. Inactivation of microbes using ultrasound. International Journal of Food Microbiology, 87: 207-216.
54. Leistner, L., 2000. Basic aspects of food preservation by hurdle technology. International Journal of Food Microbiology, 55: 181-186.
55. Brewer, M., 2009. Irradiation effects on meat flavor: A review on Meat Science, 81: 1-14. Central Statistical Agence (CSA, 2016).
56. Day, B., 2000. A perspective of modified atmosphere packaging of fresh produce in Western Europe. Food Science and Technology Today, 4: 215-221.
57. Eilert, S., 2005. New packaging technologies for the 21st century. Meat Science, 71: 543-546.
58. Jeyamkondan, S., D. Jayas and R. Holley, 2000. Review of centralized packaging systems for distributing of retail-ready meat. Journal of Food Protection, 63: 796-804.
59. Hintlain, C.B. and J.H. Hotchkiss, 1986. The safety of modified atmosphere packaging: A review. Food Technol., 40(12): 70-76.
60. Harshavardhan Thippareddi, 2019. Modified Atmosphere Packaging (MAP): Microbial Control and Quality University of Nebraska; Randall K. Phebus, Kansas State University.
61. Nerin, C., L. Tovar, D. Djenane, J. Camo, J. Salafranca and J. Beltran, 2006. Stabilization of beef meat by new active packaging containing natural antioxidants. Journal of Agricultural and Food Chemistry, 54: 7840-7846.
62. Guthrie, J., L. Fox, Cleveland and S. Welsh, 1995. “Who Uses Nutrition Labeling and What Effects Does Label Use Have on Diet Quality?” Journal of Nutrition Education, 27: 163-172.
63. Shine, A., O. Reilly and K. O’Sullivan, 1997. “Consumer use of nutrition labels’’. British Food Journal, 99: 290-296.
64. CSA (Central Statistical Agency), 2017. Agricultural Sample Survey 2016/2017. Report on Livestock and Livestock characteristics. Statistical bulletin, Vol II: 585, Addis Ababa, Ethiopia.
65. Addis Ababa Chamber of Commerce and Sectoral Associations (AACCSA), 2015. Value Chain Study on Meat Processing Industry in Ethiopia, “Strengthening the Private Sector In Ethiopia” Project Finance by the Danish Embassy in Ethiopia
66. Kim, F., S. David and B. Erdogan, 2004. The Influence of religion on attitudes towards the advertising of controversial products. Marketing, 38: 537-555.
67. Filip, C., 2006. Ethiopian Livestock Value Chain Analysis Report. Pastoralist Livelihood Initiatives Livestock Marketing Project, 34: 432-764.