Review

Review: Goat and Sheep Meat Production in Indonesia

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Abstract: This review describes the production systems and products pertaining to goats and sheep (GS) in Indonesia. These small ruminant species are found across 38 provinces in Indonesia. Almost 99% of the GS are farmed by smallholders, with the animals either being housed in an enclosure (small shed near the farmer’s house) or in a mix of both grazing and confinement. The livestock are typically fed natural and/or artificial feed. Two sheep types, thin-tailed and fat-tailed are the most popular with smallholder producers, while Bali, Etawah, Boerawa, Jawa Randu Kosta, and Gembrong are the dominant goat breeds. As one of the biggest Muslim countries in the world, Indonesian production and consumption of GS is influenced by culture and religious systems. The Halal slaughter method applied is described, as are the religious/cultural festivals in Indonesia, which have a significant relationship on the GS demand and consumption, such as Eid al-Adha and Aqiqah. The preparation, processing, and consumption of GS meat in Indonesia are strongly influenced by the use of spices, being part of the Moluccas archipelago, also known as the “Spice islands’’ with over 30,000 species of spices grown. Some traditional meats and meat processing technologies in Indonesia are presented to provide insight into how GS meat is processed. The main challenges in the processing of GS meat in Indonesia and some current research on the development of GS production are presented in this paper. Implications: Goat and sheep belong to the most widely consumed meats in the world after pork, poultry, and beef. There are some reasons why GS meat has become one of the more popular protein choices for many families, of which its low-fat levels are one. GS meat is also considered one of the only meats with minimal religious taboos in the world. For these reasons, GS meat is also favored by Indonesian people in the most populous Muslim-majority country. However, information regarding goat and sheep in Indonesia is still lacking. This review aims to provide information on the distribution of GS in Indonesia over 38 provinces, the breed types that grow there, their production, and Indonesian consumption behavior, highlighting the religious festivals that cause the highest demand for these meats. This review provides information to the stakeholders of goat and sheep production chains.

Keywords: goats; sheep; production system; feed; meat quality; meat processing; halal

1. Introduction

Indonesia has more than 16,700 islands stretching 5600 km from east to west and 1600 km from north to south, accumulating in an area of approximately 1,916,000 km² in total. Sumatera, Kalimantan, Java, Sulawesi, the Nusa Tenggara Islands, Maluku, and Irian Jaya are the main islands. Kalimantan is the largest island, comprising around 28% of the total geographical area. Java Island is relatively small with a total of 6–7% of the total land area; however, it is the most heavily populated in terms of population and livestock [1].
Indonesia is a country with a developing economy, where fast population growth and economic development are the main drivers of the supply of food for animals. Red meat is a common food source in Indonesia [2]. Approximately 30% of Indonesia is agricultural land [3]. Of this, 43% or 235,000 km$^2$ is classified as arable land, i.e., land under annual crops or any fallow or pastureland used for annual crops during any five-year period. The remaining agricultural land is used for planting crops, including palm oil, coconut, rubber, coffee and sugar cane, or is permanent pasture (natural or seeded grassland that has remained unplowed for many years) [4]. The major GS meat production areas in Indonesia in 2015–2019 were West Java, East Java, and Central Java [3].

1.1. Rainfall in Indonesia

Indonesia has a humid climate with temperatures between 23 and 32 °C in lowland areas and between 18 and 27 °C in highland areas. The variable pattern of rainfall affects the agricultural systems practiced more strongly than the temperature [1]. In Indonesia, the rainy season in December–February coincides with the summer monsoon of the Southern Hemisphere [6] and the appearance of the Inter-Tropical Convergence Zone (ITCZ) [7]. Meanwhile, the dry south-easterly winds from Australia occur when Indonesia has the dry season in May–September, whilst April and October are the transition periods between the wet and dry seasons [8].

1.2. The Number of Goats and Sheep

The production of goat meat in 2019 was 75,553 tons, and sheep production (91,029 tons) was higher. Goat and sheep production in 2019 increased considerably compared to the previous years; the availability for consumption of goat meat in Indonesia shows an increasing trend of 1.44% per year. Meanwhile, the trade balance of goat and sheep meat in Indonesia from year to year always experiences a deficit and has an increasing deficit trend of 18.77% per year over the last 10 years. Indonesian goat and lamb meat imports mainly come from Australia and the United States [5]. Indonesian goat and sheep meat production from 2019 to 2023 is projected to increase by an average of 1.85% per year [5]. This demand is fueled by the development of potential export markets [9] and has prompted the Indonesian Sheep and Goat Farmers Association (HPDK) to initiate the development of farming clusters to increase productivity. The distribution of goat and sheep in Indonesia is presented in Figure 1.


Based on 2015–2019 average data sourced from the Indonesian Animal Husbandry and Animal Health Statistics, the main areas of the goat and sheep population in Indonesia are in four provinces, namely West Java (89.82%), Central Java (18.63%), East Java (12.64%) and North Sumatra (4.93%) [5].
Three agro-ecological zones are defined in Indonesia, especially in Central Java: lowlands, middle zones, and uplands. Each zone has varying topographic features, soil conditions, soil quality, and agro-climatic conditions. These result in various crop cycles, land use control, development capacity, and feed supplies. Lowlands (<100 m asl) are distinguished by irrigated paddy fields combined with cassava. The major feed is field grass. Middle areas are about 100–500 m asl. In this region, the major practice in agriculture is multiple crop systems with an important mix of paddy fields and annual crops (maize, groundnut, cassava, vegetables). The number of small ruminants and large ruminants in this region is the same. Yearly crop production systems are implemented in the Uplands (>500 m asl), with the main crops being cassava, maize, groundnuts, and vegetables. Several perennial crops such as banana, cacao, and coconut are also produced.

2. Production Systems and Feed Sources

Indonesia’s natural feed options for goat and sheep are rice bran, cassava peels, elephant grass, and field grass. Court grass is usually harvested from paddy field dykes, football fields, roadsides, and field edges. Leaves are obtained from fruit trees, legumes, and hibiscus. Many farmers produce cassava in the lowlands and use the peeling to feed sheep. During the rainy season, maize straw is substituted by leaves in the lowlands. For sheep, the various feeds used are roughly similar to feeds in the dry and rainy seasons [10].

In Indonesia, artificial feed is used to improve goat and sheep performance, whilst blood meal is frequently used to enhance the quality and quantity of semen from Bligon bucks [11]. Furthermore, sludge made from livestock manure, which is formed into a pellet, is also used for goat feed [12]. Where possible, natural feed is enhanced with agricultural by-products; for example, the in-vivo digestion of crude fiber in sheep fed a cocoa pod-based fermented complete feed increased when compared to the control treatment [13]. Cocoa pod, which is abundant in Indonesia, has become one of the feed alternatives for ruminants, especially goat and sheep.

Almost 99% of small ruminants are farmed by smallholders [14]. Small ruminants are considered easy to handle, have a ready demand, function as savings when farmers have urgent cash needs, have socio-cultural positions, and even provide manure to fertilize land [15]. The Indonesian Government is encouraging the intensification of small-scale ruminant production to maximize the intake of animal protein in the country and to enhance the income situation of rural households. Agro-ecological environments are assumed to have a major effect on the form of small ruminants farmed. Sheep are ideal for lowlands, with some grazing areas and agricultural systems dominated by rice and cassava. This allows farmers access to rice bran and peeling cassava. Sheep are deemed to be the better option for the use of these crop residues [16].

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Most small ruminants are now housed in enclosures (small shed near the farmer’s house) or in a mix of both grazing and confinement. In Central Java, it is estimated that up to 76% of the sheep still graze, particularly in the lowlands (<100 m above sea level [asl]). Only ~60% of sheep farmers also graze their sheep in the middle (100–500 m asl) and upland (>500 m asl) regions [16]. For goats, most are farmed by smallholders. In smallholder farming systems, goat production is usually closely integrated into the overall food production system, for example, the production system of PE (Peranakan Ettawah) goats in the Banyumas follows a traditional system characterized by small-scale production with mostly 2–8 animals of various physiological ages per farm [17]. Use of the animals is a function of subsistence, cash income, security, and investment [18]. Within this system, it is difficult to control the forage composition since the forage availability varies during the season [19].

The most prominent places of grazing are roadsides, fallow fields and football grounds. Farmers move their livestock to these fields and send them home at noon, as they come back from activity in the fields. In Indonesia, particularly Central Java, the regular grazing hours (for sheep with grazing opportunities) ranged from 4.1 in lowlands to 3.5 in other regions. The DM and CP intakes of the feeds supplied were estimated to be just 1–2%
lower in small ruminants permitted to graze and small ruminants not being permitted to graze but rather fed the cut-and-carrying system where the feed is brought to them in the pens [18]. Sheep are only grazed during the dry season while there is sufficient fodder available. They are fed early in the morning before they are sent out for pasture. In the rainy season, farmers do not graze small ruminants as they are fearful of bloat and parasites. In Central Java, thus, grazing is not a key element in the diet of sheep, opposing the common belief that grazing is quite crucial for sheep. However, grazing enables the sheep to exercise and offers the farmers the chance to sanitize the pens [18].

Many farmers, especially in the lowlands, process cassava and use peelings thereof to feed their sheep. Farmers are reluctant to give cassava peelings to goats, as this has led to large losses of goats in the past [20]. The use of cassava as a main feed component in animal feeding schemes in Indonesia was restricted due to the prevalence of toxic cyanogenic materials in different fractions and cultivars and due to their high amounts of fiber and ash in the peels [21]. Farmers who live close to woodland areas in each of these zones also combine their crops with legumes, which act as a fence and feed for their small ruminants. In the dry season, however, farmers feed their goats rice bran as an extra feed, although in limited quantities. In the rainy season, goat farmers provide elephant grass (*Pennisetum purpureum* Schumach) and avoid adding the rice bran to the goats’ diet. Sheep farmers tend to use rice bran more readily since sheep processing systems are more incorporated into the production of rice than goats. In the lowlands, goat farmers replace maize straw with leaves during the rainy season. Leaves are typically collected from legume trees, fruit trees, and hibiscus. In the lowlands, for sheep, the different feeds used are the same in the dry and wet seasons [11].

The majority of Indonesian farmers apply traditional (smallholders) farming systems where they do not plant crops as feed for their livestock [22]. There are four major livestock management systems [23], which include (1) herding systems (full grazing), (2) hand feeding systems (cutting and carrying feeding), (3) tethered and (4) free grazing systems; however, many variations of these systems are implemented. On the other hand, Indonesia’s traditional small-scale ruminant production systems are [20] (1) cut-and-carry for continually housed livestock, where forages and other feed are transported, and (2) grazing along road sides, under tree crops, on temporarily idle croplands and on football fields. The majority of sheep farmers practice grazing in the lowlands and over half of the sheep farmers also graze their livestock in the middle and the uplands. Goat farmers prefer to keep their goats in cut-and-carry feed systems, even in the lowlands, although 60% of goats are still grazed here. Due to the constraint of available labor, only small numbers of ruminants are kept entirely in the herded and tethered gras sing system.

In Indonesia, because of land ownership limitations, forage is not widely grown for ruminant animals [1]. As a result, the farmer relies on whatever the farmer may obtain—fibrous agricultural residues have become the primary source of feed for ruminant animals in food crop-producing areas. The available materials to feed animals are used; this is particularly noticeable in heavily populated areas with high stocking rates, such as Java. In agricultural areas, straw (*Oryza sativa*) is the most plentiful of the essential residues required for feeding livestock.

### 3. Goat and Sheep Breeds in Indonesia

In Indonesia, there are two different sheep breeds, thin-tailed and fat-tailed, with certain breed characteristics. The Javanese Thin Tail (JTT) and Javanese Fat Tail (JFT) are the most important sheep breeds in Indonesia (Figure 2). In the eighteenth and nineteenth centuries, the local thin-tailed sheep breeds were crossed with fat-tailed sheep from southwest Asia and Africander sheep from South Africa to produce the Javanese fat-tailed sheep [18]. As a result, the Sumatra Thin Tailed, Semarang, Garut, and Priangan sheep are included in these important breeds. There are also temperate breeds of sheep (for example, Merino, Suffolk, Dorset, Suffas, Dormer, St. Croix, and Barbado Blackbelly) [24]. Small ruminant development programs were initiated about 100 years ago [18].
Indonesia has numerous goat breeds, such as Bali, Etawah, Boerawa, Jawa Randu, Kosta, Gembrong, Marica, Samosir, Kacang, Kapra, Muara, Etawah crosses, Saanen, Boer and Boer crosses (Figure 3). Etawah, Etawah crossbreed (Etawah × local Kacang goat) and Saanen goats are the only dairy goats. The dairy goat breeding center in Indonesia is located in Kaligesing-Purworejo, Central Java. Animals are sent from the breeding center to areas with potential to enhance their productivity, such as Yogyakarta, Bogor, Bandung, and Pasuruan [25]. A comparison of the body weights and characteristics of seven goat breeds indicated significant variation in sizes, etc. [26]. Augustin and coworkers [27] quantified some of the factors influencing litter size in goats, with the Boer goat, Jawaranu, and Borja goats as the basis, and concluded that as litter size varied greatly within the doe’s breed, doe selection (for fecundity) could increase the litter size.

Figure 2. Javanese thin-tailed (A) and fat-tailed (B) sheep.

Figure 3. Prominent Indonesian goat breeds.
4. Market System

Marketing of small ruminants includes many stakeholders [28]. Farmers have even less marketing knowledge and typically complain about the prices they obtain. Small ruminant markets in Java are held every five days. Farmers market their livestock through the local distributor of the village. This person will take them to the small ruminant market. Traders are working among small ruminant markets. Prices depend on a visual assessment of the animal and an estimation of the body weight. Traders have small cars in which livestock are transported; some traders send the animals to the town. The customers of these merchants may be local vendors, butchers, or consumers. Mostly consumers are those who want to sacrifice the livestock to commemorate their children’s birth, celebrate Eid al Adha, or sell at roadside stalls and mosques as part of the marketing scheme. The majority of customers purchase their small ruminant meat from traditional outlets, but the younger generation appears to tend to buy their meat from modern markets [29].

4.1. Production, Consumption, Export, and Import

The trading in sheep and goats is mostly owned by smallholders with an average of between four and six animals (about 95 percent) [30]. The amount of consumption of goat and sheep meat in 2019 was 6872 tons, while the production achieved was 163,592 tons. Production of goat fluctuated between 2009 and 2019, with the peak production in 2009. (Table 1). While sheep production was lower than goat production, it achieved a peak in 2019. With the exclusion of 2011, Indonesia did not export any goat or sheep meat; in addition, there were 2000 tons of sheep and goat imports over four years, from 2016 to 2019.

Table 1. Production, consumption, export, and import of goat and sheep.

<table>
<thead>
<tr>
<th>Population (Thousand)</th>
<th>Goat (Ton)</th>
<th>Sheep (Ton)</th>
<th>Goat (Ton)</th>
<th>Sheep (Ton)</th>
<th>Goat/Sheep</th>
<th>Export (Ton)</th>
<th>Import (Ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>15,815</td>
<td>10,198</td>
<td>73,825</td>
<td>54,260</td>
<td>12,112</td>
<td>0</td>
<td>862</td>
</tr>
<tr>
<td>2010</td>
<td>16,619</td>
<td>10,725</td>
<td>68,793</td>
<td>44,900</td>
<td>12,237</td>
<td>0</td>
<td>787</td>
</tr>
<tr>
<td>2011</td>
<td>16,946</td>
<td>11,790</td>
<td>66,345</td>
<td>46,793</td>
<td>11,993</td>
<td>0</td>
<td>994</td>
</tr>
<tr>
<td>2012</td>
<td>17,905</td>
<td>13,420</td>
<td>65,216</td>
<td>44,357</td>
<td>12,398</td>
<td>0</td>
<td>1270</td>
</tr>
<tr>
<td>2013</td>
<td>18,500</td>
<td>14,925</td>
<td>65,169</td>
<td>41,487</td>
<td>12,760</td>
<td>0</td>
<td>1360</td>
</tr>
<tr>
<td>2014</td>
<td>18,639</td>
<td>16,091</td>
<td>65,142</td>
<td>43,612</td>
<td>12,932</td>
<td>0</td>
<td>1930</td>
</tr>
<tr>
<td>2015</td>
<td>19,012</td>
<td>17,024</td>
<td>64,948</td>
<td>44,525</td>
<td>13,291</td>
<td>0</td>
<td>2733</td>
</tr>
<tr>
<td>2016</td>
<td>17,847</td>
<td>15,716</td>
<td>67,845</td>
<td>45,912</td>
<td>13,442</td>
<td>0</td>
<td>2095</td>
</tr>
<tr>
<td>2017</td>
<td>18,208</td>
<td>17,142</td>
<td>70,354</td>
<td>55,112</td>
<td>13,590</td>
<td>0</td>
<td>2539</td>
</tr>
<tr>
<td>2018</td>
<td>18,306</td>
<td>17,611</td>
<td>70,155</td>
<td>82,275</td>
<td>6872</td>
<td>0</td>
<td>2034</td>
</tr>
<tr>
<td>2019</td>
<td>18,463</td>
<td>17,833</td>
<td>72,553</td>
<td>91,039</td>
<td>7297</td>
<td>0</td>
<td>2420</td>
</tr>
</tbody>
</table>

(Livestock Commodity Outlook, 2019) [5].

As mentioned, large volumes of goat and sheep meat are consumed during religious and cultural celebrations. The former is particularly applicable to the Muslim community within Indonesia.

4.2. Halal and Non-Halal Concept of GS Meat in Indonesia

With over 1.4 billion Muslims worldwide, Islam is one of the world’s fastest-developing communities [31]. The rigid ritualistic standards of the process of slaughter are disputed, even within various Muslim communities. The different techniques of slaughter can have a substantial effect on the process technology used [32]. Halal (permitted) food can become Haram (non-permitted) if it is in contact or tainted by non-Halal foodstuffs [33]. Halal foods can be described as ‘those that are safe from any ingredients that Muslims are forbidden from eating’ [33]. Halal is described as ‘all aspects of slaughtering, stocking, display, preparation, hygiene practices,’ meaning ‘Halal’ is more than just a slaughter process [34]. The regulation in Indonesia regarding halal is controlled by the government through Government Regulation 39 of 2021, also known as the Halal Certification Regulation on the
implementation of Halal Product Assurance. This regulation requires a wide range of goods and services to be certified as Halal.

A number of requirements need to be followed and enforced for poultry and other non-pork meat products to be considered Halal. The animal must be alive at the time of slaughter; a professional worker must carry out the slaughter procedure; the slaughterer must cut a set number of structures in the throat of the animal without cutting the head; the animal’s blood must be pumped out; and prayers must be recited during the slaughter process. Halal products could become Haram if they interact with food that is not permitted. These include other food materials that have not been slaughtered or handled in such a way as to be considered Halal and pork-based resources. In addition, interaction with the manufacturing machinery used in the manufacture of non-Halal food may be considered to constitute contamination of the otherwise lawful food and make it Haram. The risk of such contamination is not only a concern of slaughter or food processing but spreads across the supply chain, including transport within the factory, storage, delivery, and retailing. In addition, contact with non-permitted materials that may include food products, food additives, cleaning agents, process lubricants, or other materials may also result in the processing of Haram food [35].

5. Cultural Festivals in Indonesia

There are cultural festivals and ceremonies that significantly relate to the demand and consumption of Indonesian GS. As Indonesia is one of the largest Muslim countries in the world, Indonesia celebrates Eid al-Adha as a national holiday, which is not only celebrated by Indonesian Muslims but is also a cultural event for everyone. Specific cultural festivals that have an impact on the demand for GS are mentioned below.

5.1. Eid al-Adha

The Eid al-Adha period has a huge effect on the supply and demand of small ruminants [36]. Many people began to sell livestock on the road two weeks prior to the celebration of Eid al-Adha even though they typically do not sell livestock in everyday life. These people are called roadside livestock traders or roadside sellers [20]. The volume of livestock slaughtered during Eid al-Adha in 2016 was 1,019,777 head: 279,211 head of cattle, 7535 buffaloes, 650,583 goats and 82,438 head of sheep [37].

Eid al-Adha is the feast of sacrifice that is to be celebrated on the 10th day of Dhu al-Hijjah. It is the second Eid to be celebrated globally and is believed to be the holiest. It acknowledges the commitment of Ibrahim (Abraham) to sacrifice his son in conformity with God’s command until God interfered by delivering his angel Jibrail (Gabriel) to convey that the dedication had already been acknowledged. Traditionally, Muslims slaughter animals, including sheep, goats, buffalo, cattle, and camels, on this holy day to honor the mercy of Allah, who spared Prophet Ibrahim from killing his son, Ishmael. Eid al-Adha is a moment when Muslims from all over the world come together to sacrifice their livestock [38]. This is the culminating accomplishment of the Hajj, and every household that has the financial ability, in honor of Ibrahim, and as a demonstration of obedience to God, sacrifices a male domestic ruminant. Three days of celebration and ceremony follow Eid al-Adha [39]. In Indonesia, the festival is also recognized as Eid al-Adha or Hari Raya Haji.

The majority of households buy livestock directly from farmers, animal markets, and stands. During the Eid al-Adha period, sacrificial livestock are also sold in urban and peri-urban areas. Many sellers also sell their livestock along the road to celebrate this festival. In urban areas where most animals are on leased land on the edge of the region, the time spent selling the livestock is longer. The stalls are often open longer resulting in the number of customers on the road being very numerous [37].

In Indonesia, sacrificial animals are often purchased from farmers, animal markets, and roadside merchants. The buyer turns the animal over to the committee for killing and distribution of the Eid al-Adha in the Mosque. Slaughterers are men who understand and are experts in religion [40]; slaughter is usually carried out in the mosques and is attended
by all the village members. People gather to see the festival and work together to prepare the meat. In some places, the festival committee will have a collaboration/agreement with a local university to provide a veterinarian in order to evaluate the animals’ condition and health as well as the meat post-slaughter.

The slaughtered animal will hang in a space provided for this purpose within the mosque and is skinned by some other village members. Thereafter, the meat will be divided and placed into plastic bags equivalent to the number of village residents and distributed to each home. Some goat and sheep meat will also be cooked in the place of slaughtering and will be eaten together by all the festival participants.

Devotees infrequently sacrifice their livestock and allocate them on their own. There is local wisdom to create harmony amongst the people when the animals are slaughtered in the Mosque. The number of animals killed for Eid al-Adha in Indonesia is considerably more than the number of animals that are slaughtered daily [41]; the number of sheep sold in the Eid al-Adha period is 127% higher than on regular days [41]. It is crucial to highlight that the proportion of small ruminants sold on the roadsides is considerably higher than in the markets.

5.2. Aqiqah

The other cultural tradition that influences the demand for GS in Indonesia is called Aqiqah. Instead of having a baby shower as Western people do, to welcome a baby’s birth, Indonesians have Aqiqah. This ceremony is traditionally held on the seventh day after the birth of the child. Managed by the baby’s parents, the Aqiqah involves a traditional practice and the family slaughters one goat or sheep for a baby girl and two goats or sheep for a baby boy. A third of the meat is donated to the needy as a charity, while the rest is eaten with family, friends, and neighbors. Around 4.2 million babies are born in Indonesia every year which creates a high demand for GS for their birth ritual.

6. GS Meat Processing in Indonesia
6.1. GS Meat Processing Industry

Global consumption of goat and lamb meat in Indonesia is still very low (5% of world consumption) compared to other developed countries such as Europe (12% of world consumption) [42], with the contribution of goat meat to national meat production at only 3.56% [43]. Nonetheless, the supply of goats and lamb in Indonesia currently fulfills the needs of sacrificial meat during Eid al-Adha, and Aqiqah, whilst a smaller but continuous volume is destined as cut meat for culinary purposes.

Common processed meats consumed in Indonesia are dry shredded meat (abon) (Figure 4a) and meatballs (bakso) (Figure 4b). The growth of the formal Indonesian meat processing industry has become the focus of researchers in the last few decades [44]. Based on the data from the Central Bureau of Statistics (2014) [45], the demand for processed products in which meat is an ingredient is increasing steadily and was ~51% between 2007 and 2013. This growth and productivity experienced in the meat processing industry in Indonesia are related to the industrial concentration, the size of the company, the use of imported goods as input, and the behavior in the industry and government policy [46]. There are three types of slaughterhouses in Indonesia: public slaughterhouses, modern mechanized line slaughterhouses, and private slaughterhouses [47]. The local government runs public slaughterhouses under the supervision of the regional meat inspector and under the supervision of the Directorate-General for Livestock Services of the Ministry of Agriculture [48].

The slaughterhouses must apply Hazard Analysis Critical Control Point (HACCP) systems [47]. Since Islam is the predominant religion in Indonesia, the slaughter of livestock must be conducted by Muslim officials in compliance with the authorized system adopted by the Indonesian Islamic Council (MUI). Halal meat must satisfy two main criteria; it must be halal in slaughter and halal in manufacturing. For the above, the meat should adhere to authorized handling practices and techniques. Some requirements must be applied, e.g.,
the meat has to have been hanging for at least eight hours on a rail in a chiller room at a low
temperature that has adequate air circulation, is sterile, and is in a hygienic environment.
Also, the meat and its derivative products should not be placed with materials or chemicals
that can damage or destroy its natural color.

![Traditional processed meats consumed in Indonesia.](image)

Figure 4. Traditional processed meats consumed in Indonesia.

In order to set up a meat production system, a number of protocols need to be followed.
These involve a feasibility report, descriptions of the raw material suppliers, a marketing
plan, and the practical details of the system [47]. According to the Directorate General of
Livestock and Animal Health [30] of Indonesia, Animal Slaughterhouses or RPH (Rumah
Potong Hewan) must serve to implement 1. proper animal slaughter, 2. ante-mortem
inspection, post-mortem inspection, and carcass inspection to prevent transmission of
zoonotic disease to humans, 3. monitoring and surveillance of animal disease and zoonosis
found in ante-mortem and post-mortem examinations.

Slaughtering of meat in Indonesia is, according to the guidelines of the Directorate
General for Livestock Service (DGLS), administered by Decree No. 413/Ktps/TN.310/1992,
as signed off by the Minister of Agriculture [49], which describes that before the slaugh-
tering, the inspective officer has to carry out an ante-mortem examination of animals
standing and moving from all directions. The lips, nose and eyes, skin, sub-maxillaries,
lymph node, paratidea, scapularis pre and inguinal glands should be investigated for any
deformity. The auditor may also check for any signs of hormonal therapy and unusually
elevated body temperature. The Legislation of the Agriculture Minister No. 64/PERME-
NTAN/OT:140/5/2013 [50] rules that the application of hormones may only be used for
treatment, under the guidance of veterinary experts, and the use of a growth stimulant or
substance used to stimulate growth is forbidden.

According to Regulation of The Minister of Agriculture No. 13/PERMENTAN/OT:140/
1/2010 [51], facilities that must be part of an abattoir are the unloading area, productive
female shelter (to accommodate both productive females that are allowed to be slaughtered
and for the isolation of females that are not allowed/fit to be slaughtered), isolation pens,
chilling room, loading area, and waste area (area for livestock waste). Ante-mortem inspec-
tion is one of the procedures conducted in slaughterhouse facilities and is an examination
that takes place by an authorized examiner before the slaughter, while post-mortem inspec-
tion is an examination by an authorized examiner of the health of the innards and carcasses
after the slaughter.
6.2. Traditional Indonesian Foods

Goat and sheep meat are used in various Indonesian traditional meat dishes. The taste depends on the region where they are cooked; for example, gule that is cooked in the area of Sumatera will taste spicy; however, the basic seasoning of those traditional meat dishes are similar (Figure 5).

![Image of traditional Indonesian dishes]

**Figure 5.** (A) Offal curry (gule jerohan); (B) grilled satay with soy sauce; (C, D) Klathak satay; (E) Tomgseng and Rib and leg tengkleng; (F) Head and leg soup.

Offal curry (A) is a curry dish of the offal of either goat/mutton—various additional spices and condiments are added to the basic curry resulting in a sharp/strong flavor. Offal gule (6) is made from goat organs such as tripe, intestines, lungs, etc. The seasoning used for Gule is similar to Tengkleng (E) seasoning. Compared with Tomgseng and Tengkleng (E), the Gule taste is more savory and concentrated because of the large volumes of coconut milk used. Gule is mostly yellow because it contains turmeric, candlenut, etc. Grilled satay with soy sauce (B) is satay from GS meat which is cut into small pieces and stabbed onto a stick of coconut or bamboo leaf bone sticks before being roasted above charcoal coals (very similar to kebabs). Satay is served with a variety of seasonings (peanut sauce or soy sauce seasoning) depending on variations of the satay recipe. Klathak satay (C & D) is a dish of seasoned, skewered, and grilled meat, served with a sauce. The skewers used for grilling are made of iron, unlike other satay that use bamboo sticks. Klathak satay is usually served with thick gule (succulent curry-like) sauce. The iron skewer functions as a heating conductor, making the meat well-cooked from the inside. Tengkleng (E) is a kind of soup dish with the main ingredients being goat bones, such as leg bones, ribs, and back bones. Tengkleng is cooked with coconut milk sauce and has a sharp flavor like gule. The most commonly used goat body parts for Tengkleng dishes are the ribs and spine. Tomgseng is cooked using a special recipe-usually with sweet soy sauce (kecap manis) added during the cooking. The goat meat used in this dish has normally been diced. Spices for Tomgseng include garlic, onion, pepper, tomatoes, and other seasonings. Tomgseng is cooked by sauté; some dishes have soy sauce added to them so that the taste of the goat meat is enhanced. Generally, Tomgseng does not contain coconut milk. Tomgseng usually contains kikil (goat leg skin) and the head, legs, and tongue of the goat. Head and leg soup (F) is a tongue and leg processed dish that includes the head of the goat. This dish is made from GS, tomatoes, celery, leeks, ginger, candlenut, and orange leaves; the broth is a yellowish clear fresh broth. In Indonesia, this soup is served with a savory broth and enriched with herbs.

These traditional dishes are typically prepared at side street restaurants or local food tents known as warung. In larger restaurants, these dishes are also included on the menus.
However, these dishes are also served at home, especially during certain festivals, for example, Eid al-Adha, Eid Al-Fitr, and Aqiqah (Muslim Festival).

6.3. New Modern Goat and Sheep Processed Foods

Several advanced processed goat and sheep meat products, including emulsions, dried, sausage, roasted meat, and cured products are also found in Indonesia and seem to be increasing in abundance. Some of these products have been reported in the scientific literature (Table 2). These products are found in markets, such as supermarkets, retailers, street vendors, restaurants, and in food-streets (warung).

Table 2. Typical goat and sheep processed foods found in Indonesia.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Typical Products</th>
<th>Product Features</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emulsion</td>
<td>Goat meatball</td>
<td>Greyish, springy, little rough</td>
<td>[52]</td>
</tr>
<tr>
<td>Dried</td>
<td>Lamb jerky</td>
<td>Black/brown, sweet</td>
<td>[53]</td>
</tr>
<tr>
<td></td>
<td>Sliced goat jerky, ground goat jerky</td>
<td>Brown/red, light fine</td>
<td>[54]</td>
</tr>
<tr>
<td>Sausage</td>
<td>Fermented goat sausage</td>
<td>Hard, fibrous</td>
<td>[54]</td>
</tr>
<tr>
<td></td>
<td>Fermented sheep sausage</td>
<td>Juicy, strong odor</td>
<td>[55]</td>
</tr>
<tr>
<td>Roasted</td>
<td>Goat satay</td>
<td>Goaty, Black/brown, smoky</td>
<td>[56]</td>
</tr>
<tr>
<td>Cured</td>
<td>Tongseng with wine mix</td>
<td>Brown color, soft texture</td>
<td>[57]</td>
</tr>
</tbody>
</table>

6.4. Nutritional Properties of Goat and Sheep Meat

Goat meat is classified as a red meat that has low levels of total fat and calorie content (USDA, 2011), so it is considered a healthy meat [58]. In general, the consumption of goat meat in Indonesia is still very low [42]. In Indonesia, the focus of research has mainly been on improving productivity with a focus on providing/evaluating modified feeds. The research on the chemical composition of goat meat is scarce [59]. A few studies have evaluated the effect of feed on various goat breeds/lines: Imam and co-researchers showed that the chemical composition of Kacang goat meat from animals fed with differing qualities of energy and protein was similar [60]. It has been reported that the low-fat content of Kacang goat is caused by undernutrition due to traditional management systems where the goats are only fed roughage without concentrates (energy source) [61], whilst it has also been shown that the amount of nutrients consumed by the animal is influenced by the nutrient content of the feed given [62]. Kacang goat fed with fermented cocoa shell without an additional starter feed (containing high nutrients) was shown to lower the cholesterol content of the meat [63]. Furthermore, it was found that silage completely from natural grass as feed increased the contents of collagen and cholesterol in goat meat [64]. Interestingly, many functional compounds of goat meat such as taurine, carnosine, coenzyme, Q10, creatine, and creatinine have been identified [65].

Feed supplements were also explored as a way of optimizing nutrients and strengthening the nutritional properties of goat and lamb meat. Vitamin E supplementation in rations containing capsulated crude palm oil affected the chemical composition of Bligon goat meat; it decreased the malondialdehyde (MDA) content, increased the vitamin A content, and increased the cholesterol content of the meat [66].

6.5. GS Meat Quality: Physical, Chemical, and Sensory

Meat quality encompasses a lamb's physical and chemical characteristics [67]. The physical quality of GS meat, similar to meat derived from other species, is affected by the interaction of various physical and chemical parameters such as the meat’s pH, color and tenderness, chemical composition/quality. These parameters are also determined by pre- and post-slaughter factors. Ante-mortem factors that affect meat quality are genetics, species, breed type, gender, age, fodder/feed, and additives (hormone, antibiotics, and mineral), as well as stress levels.

Interestingly, it was reported that the energy content of Boer goats’ finisher diet did not affect the sensory attributes or physical or chemical characteristics of the meat [68].
Some post-mortem factors have been reported to influence goat meat quality such as the aging method, slaughtering and stunning technique, chilling methods, temperature, and deboning time [69]. The performance of GS meat is severely impaired by pre-slaughter and ante-mortem conditions. Some aspects are influenced by seasonal changes in temperature and include the glycogen amount in the muscles after the slaughter, ultimate pH, and the physical characteristics of the meat. Post-slaughter treatment of livestock requires both practices and procedures that animals are subjected to after sticking. The animal body slaughtered for food is now known as a carcass [70]. The carcass experiences different post-slaughter/post-mortem processing procedures, and the way in which this is performed often impacts the characteristics of the meat; also, a low-quality carcass would certainly represent a poorer quality of meat [70].

One of the important quality traits of meat is its color. Meat color is one of the first quality attributes a consumer evaluates before buying goat and sheep meat [71]. Table 3 indicates the chemical, physical, and sensory qualities of goat and sheep breeds found in Indonesia.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Goat Meat (g/100 g Meat)</th>
<th>Goat Breed</th>
<th>Sheep Meat</th>
<th>Sheep Breed</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>19.40</td>
<td>Kacang</td>
<td>9.65</td>
<td>Thin tail</td>
<td>[60,72]</td>
</tr>
<tr>
<td>Fat</td>
<td>2.57</td>
<td>Kacang</td>
<td>20.59</td>
<td>Thin tail</td>
<td>[60,72]</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>81.38</td>
<td>Kacang</td>
<td>19.2</td>
<td>Thin tail</td>
<td>[60,73]</td>
</tr>
<tr>
<td>Physical Quality</td>
<td>5.48</td>
<td>Kacang</td>
<td>5.86</td>
<td>Thin tail</td>
<td>[74,75]</td>
</tr>
<tr>
<td>pH</td>
<td>36.63</td>
<td>Kacang</td>
<td>24.6</td>
<td>Thin tail</td>
<td>[74,75]</td>
</tr>
<tr>
<td>Water Holding Capacity</td>
<td>0.78</td>
<td>Kacang</td>
<td>2.94</td>
<td>Thin tail</td>
<td>[74,75]</td>
</tr>
<tr>
<td>Tenderness</td>
<td>6.00</td>
<td>Bligon</td>
<td>5.56</td>
<td>Thin tail</td>
<td>[76,77]</td>
</tr>
<tr>
<td>Aroma</td>
<td>2.33</td>
<td>Kacang</td>
<td>5.18</td>
<td>Thin tail</td>
<td>[77,78]</td>
</tr>
</tbody>
</table>

The species variations in taste are primarily caused by variations in lipid-derived volatile compounds [79]. These substances are essential sources of the odor of sheep and goat—one hundred and thirty-three components were measured in lamb and goat grilled meat [80]. These consist of 87 lipid-derived and 46 Maillard-derived compounds, comprising 22 hydrocarbons, 16 alcohols, 11 pyrazines, 25 aldehydes, 25 ketones, 10 dimethyl, 8 furans, sulfides, 7 nitrogen-containing compounds, 4 acids, 4 thiophenes, and 1 thiazole. For the first time, 15 of these compounds have been identified in lamb or goat meat. The high amounts of pyrazins and thiazole in goat meat will improve the roasted and overall taste of goat meat. The amounts of the sulfur-containing Maillard-derived volatiles, thiophenes, and dimethyl sulfides are the same in goat and lamb; thus, their effect on the simple meaty flavor appears to be the same. Substances that have the largest distinction between goat and lamb meat, e.g., C4-C5 n-alcohol and C6-C9 n-alkanal, 1-octen-3-ol and 2-butanone, are expected to have the most important impact on the distinctions in taste between goat and lamb. It is also known that amongst others, the diet fed will influence the meat’s lipid-derived volatile compounds [80]. To date, none of these compounds have been researched in any of the Indonesian goat or lamb meat, nor has their effect on consumer satisfaction been evaluated.

6.6. The Effect of Different Post-Mortem Processing Methods on the Quality of GS Meat

Studies have shown that various cooking methods have various impacts on the aromatic and flavor profile of lamb meat, contributing to increased taste and odor [81]. Compared to boiling, roasting is more acceptable and improves the quality of juiciness, taste, and aroma [78]. The effect of the cooking method on goat meat in Indonesia has been reported [82]; goat meat satay grilled for 7 min resulted in a low quality of flavor, while
goat meat satay grilled for 3 min was more acceptable. Similarly, cured goat meat with curcumin pasta had better quality as pertaining to tenderness [83].

Salting and air-drying the meat decreases the water activity in meat, while a longer period of aging reduces the toughness [84]. Many other new developments, such as superheated steam, ohmic cooking, and infrared cooking, have been found to enhance the texture and flavor of the meat while decreasing nutritional losses, reducing microbial contamination/growth, and also reducing the production of dangerous compounds compared to the methods applied during traditional cooking [85]. The color of cooked lamb meat is an essential sensory characteristic that appeals to consumers—caramelization and the Maillard reaction both influence the exterior color of the meat when cooking [86]. In comparing with roasting, frying, and grilling methods, cooking methods of sous-vide based upon lower cooking temperatures lead to less browning on the surface of meat; however, none of these cooking methods have been evaluated to date on GS in Indonesia [87].

The increased demand for goat and sheep meat in Indonesia has become the main reason for providing a better quality of meat, as traditional cooking methods cannot maintain both good quality and efficiency. Traditional cooking procedures have been suggested to reduce the nutritional content of lamb meat by changing nutrients, vitamins, and fatty acids [88]. Sous-vide cooking is characterized as raw materials or raw materials with intermediate products cooked inside vacuum pouches under monitored conditions of temperature and time [89]. In addition, ohmic cooking is a modern procedure based on electromagnetic waves. It is deemed to be very advantageous for meat products such as lamb because the heat is generated easily and evenly dispersed due to high electrical conductivity within the meat, resulting in increased nutrient and flavor retention [90]. The electrical conductivity in medium and current are critical aspects in ohmic cooking [91]. The rise in salt has been found to increase electrical conductivity and ohmic cooking while the fat reduces conductivity; therefore, particularly goat meat, with its lean meat content, should benefit from this cooking technology. However, with ohmic cooking, consideration of the damage to the electrodes, the difficulties of controlling the temperature–time relationship, and the complicated coupling between the temperature and the transmission of the electrical field is required and warrants further research [92].

Indonesian goat meat products can be produced by addressing the needs of consumers as pertaining to the products’ characteristics and understanding their underlying mechanisms. In the near future, with the development of meat science and technology, more modern technologies will be implemented for goat and sheep meat in Indonesia. As shown in Table 4, ozonized water, electrolyzed oxidizing water [93], spectroscopy [93], cold plasma technology [94], ultrasonic technology [94], and pulsed electric fields [95] are all some of the technologies that have been tested on goat and sheep meat. Further development of these technologies will facilitate the enhancement of the production of goat and sheep meat, thereby further encouraging the growth of the Indonesian sheep and goat industry.

Table 4. The potential application of advanced technology on goat/sheep meat.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ozonated water</td>
<td>Inactivating <em>Escherichia coli</em></td>
</tr>
<tr>
<td>Electrolyzed oxidizing water</td>
<td>Inactivating <em>Escherichia coli</em></td>
</tr>
<tr>
<td>Cold plasma technology</td>
<td>Sterilization of fresh goat meat</td>
</tr>
<tr>
<td>Ultrasonic technology</td>
<td>Maximizing the manufacturing technology of meat products</td>
</tr>
<tr>
<td>Pulsed electric field</td>
<td>Thawing of frozen goat meat</td>
</tr>
</tbody>
</table>

6.7. *The Effect of Food Additives on the Quality of Processed GS Meat*

One of the major contributors to meat degradation is the oxidation that occurs in the changing process from muscle to meat during storage or processing [96]. Sheep and goat are known as red meat due to their high content of myoglobin (and thus iron), which leads meat to oxidize readily [97]. The meat processing industry supplements antioxidants in the formulation of meat products to avoid meat oxidation reactions. However, most
of these ingredients are chemical, primarily butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), and propyl gallate (PG). However, several studies have reported that synthetic antioxidants have a negative impact on the human health of users, thereby increasing the market for natural preservatives [98].

Numerous antioxidants have been used for processed goat/lamb meat (Table 5) to increase the products’ water-holding capacity and minimize lipid oxidation, thereby improving the products’ sensory quality and the acceptance of Indonesian consumers.

Table 5. Effect of different processing methods on meat quality.

<table>
<thead>
<tr>
<th>Additives</th>
<th>Quality Attributes</th>
<th>Study Objective</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modified cassava flour</td>
<td>Water holding capacity (↑), tenderness (↑)</td>
<td>Lamb meatball</td>
<td>[99]</td>
</tr>
<tr>
<td>Eleutherine americana Merr</td>
<td>Tenderness (↑), flavor (↑), aroma (accepted), texture (↑)</td>
<td>Mutton sausage</td>
<td>[100]</td>
</tr>
<tr>
<td>Pomegranate peel extract</td>
<td>Hardness (↑), gumminess (↑), TBARS (↓)</td>
<td>Goat nugget</td>
<td>[101]</td>
</tr>
<tr>
<td>Pomegranate peel extract</td>
<td>TBARS (↓)</td>
<td>Ground goat meat</td>
<td>[101]</td>
</tr>
<tr>
<td>Borage and green tea</td>
<td>Lipid oxidation (↑)</td>
<td>Lamb leg chop</td>
<td>[102]</td>
</tr>
<tr>
<td>Zataria multiflora</td>
<td>Lipid oxidation (↑)</td>
<td>Ground sheep meat</td>
<td>[103]</td>
</tr>
<tr>
<td>Syzygium aromaticum</td>
<td>Lipid oxidation (↑)</td>
<td>Ground sheep meat</td>
<td>[103]</td>
</tr>
<tr>
<td>Inorganic Sodium Trypolyphosphat</td>
<td>Water holding capacity (↑), tenderness (↑)</td>
<td>Lamb meatball</td>
<td>[104]</td>
</tr>
</tbody>
</table>

↑ = increase the attribute quality; ↓ = decrease the attribute quality.

6.8. The Effect of Packaging and Storage on The GS Meat Product Quality

Meat oxidation may influence the quality of the lipids, proteins, and pigments and contribute to the decreased quality and shelf life by influencing the color, aroma, texture, and nutritional composition whilst also producing potentially toxic compounds that harm human health [105]. Time and storage of meat products are critical factors for food processing as storage stability issues are frequently encountered [106].

Amaral and co-workers [107] reported that storing lamb paté in a polyamide casing rather than in a glass container caused an increase in hardness. Also, packaging under a modified atmosphere [108] significantly reduced the total number of viable bacteria and enterobacteria counts.

One alternative food processing technology used in Indonesia to improve the quality of the meat is pulse electric fields [109]; this technology is used to inactivate pathogenic microbes. The advancement of technology has changed the meat industry to become more industrialized and modernized. A number of advanced technologies such as IoT (Internet of Things) have eased the production process in the meat industry. In storage, the temperature affects the quality of meat; Nagaraj and Santhanam [110] found that the role of biochemical properties of myofibrils (calpains) in the proteolysis of myofibrillar proteins was highly affected by the chilling/freezing temperature. Muela and co-workers [111] reported that a freezing tunnel is the better method to freeze lamb than the air blast freezer or nitrogen chamber since the time of freezing is short and there is less thawing loss and oxidation during the display.

6.9. GS By-Products

By-products in Indonesia are used in a variety of ways, some of which are used as fertilizer and biogas, even when it is also consumed as a food. As an example of the former, in Sindabarang village (Sub-district of Jalakansana of the Kuningan district), most villagers are farmers who practice animal husbandry with their main activities focused on goats; they use manure as alternative energy and fertilizer [112].

Goat and sheep organs are used as food in Indonesia, such as offal, liver, lungs, brain, blood, kidney, intestine, spleen, and head [109]. Offal is one of the favored components from livestock for Indonesians to consume; according to the Indonesian Food Outlook Analysis 2015–2019, offal is the second largest imported animal-derived component after
frozen meat. However, the number of imported items has been limited due to health and halal considerations.

An effort to enhance goatskin as a by-product that is not easily damaged and can increase its economic value is by tanning the skin [113]. The goatskin is used as raw material to create high-quality Batik leather (Indonesian traditional fabric) tanned with chrome [114]. Studies on the use of goat and sheep skins included the application of gambier and alum as tanning agents, and the result of using alum and gambier as tanning agents meets Indonesian standards—National Standard SNI-06-0463-1989 [115], which is the standard for the leather layer of tanning combination, and SNI-0253-2009 [116], which is the standard for the upper skin of goat legs as pertaining to their chemical and physical properties [115].

Gelatine derived from goat skin has high protein (86.6%), suitable moisture (9.6%), and low fat (1.5%) contents [117]; because of its unique properties, gelatine is (frequently) used in pharmaceutical, food, and cosmetic industries [118]. Goat leg gelatine also has a positive effect when applied to food products [119]. Furthermore, the bone by-product of goat is used as activated charcoal [120] through the carbonization process and chemical activation by using sulfuric acid as an activator on the bones.

7. The Main Challenges in the Processing of GS Meat in Indonesia

There are a number of challenges facing the Indonesian GS industry that need to be addressed through research. Microbial meat contamination occurs before and after slaughtering. After exsanguination as used during religious slaughter, the blood still circulates to all parts of the animal’s body. Therefore, the use of unclean blades causes microorganisms to enter the blood. Microbial contamination of meat also occurs through the surface of the meat during carcass division, cooling, freezing, defrosting of frozen meat, cutting, making processed meat products, preserving, packing, storing, and marketing [121]. These contaminations might occur in slaughterhouses; some Indonesian slaughterhouses may have a variety of microbes, in part due to a lack of knowledge and hygiene protocols [122].

Another problem in the meat industry is meat fraud, which is categorized as unethical activities, including falsification, replacement, stolen animals, grey market products, smuggling, distortion, and mislabeling—all of which are not in accordance with the halalan toyibban standard (the essential principle in Indonesia with its high population of Muslim). Criminals, especially in the meat industries in Malaysia and Indonesia, utilize dangerous and unhealthy materials in counterfeit meat products, including formalin, carrion, artificial meats, exotic meats, aniline, and garbage [123]. In addition to safety issues, there are also halal-specific problems such as halal meat combined with (illegal) haram meat/carcasses, beef replacement with pork meat, and mutton substitution with dog meat [123]. To identify the contamination of pork in the meatballs of an Indonesian market, a polymerase chain reaction-restriction fragment length polymorphism (PCR-RFLP) was developed. The method detects the cytochrome b gene, which is found in non-halal meat [124]. Indonesian researchers also developed a particular primer derived from the mitochondrial cyt b of Sus scrofa (1F1R primer) for the study of pork contamination in meatball items [125].

The initial stage of the GS value chain starts from on-farm production, which needs to implement good farming practices (GFP), including sanitation of the pen/cage (the majority of small ruminants are now kept in confinement) and the environment around the pen and animal feed, which should be free of fungi or aflatoxins or any other contaminants [121]. This is also related to where the animals are grazed; the most common grazing areas are fallow fields, roadsides, and football fields [18]. Furthermore, in the post-harvest stage, it is necessary to practice good handling practices (GHP). At this stage, it is necessary to pay attention to the design of the facilities, equipment, or machinery used for postharvest handling [121]. Also, throughout the whole value chain, animal welfare is of paramount importance.

Based on the challenges that are arising in the value chain of goat and sheep meat in Indonesia, addressing all the facets, whether it is microbial contamination, the needs of ASUH (safe, healthy, whole, and halal), the limit of antibiotic residues, and fraud activities,
will strengthen regional collaboration in developing the meat industry by empowering and preserving regional systems.


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